United States Patent

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[54] **TEXTILE YARN STORAGE AND ADVANCING APPARATUS AND METHOD**
22 Claims, 10 Drawing Figs.

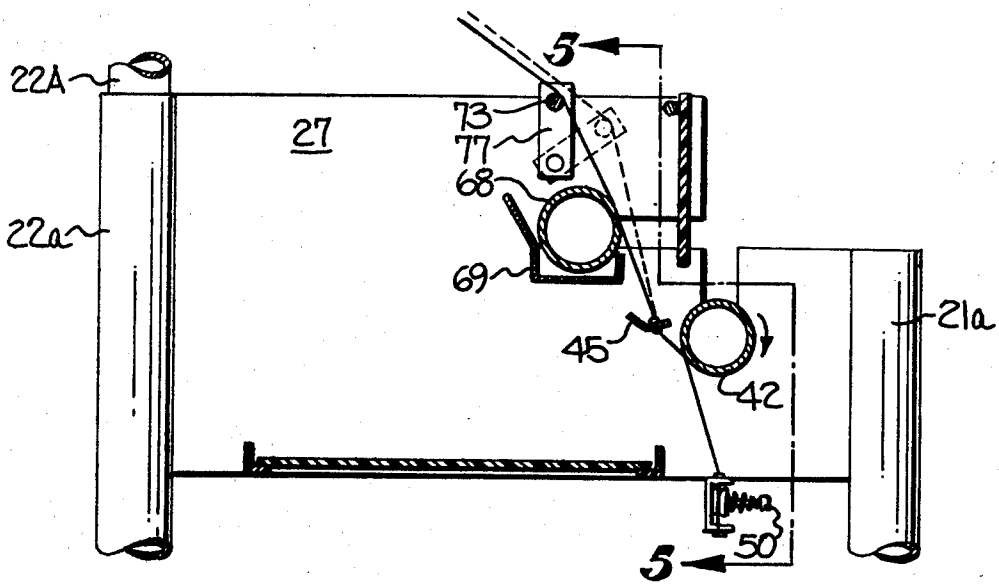
[52] **U.S. Cl.** **242/131,** 242/45, 242/155
[51] **Int. Cl.** **B65h 49/02,** D02h 1/00, D03j 5/08
[50] **Field of Search** ..... 242/130, 131, 131.1, 156.2, 45, 149, 151—155

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ABSTRACT: Apparatus for storing a plurality of packages of yarn and for furnishing ends of yarn from the packages under controlled tension conditions, wherein the ends of yarn have predetermined tensioning forces applied thereto by tensioning means and have the tension therein reduced by a predetermined ratio to compensate for and reduce variations in tension in the yarns, and a method of supplying yarns under controlled tension conditions.



