APPARATUS FOR PROCESSING TEXTILE YARNS

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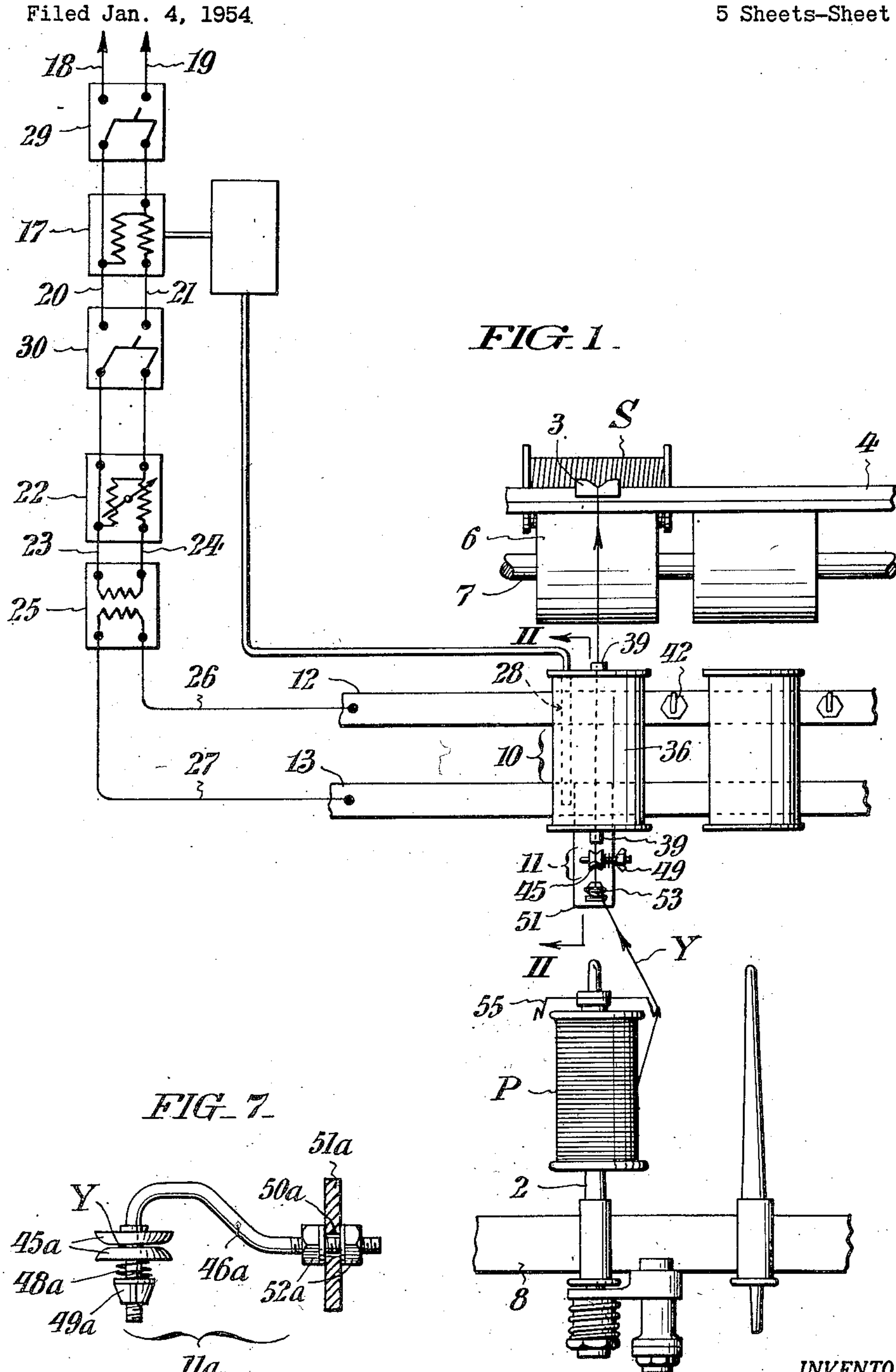

FIG. 1.

FIG. 7.

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APPARATUS FOR PROCESSING TEXTILE YARNS

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FIG. 3.

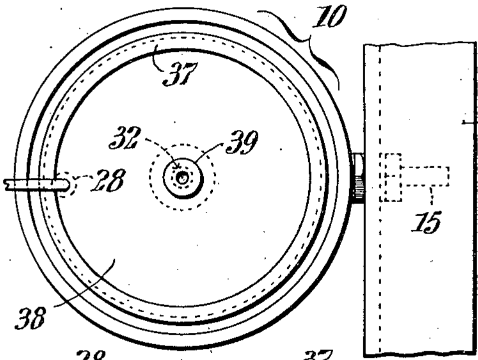


FIG. 5.

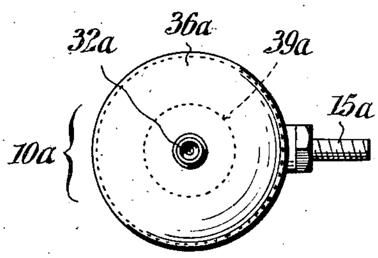


FIG. 2.

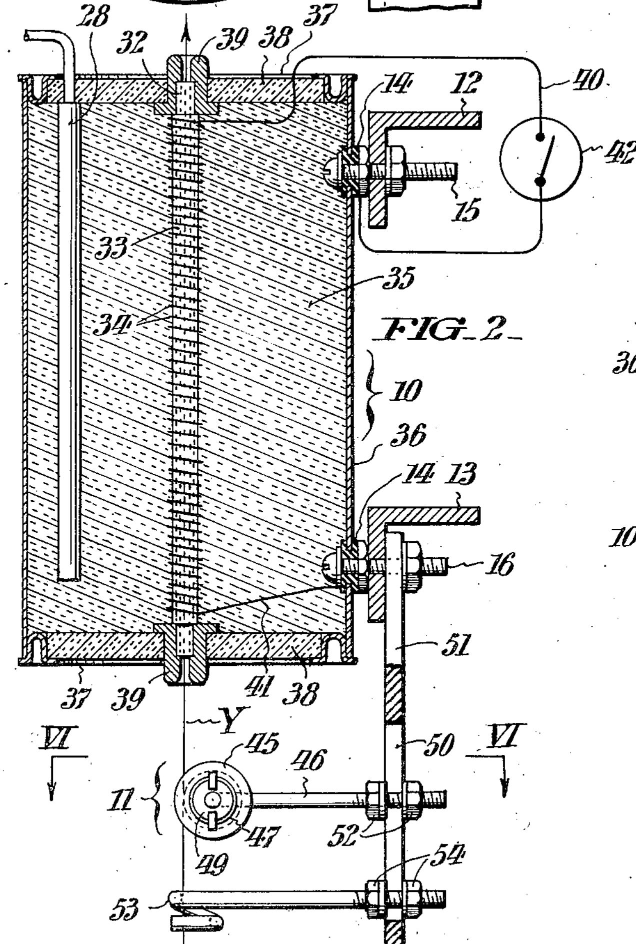


FIG. 4.