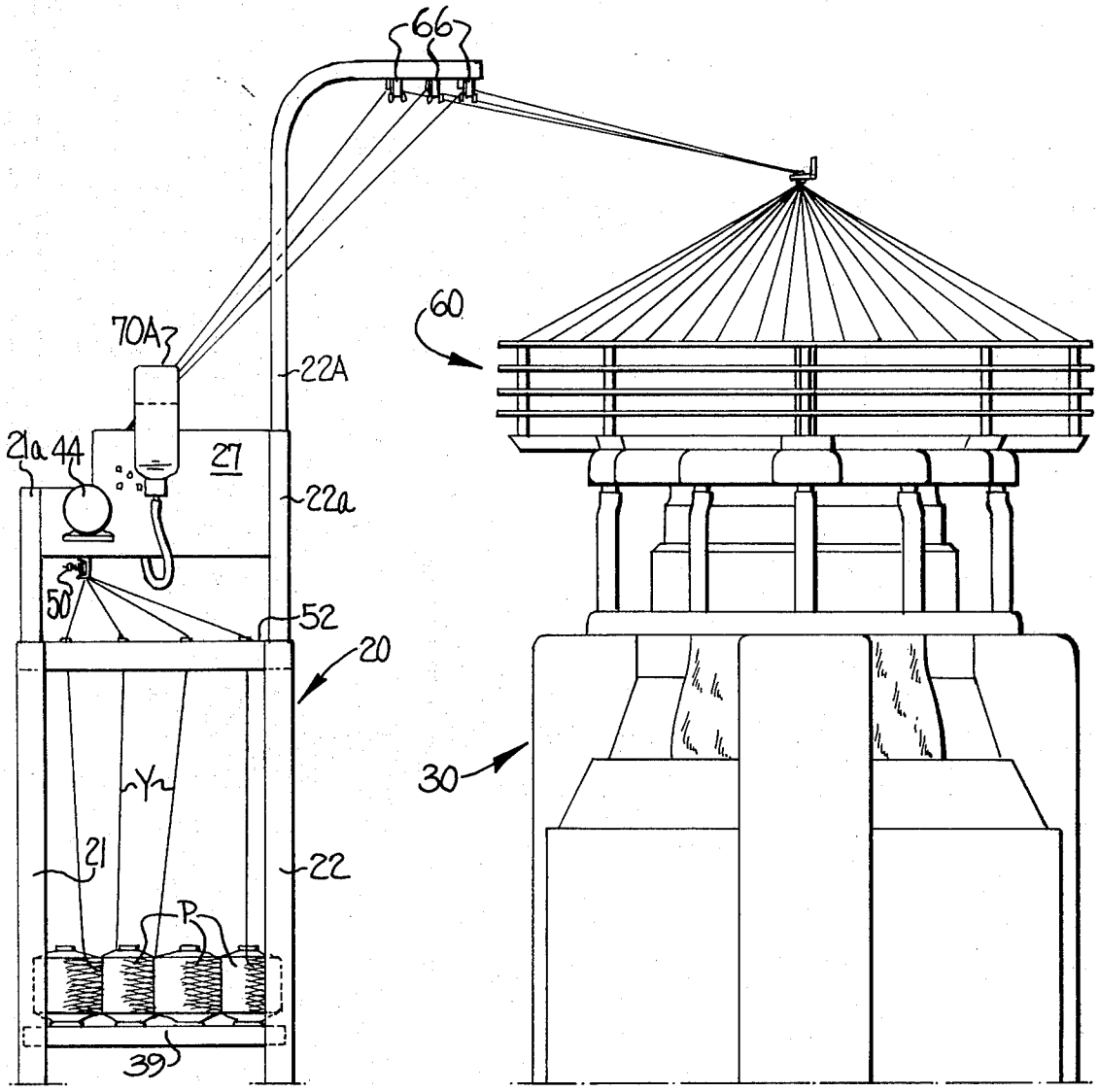


Fig-1

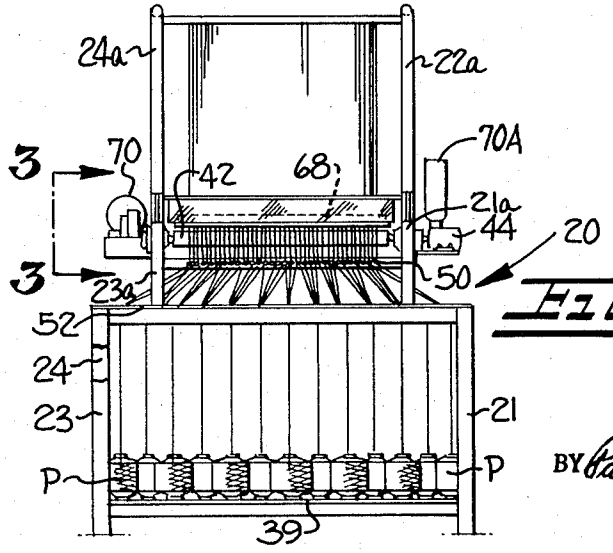


Fig-2

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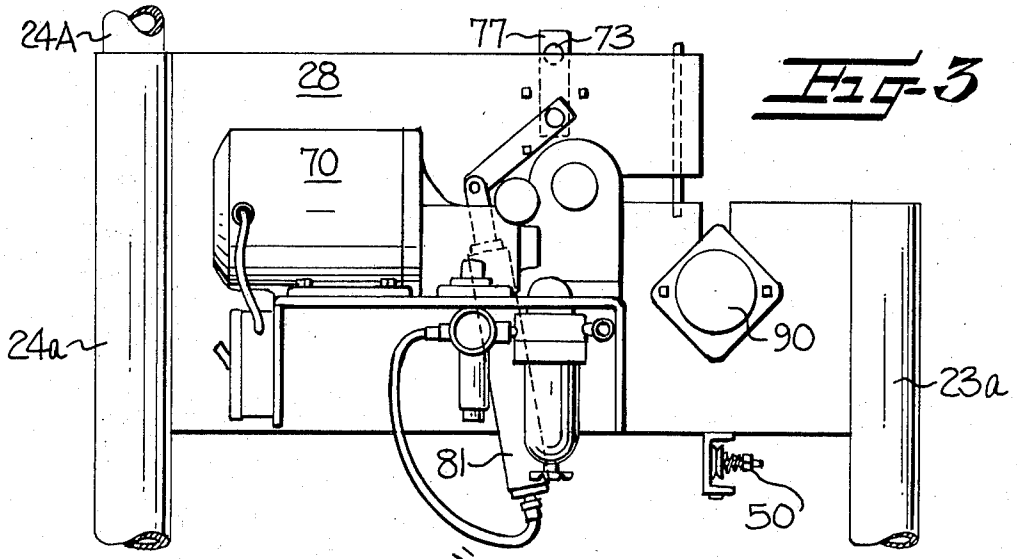