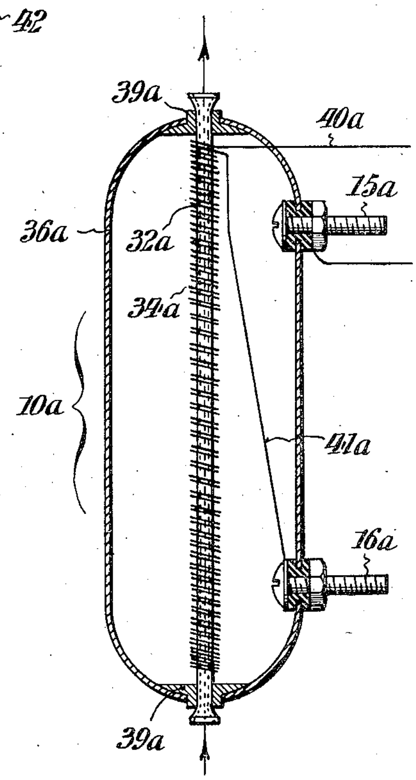
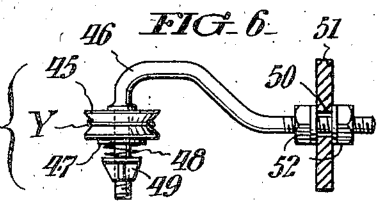


FIG. 6.



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APPARATUS FOR PROCESSING TEXTILE YARNS

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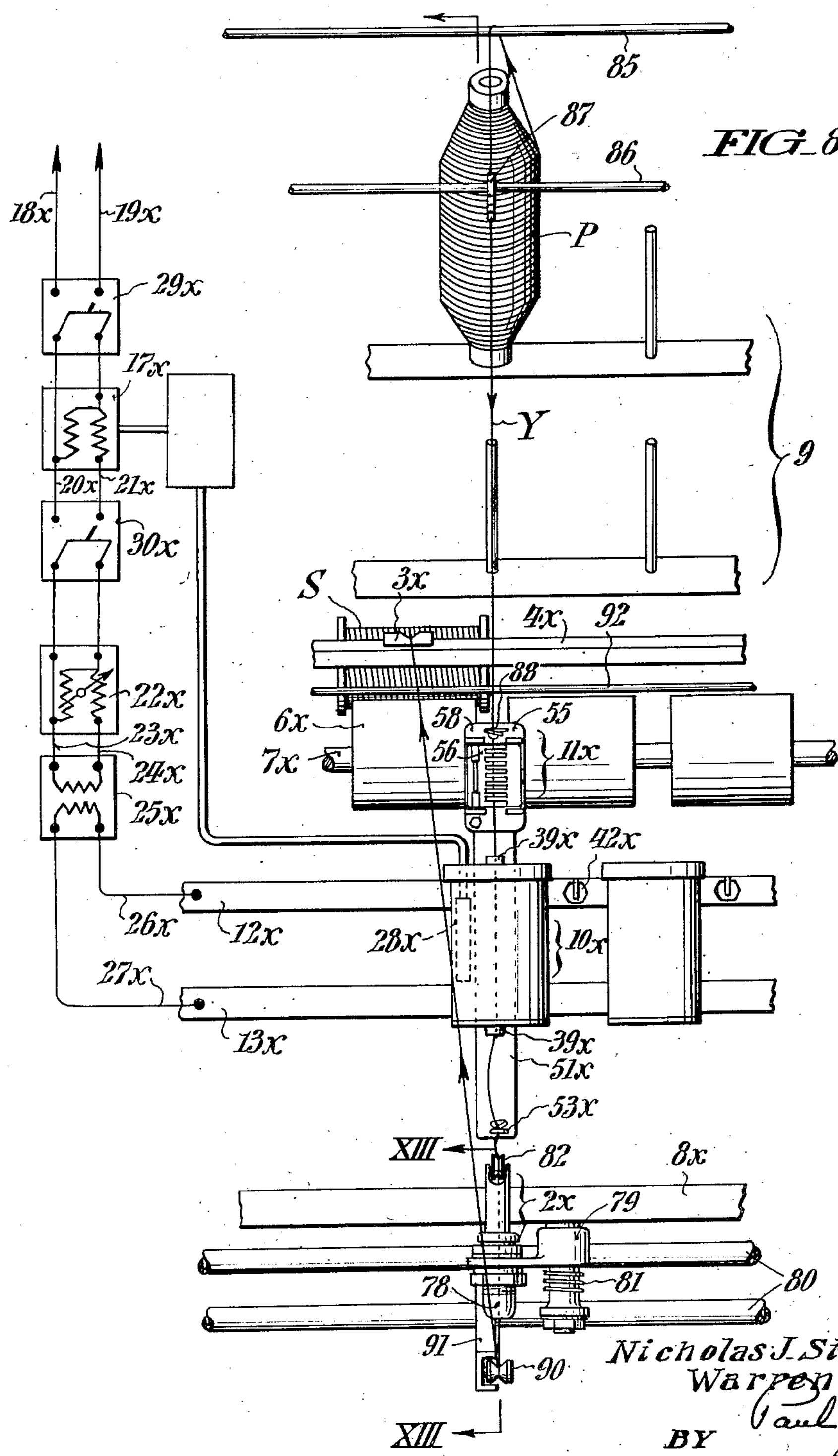

FIG. 8.