Fig-3

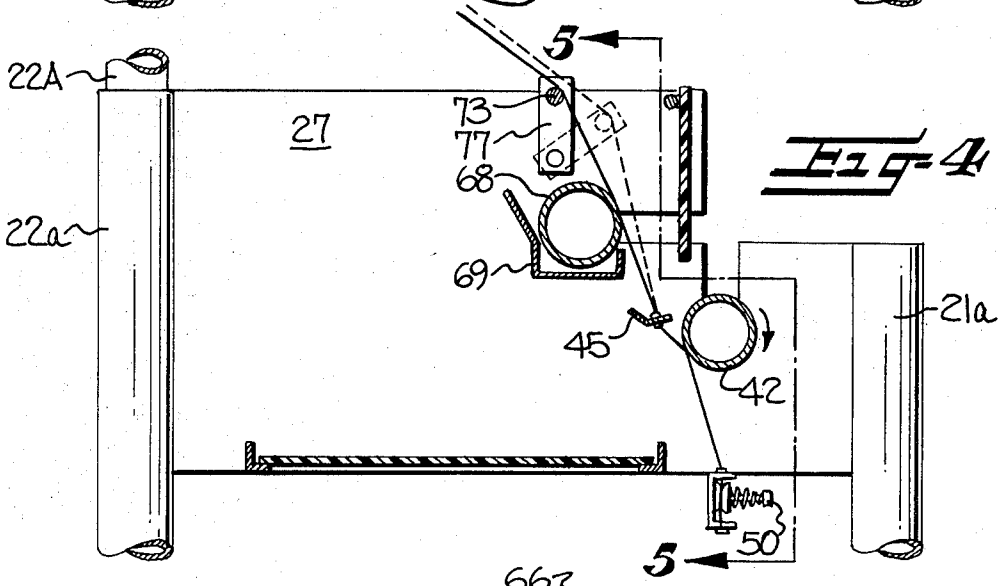


Fig-4

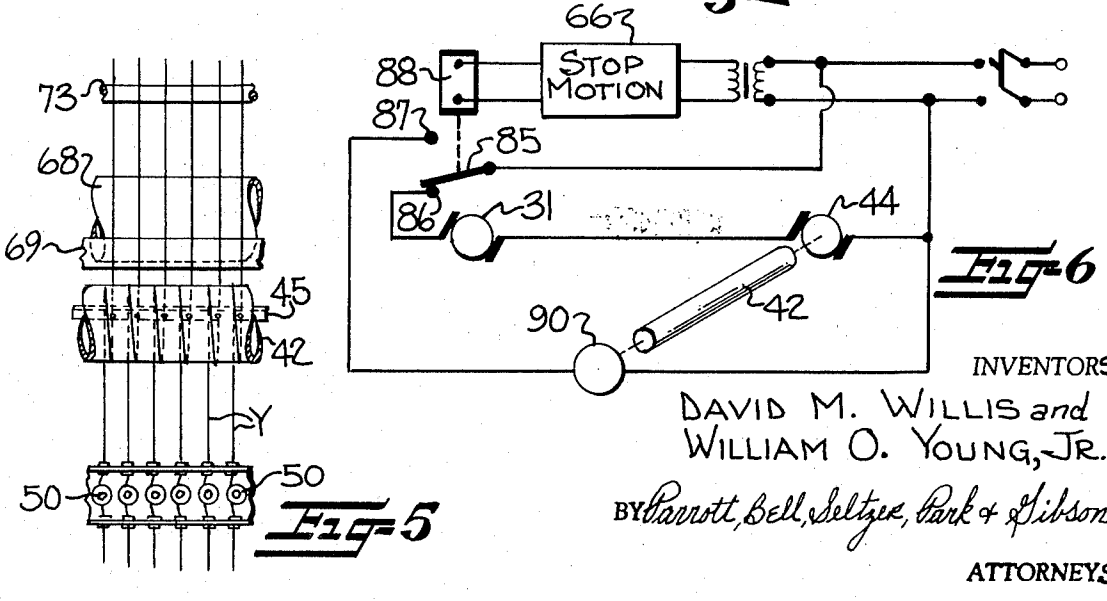


Fig-6

Fig-5

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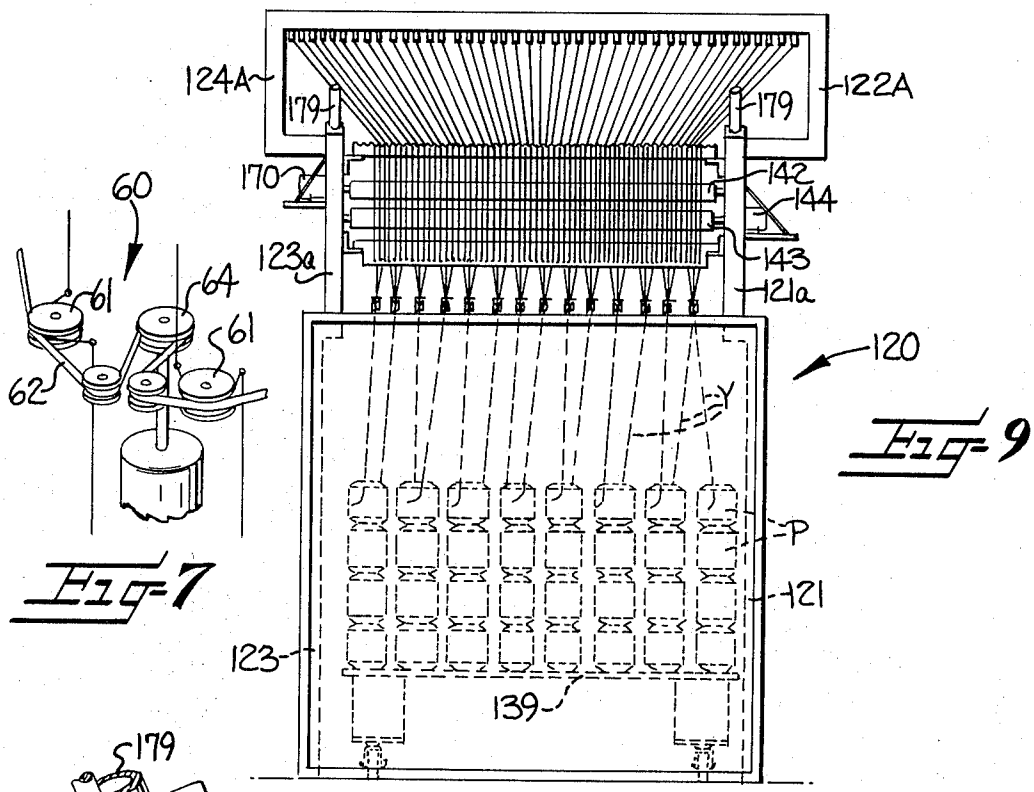


Fig-9

Fig-7

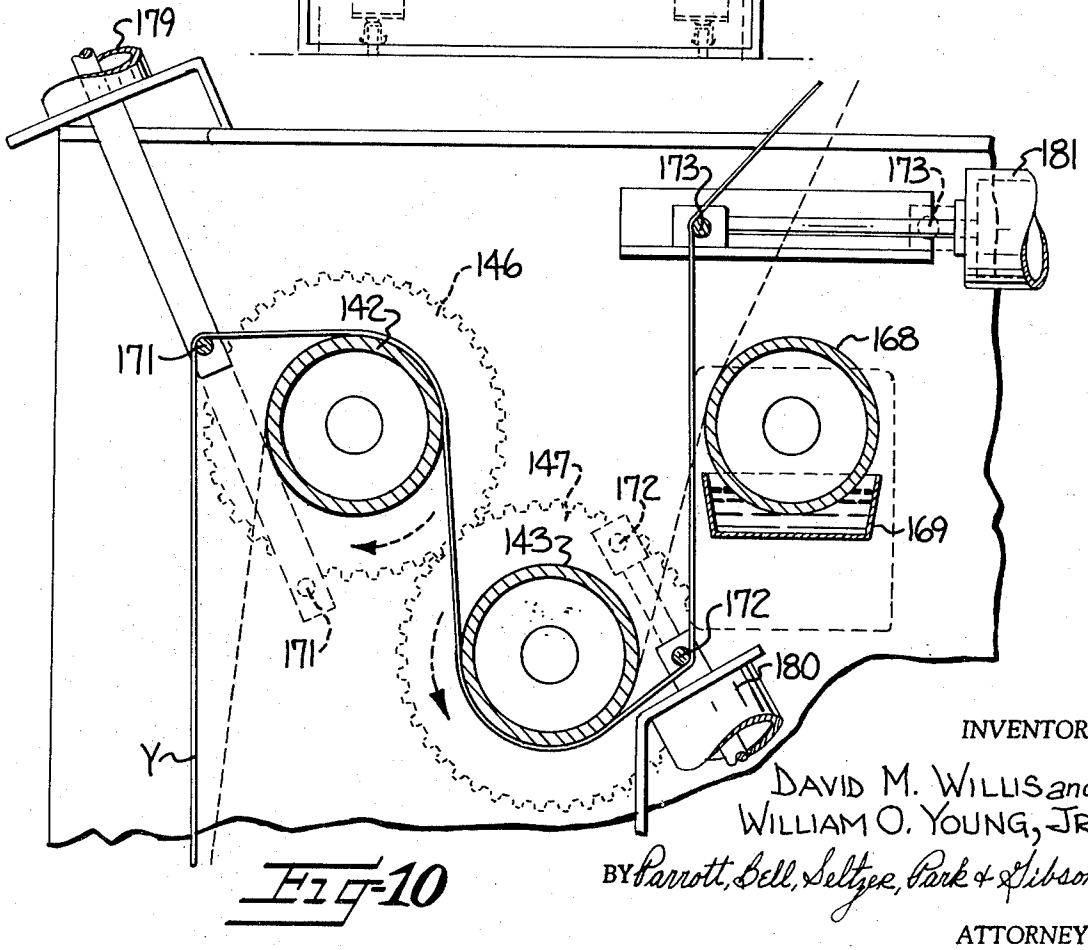


Fig-10

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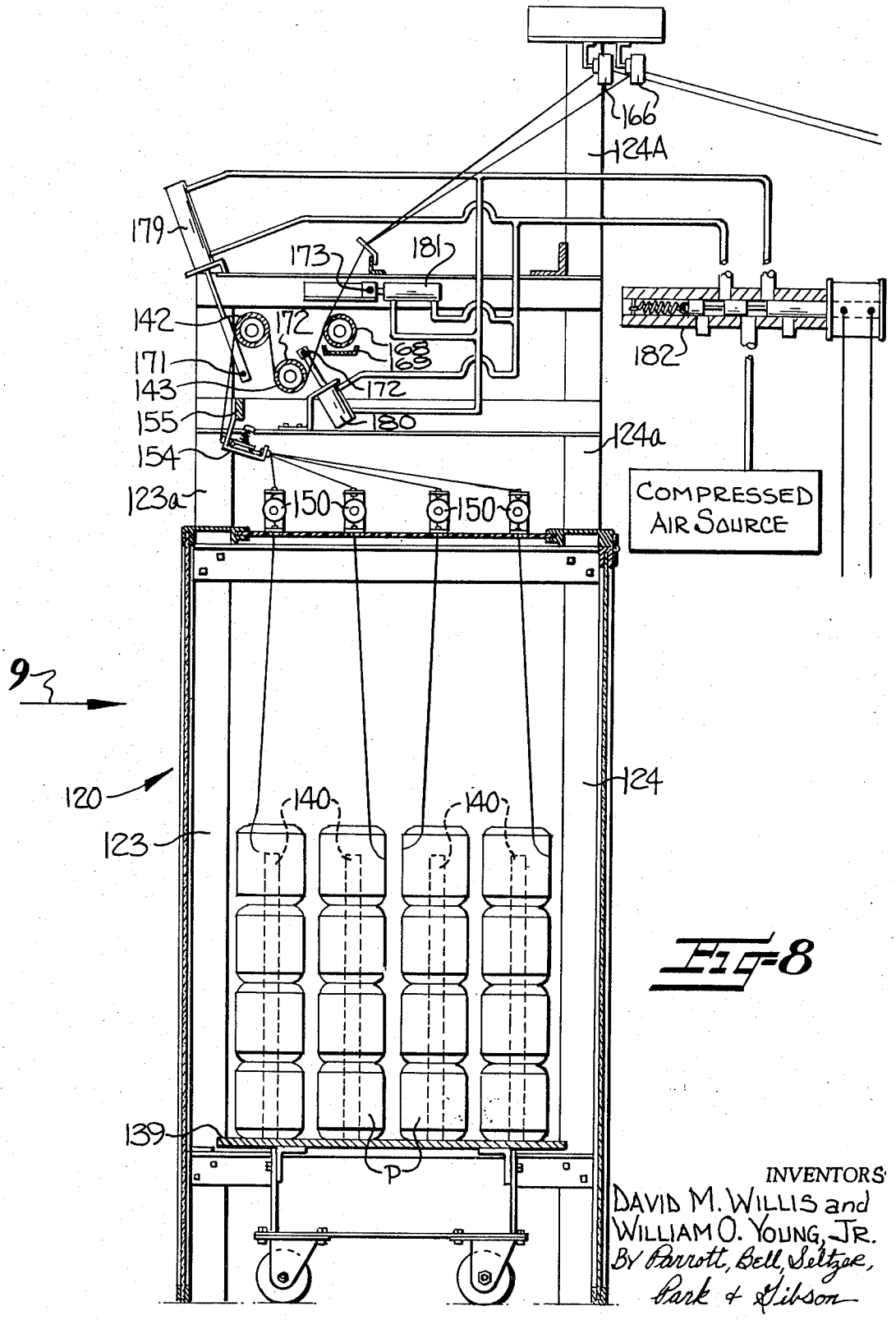