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APPARATUS FOR PROCESSING TEXTILE YARNS

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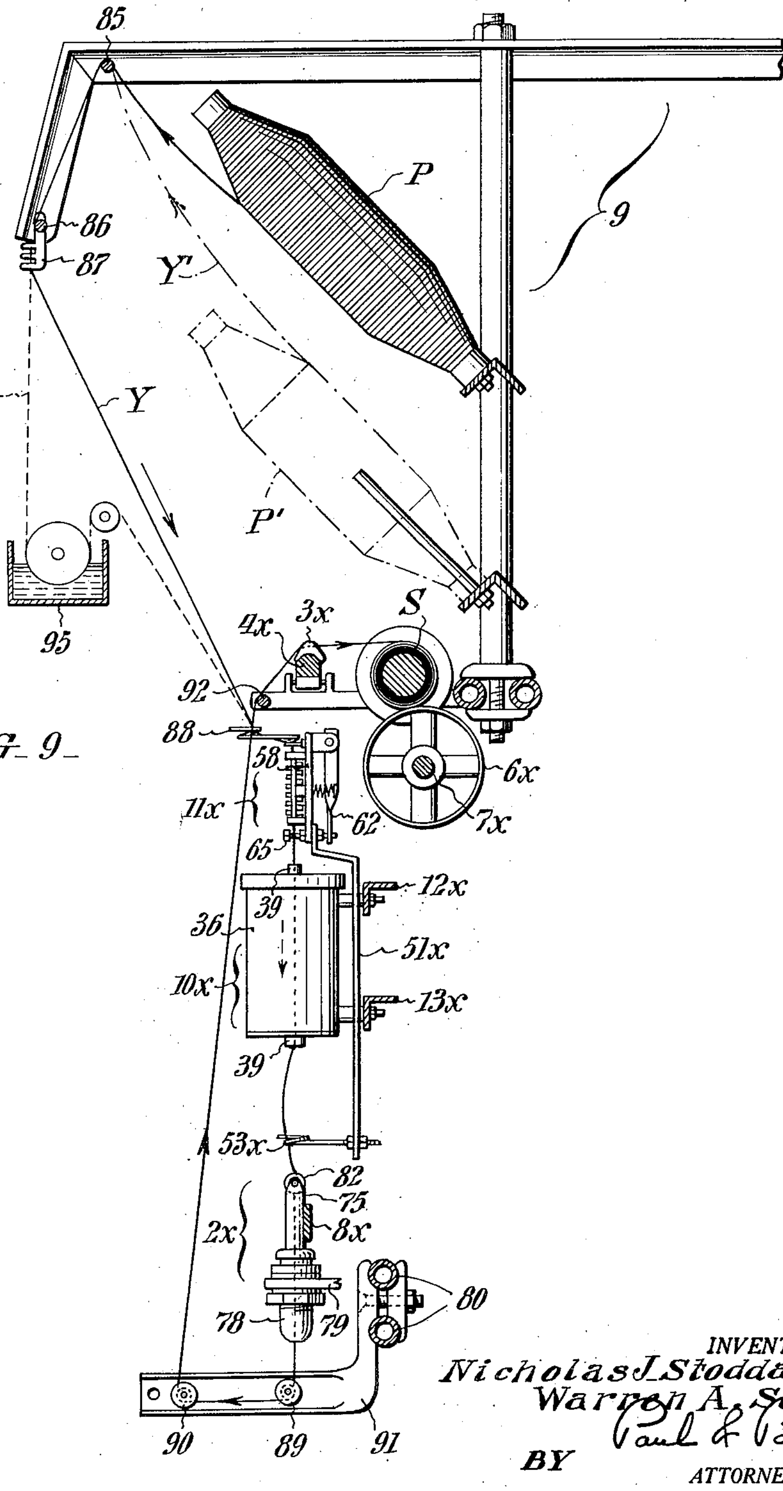

FIG. 9

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FIG. 10

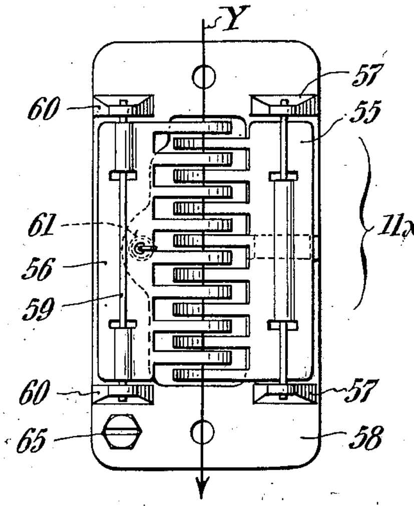


FIG. 11

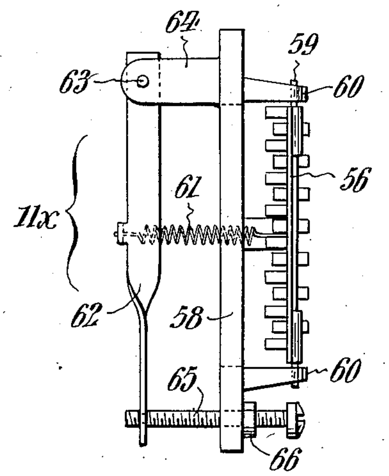


FIG. 12

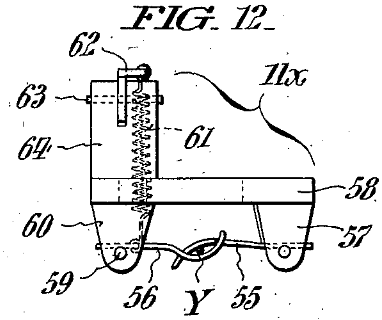
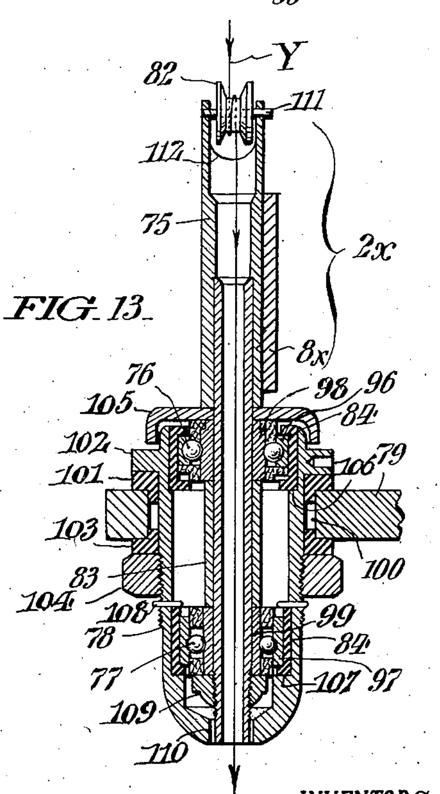


FIG. 13



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United States Patent Office 2,803,105
Patented Aug. 20, 1957

2,803,105

APPARATUS FOR PROCESSING TEXTILE YARNS

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Application January 4, 1954, Serial No. 401,952

7 Claims. (Cl. 57—34)

This invention relates to apparatus for processing thermoplastic textile yarns. More particularly it is concerned with apparatus useful in processing polyamide and other thermoplastic yarns such as nylon, Vinyon, Orlon, Velon, Dacron, saran and the like (as distinguished from yarns of cotton, linen, rayon, silk or wool and the like) by thermal treatment with incidental winding, twisting, twisting-untwisting, plying, coning, copping, nubbing, drying, dyeing, coating, singeing, sizing and the like, according to the improved continuous methods disclosed in copending applications, Serial Nos. 401,803 and 401,951, filed by us concurrently herewith.