Fig-8

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TEXTILE YARN STORAGE AND ADVANCING APPARATUS AND METHOD

This application is a continuation-in-part of our copending U.S. Pat. application Ser. No. 748,787 entitled TEXTILE MACHINE YARN STORAGE AND ADVANCING MEANS and filed on July 30, 1968, now abandoned.

In many textile operations where yarn is supplied to a textile machine for manipulation by instrumentalities of the machine, fluctuations in the tension condition of the yarn as supplied to the machine have an adverse effect on the machine operation and particularly on the quality of the product obtained from the particular machine process. In such textile operations, uniformly of tension in yarns supplied to a textile machine is usually sought by controlled winding of the yarn from one processed package configuration into another package configuration such as a cone whereby more even density and ready release of yarn is obtained. The cones of yarn are then creeled at the machine. Such preparation of the yarn thus requires, in an overall textile manufacturing process, an additional winding or packaging step for the yarn which both increases the cost of preparing the yarn and exposes the yarn to possible breaking or other damage.

These deficiencies and difficulties desirably could be avoided by eliminating the presently required preparatory step and assuring the proper advancement of yarn is obtained without regard to the specific type of package in which the yarn is formed by the next preceding process or the condition of the yarn in such a package.

The necessity for this extra winding or rewinding step arises out of the fact that significant fluctuations or variations in tension usually occur as the yarn is withdrawn from a processed package. In particular, where the package has been subjected to a finishing process such as dyeing or bulking, the yarn in the package is usually tangled. Removal of yarn from a package which has undergone such a finishing process may proceed easily and freely for an indeterminate incremental length of yarn and, then upon the occurrence of a "hangup"suddenly encounter a high tension condition as the yarn must be pulled free from entanglement. Such tension fluctuations adversely affect a textile operation, such as in a knitting operation by causing uneven stitches and the fluctuation may become of such magnitude as to cause the product of the particular process to be unacceptable.

With the foregoing in mind, it is an object of the present invention to provide, in combination with a textile machine having yarn takeup means for taking up a plurality of yarns at predetermined demand rates, apparatus for supplying yarns under controlled tension conditions and in such a manner as to compensate for varying amounts of tension in the yarns otherwise resulting from uneven density and yarn release characteristics of packages from which the yarn is supplied to the apparatus. In accomplishing this object of this invention, control over the tension of a plurality of ends of yarn is obtained by the cooperation of tensioning means applying an individually predetermined tensioning force to each of the yarns and tension reducing means feeding the yarns at a linear rate greater than the predetermined demand rates of the yarn takeup means of the associated textile machine for reducing the amounts of tension in the yarns in a predetermined ratio. By such cooperation, fluctuation in the tension in the plurality of yarns at the textile machine is minimized even during relatively extreme fluctuations of tension in the yarn at the yarn supply packages as the yarn is removed therefrom.

A further object of the present invention is to provide apparatus of the general nature discussed above, adapted to receive and support a plurality of yarn packages of uneven density and yarn release characteristics and to advance yarn from the packages while compensating for varying amounts of tension and varying demand rates in and for the yarns. In accomplishing this object of the present invention, the various means employed in the apparatus of the present invention, including the tensioning means and tension reducing means, are mounted on a creel means and positioned relative thereto and to the other means of the apparatus for receiving and acting upon yarns passing from packages supported by the creel means.

Another object of this invention is to prepare the ends of yarn being supplied to a textile machine by applying a treatment fluid thereto during passage of the yarns to the textile machine. Preferably, treatment applying means used in realizing this object are mounted for cooperation with the other elements of the yarn furnishing apparatus without interfering with the tension control exercised by the apparatus.

Yet a further object of the present invention is the practice of the method in which yarns are directed from a plurality of yarn packages along predetermined paths of travel to a textile machine while predetermined tensioning forces are applied thereto and the amounts of tension in each of the tensioned yarns is reduced in a predetermined ratio. In realizing this object of the present invention, the application of predetermined tensioning forces to each of the yarns to provide at least a predetermined amount of tension therein and the reduction of the amount of tension in each of the yarns in a predetermined ratio function together to compensate for and reduce the amount of variations in the tension in the yarns, thereby permitting delivery of the yarns under controlled tension conditions and the achievement of desirable improvements in the process being supplied with yarn.

Some of the objects and advantages of the invention having been stated, others will appear as the description proceeds, when taken in connection with the accompanying drawings, in which:

FIG. **1** is an elevation view, partially schematic, of a yarn furnishing apparatus in accordance with the present invention, shown in combination with a textile machine to which the apparatus of the present invention is supplying yarn under controlled tension conditions;

FIG. **2** is a reduced elevation view of the yarn furnishing apparatus of FIG. **1**, taken from a point to the left of FIG. **1**;

FIG. **3** is an enlarged elevation of a portion of the yarn furnishing apparatus of FIGS. **1** and **2**, taken generally as indicated by the arrows **3–3** in FIG. **2**;

FIG. **4** is a view somewhat similar to FIG. **3**, showing a section through the yarn furnishing apparatus of FIGS. **1** and **2**;

FIG. **5** is an elevation of certain portions of the apparatus of FIGS. **3** and **4**, taken generally as indicated by the line **5–5** in FIG. **4**;

FIG. **6** is a schematic wiring diagram for the combination of FIG. **1**;

FIG. **7** is an enlarged illustration of a positive yarn feeding means included in the operating instrumentalities of the textile machine of FIG. **1**;

FIG. **8** is an enlarged elevation, in partial section, of a second form of yarn furnishing apparatus as contemplated by the present invention, including a partly schematic showing of a control system for certain elements thereof;

FIG. **9** is a reduced side elevation taken generally as indicated by the arrow **9** in FIG. **8**; and

FIG. **10** is an enlarged elevation detail, in partial section, of the yarn engaging roll means and other portions of the yarn furnishing apparatus of FIG. **8**.

Referring now more particularly to the drawings, a first and preferred form of yarn furnishing apparatus in accordance with the present invention is there identified by the reference character **20** and is illustrated in combination with a knitting machine **30** to which yarn is supplied under controlled tension. At the outset of this discussion, it is to be understood that the disclosure herein of the yarn furnishing apparatus **20** of the present invention in combination with a knitting machine and particularly in combination with a circular knitting machine **30** is for purposes of illustration only, as it is contemplated that the apparatus **20** has broad utility in combination with various other types of textile machines adapted to takeup yarns at predetermined demand rates, such as flat knitting machines, warpers, slashers, etc., and the apparatus is susceptible to other arrangements and configurations, so long as the principles of construction and operation described hereinafter are incorporated.

The knitting machines **30** includes knitting instrumentalities for manipulating yarn to form fabrics and means generally indicated at **60** for feeding a plurality of ends of yarn Y to the knitting instrumentalities at predetermined demand rates (FIGS. **1** and **7**). It is typical of many multifeed circular knitting machines such as the machine **30** that certain yarn manipulating locations thereon take up yarn at linear rates approximately twice that of other locations, although the variances between the different demand rates may range to other ratios depending upon the fabric produced.

In any instance, the apparatus of the present invention furnishes ends of yarn Y to a machine which take up the ends of yarn at predetermined demand rates, which may be uniform for all of the ends supplied, which may very for all the ends supplied, or which may vary among the ends. An important function of the apparatus **20** is to supply ends of yarn to such a machine under controlled tension conditions, as described more fully hereinafter, particularly when the ends are furnished to a machine wherein variations in yarn tension are likely to significantly affect the quality of the product being formed on the machine. It is because knitting machines are particularly sensitive to tension in yarns supplied thereto that the apparatus **20** of the present invention has been shown in conjunction with that specific type of textile machine.

The details of the yarn furnishing apparatus **20** are more clear from the various elevation and section views of FIGS. **2**, **3**, **4** and **5**, wherein it may be seen that the apparatus **20** comprises a freestanding lower structural frame composed of four vertical corner members **21**, **22**, **23** and **24** and a number of upper and lower horizontal members extending therebetween to complete a generally parallelepiped structure. A package supporting shelf **39** is mounted within the lower structural frame upon the lowermost horizontal members, in order to support a plurality of packages P of yarn and to form of the structural frame a creel for the packages. The lower structural frame of the apparatus **20** stands on an apparatus room floor independently of and spaced from the associated knitting machine **30** to which the ends of yarn Y are furnished.

Ends of yarn Y are led from the packages P along predetermined paths of travel to be supplied to the knitting machine **30**, as described in detail hereinafter. Generally, and in order to aid in smooth release of the yarns Y from the packages P, the yarns are led from the packages P in a direction substantially coaxial with the central axes of the packages, shown to be vertically upwardly in FIGS. **1** and **2**.

The apparatus **20** of the present invention is particularly useful and provides major advantages when the packages P are characterized as having uneven density and yarn release characteristics. Further explanation of this characterization requires a brief discussion of the characteristics of textile yarn packages generally. In particular, it is conventional to package textile yarns by winding, with a particular package form being selected with a view to the next subsequent process step which will be involved. In many instances, packaging of the yarn into a particular desired type of package requires the inclusion in the manufacturing process of a machine operation where repackaging or rewinding is the sole function being served. This has been encountered heretofore particularly in instances where one process step so disrupts the yarn in a package as to otherwise adversely affect the efficiency of a subsequent process step.