Our present invention is directed toward the provision of simple reliable apparatus with the aid of which the aforesaid methods can be expeditiously carried out at high speeds and at much less cost than possible with the stepwise methods which had to be resorted to heretofore, for the production of improved monofilament, multi-filament, or spun thermoplastic yarns which are of improved uniformity throughout as regards their physical characteristics, i. e., denier size, elongation, elasticity, strength, yield value, contractile force, shrinkage, residual shrinkage, torsion and the like; permanently stabilized uniformly crimped, wavy or fluffed thermoplastic yarns; straight thermoplastic yarns of the kinds disclosed in U. S. Patents Nos. 2,353,666 and 2,411,132; as well as improved uniformly stabilized ply yarns whereof the components may all be thermoplastic, or some of them may be of rayon or the like, or of silk, cotton, linen, or other non-thermoplastic materials.

Other objects and attendant advantages will appear from the following description of the attached drawings, wherein:

Fig. 1 is a fragmentary view, in front elevation, of a thermoplastic yarn processing apparatus conveniently embodying our invention in one form.

Fig. 2 is a fragmentary detail section on a larger scale taken as indicated by the angled arrows II—II in Fig. 1, showing in detail a specially constructed heating device and an associated specially constructed tensioning means incorporated in the apparatus.

Fig. 3 shows the heating device in top plan.

Figs. 4 and 5 are views corresponding respectively to Figs. 2 and 3 of a modified form of heating device.

Fig. 6 is a detail sectional view taken as indicated by the angled arrows VI—VI in Fig. 2.

Fig. 7 is a view like Fig. 6 showing an alternative type of tensioning means.

Fig. 8 is a fragmentary view, in front elevation, like Fig. 1 of a thermoplastic yarn processing apparatus embodying our invention in another form.

Fig. 9 is a fragmentary view showing the apparatus of Fig. 8 in transverse section.

Figs. 10, 11 and 12, respectively, show the front view, a side view and the top plan view of a specially constructed tensioning device included in the apparatus of Figs. 8 and 9 and drawn to a larger scale.

Fig. 13 is a larger scale detail sectional view of a specially constructed high speed spindle provided in the apparatus of Figs. 8 and 9, the section being taken as indicated by the angled arrows XIII—XIII in Fig. 8.

With more specific reference first to Fig. 1 of the drawings, the apparatus there illustrated is basically what is known in the textile art as an "up-twister." One of the usual spindles for a package P of yarn Y to be processed is indicated at **2**, one of the traverse guides at **3**, the traverse rail at **4**, the take-up spool for the processed yarn at S, the drive roll for the spool at **6**, and the shaft for the drive roll at **7**, said spindle having a diametrically enlarged portion at the bottom tangentially contacted by the belt **8**.

In adapting such an up-twister to the purposes of our invention, we arrange in the interval between the spindle **2** and the traverse guide **3**, a specially designed heating device **10**, and immediately below said device, a specially constructed tensioning means **11** along the line of upward travel of the yarn Y from the supply package P to the take-up spool S.

As presently explained, the device **10** is electrically heated, current being conducted to it through two fixed horizontal bus bars **12** and **13** whereto said device is secured, with interposition of insulation bushings **14**, by screws **15** and **16** as best shown in Fig. 2. The required degree of heat is uniformly maintained by current at a constant voltage (not exceeding twenty-four volts for personal safety) through an automatic induction voltage regulator **17** from a power line **18**, **19**, said regulator being connected by conductors **20**, **21** to a manually adjustable induction voltage regulator **22** connected in turn by conductors **23**, **24**, to the primary of a step-down transformer **25** in circuit through conductors **26**, **27** with the bus bars **12**, **13**. The output of the induction voltage regulator **17** is automatically governed by a thermally-responsive sensing means **28** incorporated in the heating device **10**. The automatic and the manual induction voltage regulators **17** and **22** and the thermostatic sensing means **28** may all be of any approved standard and commercially available types by cooperation of which the temperature in the heating device is modulated compensatively with changes in ambient or room temperature and transfer of heat to a yarn travelling therethrough. Also included in the lines **18**, **19** and **20**, **21** respectively are suitable manually operable safety hand switches **29** and **30**.

The heating device

As best seen in Figs. 2 and 3, the heating device **10** comprises a tube **32** of non-ferrous material and of small diameter and bore, through which the yarn Y is passed, said tube being exteriorly insulated as at **33** with glass or other electrical insulation, and surrounded by a coil **34** of resistance wire. As further shown, the tube **32** is embedded in a thick walled jacket **35** of electric and thermal insulation which may be of fiber glass or of Sil-O-Cel granules encased in a thin cylindrical metallic shell **36**. At the top and at the bottom, the shell **36** is partly closed by covers **37**, which also may be of sheet metal, with interposition between them and the jacket material of disks **38** of Transite or the like to minimize heat transfer from the hot tube **32** to said shell. Fitted over the opposite ends of the tube **32** and passing through the disks **38**, are hard wear-resistant bushings **39** of porcelain or the like which prevent cutting of the tube by the yarn passing through it. It is to be particularly noted that the winding pitch of the heating coil increases progressively from the bottom of the tube **32** at which the yarn enters to the mid height of the tube and progressively decreases at a similar rate toward the top or exit end of said tube. As a result, a greater amount of electrical energy is provided at the entrant and exit ends of the tube thereby making possible the maintenance of a desired uniform temperature throughout tube **32** and the use of a much shorter tube than otherwise would be required. The lead **40** from one end of coil **34** is extended to the exterior through the insulation jacket **35** to the screw **15**, and the lead **41** from the other end of said coil to the screw **16**, with interposition in the latter lead of a hand switch which is diagrammatically indicated at **42** in Figs. 1 and 2 and shown as insulatedly mounted on bus bar **12**.