One specific example mentioned above, which has been encountered heretofore particularly with continuous filament synthetic fiber yarns, is a manufacturing sequence which incorporates the processing of package dyed yarns. Typically, the process of dyeing yarn in a package includes forced flow of liquids radially through the package, which results in shifting the yarn in the package to an uneven distribution of densities and in some instance matting the wound layers of yarn together. Inasmuch as knitting of yarns require that yarns be supplied to the knitting machine in a smooth flow and under relatively low tension, packages of yarn which have been subjected to a dyeing process have not heretofore been acceptable as a direct source of yarn for a knitting step. Instead, it has heretofore been necessary to rewind dyed yarn into another package in order that a smooth, even, and snag free release of the yarn from a package may be obtained and the uniform tension requirements of a knitting operation satisfied.

The present invention arises, at least in part, from a realization that a significant capital investment as well as significant processing time and labor costs can be saved by eliminating one or more rewinding steps. The apparatus and method of the present invention are particularly advantageous in permitting direct use of packages which have heretofore necessitated rewinding.

In the illustrated embodiment, the packages P are representative of dye packages which have been subjected to a dyeing process and which have not been repackaged prior to mounting in the yarn furnishing apparatus **20** of the present invention.

Interposed along the predetermined paths of travel for the ends of yarn Y from the packages P to the knitting machine **30** are yarn tensioning means for exerting an individually predetermined restraining force on each of the ends of yarn, tension reducing means for feeding the yarns at a linear rate greater than the predetermined demand rates of the textile machine being supplied with yarns, stop means responsive to an improper yarn tension condition and operative for stopping the textile machine, yarn treating means for applying a treatment liquid to the ends of the yarn as they are moved along a predetermined path, and yarn disengaging means for displacing the ends of yarn from the predetermined paths of travel upon stopping of the textile machine. Each of these means and the operative relationship therebetween will be described in greater detail hereinafter.

Turning first to the yarn tensioning means, it will be noted from FIGS. **4** and **5** that each of the ends of yarn yarn passes through a corresponding individually adjustable tensioning device **50**, being led thereto from a guiding eyelet mounted in a sheet member **52** supported by the lower frame structure to overlie the package table **39**. The guiding eyelets in the sheet member **52** are preferably positioned immediately above corresponding ones of the packages P, in order to insure takeoff of the yarn Y from the packages P substantially in alinement with the central axes of the packages. The spacing between the sheet member **52** and the packages P should be sufficient to provide a reservoir of yarn length to assist in dampening jerky release of the yarn from the packages P.

Each of the individual tensioning devices **50** preferably is of a conventional and commercially available type as, for example only, including a pair of opposing disc members urged together by a variable spring force.

Intermediate the yarn tension means and the textile machine **30** to which yarn is furnished by the apparatus **20**, the ends of yarn pass in engagement with a tension reducing means comprising yarn engaging roll means. In the first form of apparatus in accordance with the present invention as exemplified by the apparatus **20** here being described, the yarn engaging roll means comprises one roll **42** which is supported for rotation by a superstructure frame rising above the lower frame members **22—24** of the apparatus **20**. In particular, the superstructure frame includes four vertically uprising standards **21A**, **22A**, **23A** and **24A** which rise from the uppermost horizontal front and back members of the lower frame structure of the apparatus **20**, Two of the vertically uprising standards, namely the superstructure standards **22A** and **24A**, rise to an extended height and terminate in a horizontally extending portion, to provide a mounting location for stop motion devices described more fully hereinafter. Extending between pairs of the superstructure standards are side plates **27** and **28**, respectively extending between the right side superstructure standards **21A** and **22A** and the left side superstructure standards **23A** and **24A**, and providing a mounting location for the yarn engaging roll **42** and for other elements of the apparatus **20** described hereinafter.

The roll **42** is journaled for free rotation relative to the side plates **27** and **28** and is operatively connected to a driving

motor 44 to be driven thereby in rotation. In the apparatus 20 being described, the connection between the rotor of the driving electric motor 44 and the roll 42 is preferably a direct connection, so that the roll 42 is driven at the speed of the motor 44 and with rotation in the direction indicated in FIG. 4. The speed at which the roll member 42 is driven is important, and is interrelated to a number of other factors involved in proper operation of the apparatus 20, as will be brought out more fully hereinafter. The material of the roll 42 is selected for the particular frictional characteristics obtainable on the surface thereof and is formed, for example, of steel having a chromium plated surface which is highly polished subsequent to plating, in order to obtain a highly uniform surface. While it is contemplated that the roll 42 may be made of other materials and finished in other appropriate manners, it is believed that the best operation of the apparatus 20 is obtained where a substantially uniform surface frictional characteristic for the roll 42 is insured.

The ends of yarn Y, in passing in engagement with the roll 42, are directed from the individual tension devices 50 through guiding eyelets to the roll, are wrapped about the roll for approximately a 360° engagement therewith, and pass from the roll through guiding eyelets mounted in a transverse bar support 45 (FIGS. 4 and 5). In order to avoid entanglement of an individual end of yarn as passed along this predetermined path of travel, the individual eyelet guides are staggered relative to the loop of yarn which passes about the roll 42 (as best shown in FIG. 5), causing each individual end of yarn to pass about the roll 42 along a somewhat spiral path.