The tensioning means

The tensioning or restraining means **11** comprises, in this instance, a small V-grooved wheel **45** (Figs. 2 and 6) about which the yarn Y is passed one or more times, said wheel being freely revolvable about the laterally bent end of a supporting shank member **46**, and is engaged by a friction disk **47** which is pressed by a spring **48**, the pressure of the latter being finely regulatable by means of a thumb nut **49** threadedly engaged upon the distal end of said shank member. By this means it is possible to regulate the tension of the yarn in correlation to the prescribed temperature to which the yarn is heated and to the linear speed of travel of the yarn to maintain the latter at a selected uniform tension relative to the contractile force and thermal characteristics of the yarn. As best shown in Fig. 2, the shank member **46** extends through a vertical slot **50** in a bracket bar **51** suspended from bus bar **13** and is fixable after adjustment up or down and in or out by means of clamp nuts indicated at **52**. Arranged below the tensioning means **11** and similarly supported by the bracket bar **51**, with capacity for up and down and in and out adjustment, is a pigtail guide **53** for the yarn, said guide being fixed in adjusted position by clamp nuts **54**.

Modified heating device

In the modified heating device **10***a* of Figs. 4 and 5 which may be used in lieu of the one illustrated in Figs. 2 and 3, the yarn tube **32***a* is axially arranged in an evacuated round ended shell **36***a* of non-collapsible material, with its ends sealed in bushings **39***a* hermetically set into the ends of said shell. By this means it is possible to regulate the tension of the yarn in correlation to the prescribed temperature to which the yarn is heated and to the linear speed of travel of the yarn to maintain the latter at a selected uniform tension relative to the contractual force and thermal characteristics of the yarn. In this instance, the heating coil **34***a* is non-inductively wound about the tube **32***a* which has an exterior coating of insulation like that of the tube **32** of the first described heating unit. In all other respects, the modified heating device **10***a* may be considered to be generally like the device **10** and to function in an analogous capacity.

Modified yarn tensioning means

In the modified yarn tensioning or restraining means **11***a* of Fig. 7, a pair of opposing friction disks **45***a* are shown instead of a roller, these being freely revolvable about the laterally turned end of the supporting shank **46***a* and maintained in pressure engagement with the yarn Y as it passes between them, by a spring **48***a* which is finely regulatable by the thumb nut at **49***a*. With the modified tensioning means **11***a* substituted for the means **11** in the apparatus of Fig. 1, a somewhat different effect is produced on the yarn as will be explained later.

Operation

Again referring to Fig. 1, the yarn from the supply package P is threaded upwardly through one eye of the flyer **55** associated with spindle **2**, then through the guide **53**, then wrapped about the small wheel **45** of the tensioning means **11** in the manner previously stated, then through the tube **32** of the heating device **10**, and finally over the traverse guide **3** enroute to the take-up spool S. For the processing of twisted nylon yarn, for example, the induction voltage regulator is adjusted for maintenance of an effective temperature of 250° F. which is modulated with changes in ambient or room temperature and rate of heat transfer to the yarn by the thermostatic means **28** for maintenance of heat substantially constant in the device **10**. In being ravelled from the supply package P in Fig. 1, the yarn is twisted by rotation of the package before it passes to the tensioning means **11** and enters the tube of the heating device **10** enroute to the take-up spool S. By reason of adequate frictional engagement of the yarn with the small wheel **45** when wrapped about it or alternately the adequate frictional engagement of the yarn with the tines of the comb-like vanes **55** and **56** of an alternate tension device shown in Figs. 10, 11 and 12, the twist is inserted in the yarn prior to its entry into the heating device, the twist being subsequently set by heating and cooling of the yarn in the interval of its travel between the tensioning device and the take-up spool S. When an alternative tension device like that shown in Fig. 7 is utilized, the tangential frictional contact of the disks **45***a* upon the yarn is such that the disks permit the yarn passing therethrough to turn upon its axis and be twisted in the heated zone where it has been made more ductile, with stabilization of the yarn taking place as it cools in its travel between the heated zone and the take-up spool S. By adjusting the tensioning devices so that the restraint imposed is equal to the contractile force of the yarn, no stretching or shrinking of the yarn will take place. On the other hand, if the adjustment of the tensioning means is made less than the contractile force of the heated yarn, shrinking of the yarn will take place during the heating, while if the adjustment is made greater than the contractile force, the yarn will be stretched during the heating.

Many of the irregularities in the physical characteristics of commercially delivered thermoplastic yarns are substantially corrected by our means of applying uniform heat to the yarn while under uniform tension as for example, sectional lengths of yarn, stretched less than other sections in the manufacturers producing thereof will stretch more under a given tension and temperature, and uniform elevated temperatures while under various uniform tensions, will improve properties of the yarn such as dyeing, tensile strength, modulus of elasticity and the like. Also our means of quickly heating and cooling the yarn prevents heat degradation normally resulting from prolonged heating of thermoplastic yarns.

Fig. 1 illustrates the manner of equipping a conventional up-twister with the herein referred to heating and tensioning devices, but in the practice of our invention we similarly equip all throwing or yarn processing machines such as winding, twisting, twisting-untwisting, plying, coning, copping, nubbing, drying, dyeing, coating, singeing and sizing machines and the like.

Alternative form of apparatus

Like the apparatus of Fig. 1, the alternative apparatus of Figs. 8 and 9 is basically an up-twister converted to the purposes of our invention, the usual parts of the machine being designated by the same reference numerals previously employed, with addition however in each instance of the letter *x* for convenience of more ready distinction. In this case in adapting the up-twister to the purposes of our invention, we have provided it with a special overhead creel **9** for the yarn package P which is to be processed, a specially constructed tensioning device **11***x* different from either of the two hereinbefore described, and a specially constructed spindle **2***x*, the heating device **10***x* here shown being like the one illustrated in Fig. 2.

Tensioning device

By reference more particularly to Figs. 10, 11 and 12, it will be noted that the tensioning device **11***x* comprises two comb-like vanes **55** and **56** between the alternating tines of which the yarn Y is passed. Vane **55** is fixedly supported between a pair of vertically-spaced forwardlyprojecting lugs **57** of a bracket plate **58**, while vane **56** is swingable about a hinge pin **59** between another pair of vertically-spaced forwarding-projecting lugs **60** of said plate. The swingable vane **56** is connected by a tension spring **61** to a vertical lever **62** fulcrumed at **63** on a rearward projection **64** at the top of the plate **58**. The lower or distal end of lever **62** bears against a screw **65** threadedly engaged in plate **58**. By means of screw **65**, it is possible to vary the force of the spring **61** and, in turn, the pressure exerted by the wing **56** upon the yarn Y to regulate the drag or tension imparted thereto. Thus the tension of the yarn may be correlated to the prescribed temperature to which the yarn is heated and the linear speed of travel of the yarn as previously described. The jam nut at **66** serves as a means for securing the screw **65** against accidental displacement in adjusted position.

Special spindle

Our improved twisting and untwisting spindle illustrated in detail in Fig. 13 is an improvement over the types of spindles disclosed in U. S. Patents Nos. 2,089,198 and 2,089,199.

As shown, the spindle **75** is relatively short in length and formed by two sections of light weight tubing preferably of steel, the lower section being telescopically force-fitted partway into the upper section and having a small bore of a diameter to freely pass the travelling yarn. In actual practice, the upper section of the spindle **75** may be 2 in. long and have a diameter of ½ in., and the lower section may be 3⅝ in. long with an outside diameter of $\frac{5}{16}$ in. and a bore of $\frac{3}{16}$ in., the whole weighing approximately $2\frac{3}{10}$ ounces and the total length of the tube being approximately 4⅝ inches. The periphery of the upper section serves as a driving surface in contact with the belt **8**x of the otherwise conventional spinning machine. Thus the tension of the yarn may be correlated to the prescribed temperature to which the yarn is heated and the linear speed of travel of the yarn as previously described. The spindle **75** is journalled in a pair of high speed anti-friction bearings **76, 77** which are vertically spaced by a sleeve **83** approximately 1 in. long surrounding the lower section of the spindle. The bearings **76, 77** are lodged, with interposition of rubber cushioning annuli **84, 84** embracing outer races **96, 97**, within a compact cylindrical housing **78** which extends downward, with circumferential clearance, through an opening **100** in the swing arm **79**, and which itself is cushioned by a rubber washer **101** interposed between a flange **102** adjacent the top thereof and the top surface of said arm, and a similar washer **103** interposed between the bottom surface of said arm and a clamp nut **104** threadedly engaged on the lower protruding portion of said casing. As shown, the casing **78** is open at the top but protected against ingress of dirt or lint by a disk **105**, with a pendent circumferential overhanging flange, rotative with the spindle and secured between the lower end of the upper section of said spindle and the top of the inner race **98** of the upper ball bearing. It is to be noted that the rubber cushioning annuli **84** for the ball bearings **76, 77** respectively are seated upon circumferential shoulders **106, 107** circumferentially of the casing **78**, and that the lower bearing **77** is held against upward displacement by inward radial projections of a semicircular spring keeper **108** element, and that a clamp nut **109** threadedly engaged upon the lower section of the spindle and contacting the bottom of the inner race **99** of the lower ball bearing **77** serves to hold the spindle in the assembly, the lower end of the latter being somewhat reduced in diameter and extending through an axial clearance aperture **110** in the bottom of the casing. A small flanged roll **82** within the top end of the upper section of the spindle is freely revolvable about a crosswise axis pin **111**. It is also to be particularly observed that the opposing side portions of the top end of the upper section of the spindle **75** are cut away concavely as at **112** on a radius greater than that of the flanges of the roll **82**.

Of importance in the carrying on of all of the objects of this invention are the improvements in and the advantages of our twisting-untwisting spindle assembly over previously disclosed twisting-untwisting spindles, these advantages being: the interchangeability of the spindle with conventional spindles on conventional twisters; the one-half inch outside diameter of the driving surface of the spindle **75** results, without changing the belt speed, in about double the spindle speed of conventional spindles which usually have approximately one inch outside diameter of their driving surface; the thin wall, short 2 inch length and small one-half inch outside diameter result in a spindle with a substantially irreducible minimum of weight and inertia; the small one-half inch outside diameter and the short 2 inch length of the exposed upper section of the revolving spindle result in a substantially irreducible minimum of windage; the wall thickness of the hollow spindle and the 2 inch length of the exposed section of the revolving spindle are subtsantially irreducible minima for such type of spindle to be driven in excess of 20,000 R. P .M. by a conventional flat belt; the joining of two metal tube sections provides the most economical means of producing the most durable thin walled and light weight hollow spindle with a driving surface outside diameter of approximately one-half inch and smaller outside diameter bearing surface to accommodate sealed ball bearings of the most suitable presently known size and type to reduce friction losses to substantially an irreducible minimum when operating in excess of 20,000 R. P. M. under the known inertia, friction, windage, vibratory and work loads, and requiring no added lubrication for years; the 1 inch spacing between the ball bearings **76, 77** is substantially the optimum for operation in excess of 20,000 R. P. M. under the known operating loads; the rubber housing annuli **84** and rubber washers **101** and **103** absorb vibratory shocks and reduce vibratory loads, friction losses, windage and wear; the concaved roundings **112** at the upper end of the hollow spindle permit easy threading of the reverse twist roll **82**; the cover disk **105** protects the ball bearings from dust, lint and yarn waste; the retaining spring **108** serves as a most economical yet reliable means of holding the hollow spindle and bearings in position in the bearing housing **78** as well as an easy means to release the same when required; and the reverse twist roll has many advantages herein more fully set forth.

We have found that, due to the low inertia, friction, windage, vibratory and work loads of our improved spindle, it is possible to operate the spindle at more than twice the speed of conventional spindles, twisting a like yarn the same degree, without any increase in energy consumption; and we have also found that this saving in energy is adequate to operate our heating devices according to the teachings of this invention. Moreover, the design of our improved machine is such as to permit the use of large delivery packages, the absence of any revolving yarn packages makes for less yarn breakage, the twisting and untwisting at one time and at high speeds and the doubling prior to and/or after twisting and untwisting reduces the machine operator's work load, all of which results in substantial labor saving.

Reverse twist roll **82** of Fig. 13 is of particular importance in carrying out the objects of this invention; and it is of importance that anti-friction oilless bearings are utilized, that the approximate dimensions of the roll are $\frac{5}{16}''$ width, ½″ diameter 30 degree tapered flanges, $\frac{3}{16}''$ diameter roll face ⅛″ in width, and that the face tapered flanges of the roll are smooth and polished. With further reference to our reverse twist roll **82**, the oilless bearing is essential to insure free turning so that substantially no added tension is applied to the yarn at this critical point of its travel; the outside dimensions are important to create adequate windage to cool the yarn with a minimum of power consumption; the taper and depth of the flanges are essential to control the shape of yarn balloon and flow of air to cool the previously heated travelling yarn; the diameter of the roll face is of importance to provide adequate traction to minimize the number of wraps of the yarn about the roll necessary to insure the insertion of one full turn of twist for each revolution of the spindle and to create an adequate balloon to insure adequate cooling of the yarn before the untwisting; the width of the face of the roll is of importance to insure no overlapping of the wraps of yarn about the roll but aded traction as a result of the centrifugally induced abutting relation of one wrap of travelling yarn against the next; the smooth polished surfaces of the roll face and tapered flanges are important to prevent catching or chaffing of the yarn; and the size and shape of the tapered flanges in relation to the face of the roll are of importance for ease of removal of yarn waste.

In practice we have found it to be very desirable and economical to place more than one delivery package upon the supply creel for each spindle and then travel two or more ends of similar or dissimilar yarn through the same tension device, the thermal unit and the twisting-and-untwisting spindle, but in all instances at least one of the ends of yarn is thermoplastic.

We have also found it to be very practical and economical to travel similar or dissimilar yarns from two or more spindles on one take-up package, with the ends so doubled and all having been twisted in one direction or in any combination of different directions; the aforesaid doubling being facilitated in some instances by utilizing overhead thread guides between adjacent machines so as to wind onto the take-up package of one machine, yarn that has been twisted etc. on the adjacent machine.

Operation of modified apparatus

For the purposes of illustration let it be assumed that the yarn Y is in the form of a continuous multi-filament of nylon or the like. As it passes down through the device **10**x it is uniformly heated to a temperature within twenty degrees of the melting point of the thermoplastic, the temperature being predetermined by adjustment of the manual induction voltage regulator **22**x in accordance with the rate of linear speed at which it is travelled, the temperature being automatically modulated as in the first described embodiment compensatively with changes in ambient or room temperature and transfer of heat to the travelling yarn by action of the sensing means **28**, and the means **11** being adjusted for maintenance of the desired tension less than the yield value of the yarn during the heating thereof. While in a plastic state, the yarn is twisted as it traverses the device **10** by the action of the spindle **2**x and cooled by ballooning and radiation in the interval between the outlet end of the heated tube **32** of said device and small roll **82**, the yarn being wrapped one or more times about the small roll **82** of the twisting-untwisting spindle as previously explained; and the cooling being enhanced by contact of the yarn with the face and smooth sloping sides of said roll. The yarn is thus adequately cooled before it becomes untwisted which occurs as it leaves frictional contact with roll **82** and thereafter passes through and out of the lower end of the spindle tube **75** enroute, beneath the two fixedly positioned guide wheels **89** and **90** over the guide rod **92** and the reciprocating traverse guide **3**, to the driven take-up spool S. As a result of this continuous processing in accordance with our invention, a substantially permanent crimp, wave or fluff is set into the yarn. Care must, of course, be exercised to maintain the proper correlation between heat, speed and tension, for if the yield value of the heated yarn being processed is intermittent or uniformly exceeded by tensile stress, the resultant yarn, after untwisting, will be uneven and lack uniform crimp, wave or fluff and the degree of the crimp, wave or fluff will be relative to the degree to which the tension is exceeded in yield value. The degree and permanency of the crimp wave or fluff is attained by maintaining the treating temperature well up to the melting point of the thermoplastic, i. e., not less than forty percent below the melting point. By maintaining a low tension, the yarn will be permitted to shrink in the processing, while by subjecting it to a relatively high tension, a corresponding amount of stretching or elongation will take place during the heating. It is to be noted that in the apparatus of Figs. 8 and 9, the yarn is restricted against turning about its axis by frictional engagement with tension device **11**x, while revolving spindle **2**x, with the yarn in frictional engagement with roll **82** attached thereto, turns the yarn upon its axis, and since the portion of the yarn which is at the moment heated to a more ductile state by device **10** offers the least resistance to being twisted, much of the insertion of twist takes place in the heated portion of the yarn.

A spun yarn originally formed from thermoplastic staple or fibers when processed according to our invention will of course be attended by results similar to those described above in connection with continuous multi-filament thermoplastic yarn.

If desired, the yarn may be dyed or sized as an incident to the processing, and in accordance with our invention, we have provided a dye or sizing applicator **95** in Fig. 9 through which the yarn is passed enroute to the heating device **10**, the diverted path of the yarn being indicated at Y' in dotted lines. In passage of the yarn through the restricted heated zone at elevated temperature in the device **10**, the dye is effectively developed and set, or the sizing is dried as will be readily understood.

With the apparatus of Figs. 8 and 9, it is also possible to produce straight compact twisted thermoplastic yarns of the kinds disclosed in the two patents hereinbefore referred to, whose active and latent torsional forces are eliminated or controlled by twisting the ends from 3% to 60% beyond the twist desired in the final yarn, setting the twist, and then twisting the yarn in the opposite direction a number of turns. In this case the yarn is previously twisted to the ultimate twist desired on conventional twisters, and said twisted yarn is mounted upon supply creel **9** and additionally twisted under heat and correlated tension, cooled and reverse twisted the identical number of turns as twisted by the use of the apparatus of Figs. 8 and 9.

With the apparatus of Figs. 8 and 9 it is also possible to process plied yarns by placing two or more packages of yarn to be processed on the supply creel, as for example, a second strand Y2 is supplied from a second package P' supported on creel **9** above supply package P for the first end.

It is of course to be understood that in the two types of illustrated apparatus, a heating device **10** or **10**x and a tensioning device **11** or **11**x are provided for each spindle **2** or **2**x, and that in either instance, heating devices of the construction shown in Figs. 4 and 5 may be substituted, if desired or deemed more convenient, for the heating devices **10** or **10**x, with attainment of the same desired uniform effects in the processed yarns. It is to be further understood that we do not consider ourselves limited to the precise details of construction herein shown by way of example, since these are obviously subject to variation within the scope of the broader claims hereto appended.

Having thus described our invention, we claim:

1. Apparatus for thermally processing thermoplastic yarn comprising a support for a supply of yarn, wind-up means for the processed yarn spaced from said support and operable to draw the yarn continuously at a selected linear speed from the supply to said wind-up means, an electrically energized heating device defining a restricted thermally isolated heated zone for passage of the yarn

therethrough to heat the yarn to a prescribed temperature, means operable to twist the yarn before passage thereof through said heated zone, control means operable automatically to regulate the supply of heat energy to said zone compensatively according to the rate of transfer of heat to the yarn to maintain said zone uniformly at the temperature required to heat the yarn to said prescribed temperature, tension means operable to maintain the yarn at a uniform tension during passage thereof through said heating device and to the wind-up means, and means to regulate the tension means to control the tension of the yarn in correlation to the prescribed temperature and linear speed of travel of the yarn to maintain the latter at a selected uniform tension relative to the contractile force and thermal characteristics of the yarn.

2. Apparatus for thermally processing thermoplastic yarn comprising a support for a supply of yarn, wind-up means for the processed yarn spaced from said support and operable to draw the yarn continuously at a selected linear speed from the supply to said wind-up means, means to apply a liquid to the yarn passing from said supply, an electrically energized heating device defining a restricted thermally isolated heated zone for passage of the yarn therethrough to heat the yarn to a prescribed temperature, means operable to twist the yarn before passage thereof through said heated zone, control means operable automatically to regulate the supply of heat energy to said zone compensatively according to the ambient temperature and rate of transfer of heat to the yarn to maintain said zone uniformly at the temperature required to heat the yarn to said prescribed temperature, tension means operable to maintain the yarn at a uniform tension during passage thereof through said heating device and to the wind-up means, and means to regulate the tension means to control the tension of the yarn in correlation to the prescribed temperature and linear speed of travel of the yarn to maintain the latter at a selected uniform tension relative to the contractile force and thermal characteristics of the yarn.

3. Apparatus for thermally processing thermoplastic yarn comprising a support for a supply of yarn, wind-up means for the processed yarn spaced from said support and operable to draw the yarn continuously at a selected linear speed from the supply to said wind-up means, an electrically energized heating device defining a restricted thermally isolated heated zone for passage of the yarn therethrough to heat the yarn to a prescribed temperature, a false-twist device operable to twist the yarn before passage thereof through said heated zone and to untwist the yarn after said passage through the heated zone, control means operable automatically to regulate the supply of heat energy to said zone compensatively according to the rate of transfer of heat to the yarn to maintain said zone uniformly at the temperature required to heat the yarn to said prescribed temperature, tension means operable to maintain the yarn at a uniform tension during passage thereof through said heating device and to the wind-up means, and means to regulate the tension means to control the tension of the yarn in correlation to the prescribed temperature and linear speed of travel of the yarn to maintain the latter at a selected uniform tension relative to the contractile force and thermal characteristics of the yarn.

4. Apparatus for thermally processing thermoplastic yarn comprising a support for a supply of yarn, wind-up means for the processed yarn spaced from said support and operable to draw the yarn continuously at a selected linear speed from the supply on the support to said wind-up means, means to apply a liquid to the yarn passing from said supply, an electrically energized heating device defining a restricted thermally isolated heated zone for passage of the yarn therethrough to heat the yarn to a prescribed temperature, a false-twist device operable to twist the yarn before passage thereof through said heated zone and to untwist the yarn after said passage through the heated zone, control means operable automatically to regulate the supply of heat energy to said zone compensatively according to the ambient temperature and rate of transfer of heat to the yarn to maintain said zone uniformly at the temperature required to heat the yarn to said prescribed temperature, tension means operable to maintain the yarn at a uniform tension during passage thereof through said heating device and to the wind-up means, and means to regulate the tension means to control the tension of the yarn in correlation to the prescribed temperature and linear speed of travel of the yarn to maintain the latter at a selected uniform tension relative to the contractile force and thermal characteristics of the yarn.

5. Apparatus for thermally processing thermoplastic yarn comprising a support for a supply of yarn, wind-up means for the processed yarn spaced from said support and operable to draw the yarn continuously at a selected linear speed from the supply to said wind-up means, means to apply a liquid dye to the yarn passing from said supply, an electrically energized heating device defining a restricted thermally isolated heated zone for passage of the yarn therethrough to heat the yarn to a prescribed temperature, a false-twist device operable to twist the yarn before passage thereof through said heated zone and to untwist the yarn after said passage through the heated zone, control means operable automatically to regulate the supply of heat energy to said zone compensatively according to the ambient temperature and rate of transfer of heat to the yarn to maintain said zone uniformly at the temperature required to heat the yarn to said prescribed temperature, tension means operable to maintain the yarn at a uniform tension during passage thereof through said heating device and to the wind-up means, and means to regulate the tension means to control the tension of the yarn in correlation to the prescribed temperature and linear speed of travel of the yarn to maintain the latter at a selected uniform tension relative to the contractile force and thermal characteristics of the yarn.

6. Apparatus for thermally processing thermoplastic yarn comprising a frame structure, a support for a supply of yarn to be processed mounted at the upper part of said frame structure, wind-up means for the processed yarn mounted on said frame structure below the yarn support, tension means for the yarn supported from said frame structure and disposed at an elevation below the wind-up means, an electrically energized heating device mounted below said tension means and defining a restricted heated zone in alignment with the tension means for passage of the yarn to heat the same uniformly to a prescribed temperature, a spindle mounted on the frame below the heating device in alignment with the heated zone thereof operable to twist the strand of yarn before passage thereof through said heated zone and to untwist the yarn by passage through the spindle, guide means for supporting and directing the strand of yarn from said support in a downward direction to and through the tension means and thence downwardly through the heating device and spindle, guide means for supporting and directing the strand of yarn from said spindle and thence upwardly to said wind-up means, means to drive the spindle at a predetermined speed, and means to drive the wind-up means to draw a strand of yarn continuously at a selected linear speed from the yarn supply to said wind-up means, said tension means being operable to maintain the strand of yarn at a uniform tension during passage thereof downwardly through said heating device and upwardly to the wind-up means.

7. Apparatus for thermally processing thermoplastic yarn comprising a support for a supply of yarn, wind-up means for the processed yarn spaced from said support and operable to draw the yarn continuously at a selected linear speed from the supply to said wind-up means, an electrically energized heating device intermediate said sup-

port and wind-up means and defining a restricted thermally isolated heated zone for passage of the yarn therethrough to heat the yarn to a prescribed temperature, means operable to twist the yarn during passage thereof from said support to said wind-up means, control means operable automatically to regulate the supply of heat energy to said zone to maintain said zone uniformly at the temperature required to heat the yarn to said prescribed temperature, tension means operable to maintain the yarn at a uniform tension during passage thereof through said heating device and to the wind-up means, and means to regulate the tension means to control the tension of the yarn in correlation to the prescribed temperature and linear speed of travel of the yarn to maintain the latter at a selected uniform tension relative to the contractile force and thermal characteristics of the yarn.

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