Along the paths of travel of ends of yarn Y between the roll 42 and the machine 30 to which yarn is being furnished is a yarn treating means for treating each end of yarn with a conditioning liquid prior to the same being taken up by the textile machine. Such conditioning is of particular importance where the associated textile machine is a knitting machine, as the manipulation of ends of yarn during the formation thereof into a fabric is frequently facilitated by lubrication of the yarn. Such a liquid treatment is applied by an oiling roller 68, positioned adjacent to and downstream of the yarn engaging roller 42 and mounted for rotation partially within a treatment liquid retaining trough 69. The treating roller 68 is driven in slow rotation by a drive motor 70, acting through an appropriate gear train, and may rotate counter to or with the movement of the ends of yarn Y thereacross. In either instance, a uniformly thin layer of lubricant is carried on the roller 68 from a supply retained in the trough 69 and supplied from a reservoir bottle 70A mounted on the right-hand side plate 27.

Where the textile machine to which yarn is being furnished is a knitting machine, the ends of yarn being taken up by the knitting machine are advanced to the knitting instrumentalities of the machine by a positive feed means, conventionally taking the form of a tape and cylinder drive (generally indicated at 60 in FIG. 1). Such a tape drive includes a plurality of cylinders 61 (FIG. 7) positioned above and about the needle cylinder of the knitting machine 30, individually supported for rotational movement and encircled by an endless tape 62 in contact with portions of the peripheries thereof. The tape 62 is driven in rotation by a drive pulley 64, operatively connected to the drive arrangement for the knitting instrumentalities of the knitting machine 30 to be driven in rotation in coordination with the knitting of yarn thereby. Upon rotation of the drive pulley 64, the tape 62 is advanced adjacent to and in contact with the peripheries of the plurality of cylinders 61, to drive the same in rotation at a predetermined speed correlated to the formation of stitches by the knitting machine 30. Each single end of yarn Y is passed between the engaging surfaces of corresponding cylinders 61 and the tape 62, to be gripped therebetween and advanced to the knitting machine 30 at a rate correlated to the use of yarn by the knitting instrumentalities thereof. The primary function intended for the cylinders 61 and tape 62 is to control the rate of advance of the ends of yarn Y, and fluctuation in tension in the ends of yarn at the positive feeding means 60 significantly disturbs and adversely affects the quality of fabric produced by the knitting machine 10.

In most instances it is desirable, if not necessary, that a textile machine be stopped upon the occurrence of an improper operating condition such as a broken end of yarn or excessively high tension in an end of yarn being supplied, in order to minimize the production of poor quality goods. For this reason, the apparatus 20 includes stop motion devices responsive to the amounts of tension in the yarns and similar to known devices conventionally used with textile machines such as the knitting machine 30. In particular, a plurality of electrical switches 66, equalling in number the number of ends of yarn being furnished by the apparatus 20, are mounted on the horizontally extending arms of the superstructure standards 22A and 24A, for passage of the ends of yarn Y therethrough intermediate the yarn treating means and the positive feed means. Such electrical devices are highly sensitive, and are actuated in response to the absence of or excessive tension in a yarn passing therethrough, and are adapted for connection to an electrical system supplying current to a motor driving the associated textile machine 30 for interrupting operation of the machine upon occurrence of an improper amount of tension in the yarns.

In this connection, it has been noted in operation of apparatus embodying the present invention that it is important for the rotation of yarn engaging roll 42 to begin prior to a demand for the ends of yarn being established by the associated machine 30. Otherwise, the ends of yarn passing from the packages P to the associated machine 30 are broken by excessive tension due to the snubbing action of contact with the roll 42. In the specific instance of a multifeed circular knitting machine 30 as illustrated in FIG. 1, it has been discovered that the difference in inertia of the rotating elements of the knitting machine 30 and the roll 42 of the yarn furnishing apparatus 20 is such that simultaneous energization of the drive motor 44 for the roll 42 and a drive motor 31 for the knitting machine 30 will result in the roll reaching operating speed before the yarn demand is fully established. This is accomplished by wiring the drive motors 31 and 44 in series for energization on closure of a switching armature 85 with a stationary contact 86 (FIG. 6). Movement of the armature 85 between a pair of stationary contacts 86 and 87 is under the control of a solenoid coil 88, energized by an electrical circuit which includes the stop motion devices 66.

While thus not required in the specific embodiment of the present invention being currently described, it is contemplated by the present invention that an intentional delay means such as a dashpot relay may be included in the electrical circuitry to delay energization of the motor 44 driving the yarn engaging roll 42 where a low inertia machine is being supplied and the increase in demand rates for the ends of yarn comes about more quickly.

In the first form of apparatus of the present invention, it has also been found desirable to stop rotation of the yarn engaging roll 42 promptly on stopping of the associated textile machine 30. This is accomplished by the provision of magnetic brake 90 supported on the left-hand side plate 28 and energized by an electric circuit completed on movement of the armature 85 into engagement with the stationary contact 87 in response to a change in energization of the solenoid coil 88. Simultaneous deenergization of the drive motor 44 and energization of the electric magnetic brake 90 results in stopping rotation of the roll 42 within less than one full revolution thereof.

In order to avoid wicking of excess treatment liquid into the yarn from the oiling roller 68 and sticking of the yarns to such roller during such time that supply of yarn is not required by the knitting machine 30, this invention provides yarn disengaging means associated with the oiling roller 68 for displacing the ends of yarn from their predetermined paths of travel upon stoppage of the textile machine and thereby disengaging the yarn from the oiling roller. This disengaging means includes a rod member 73, extending transversely of the yarn supplying apparatus 20 for simultaneous engagement with all of the ends

of yarn Y passing therethrough. The rod **73** is supported at opposite sides of the frame of the apparatus **20** by pivoting link members **77** and is rotated by the application of air pressure to a cylinder **81** under the control of a solenoid actuated control valve electrically connected with the circuit of FIG. **6** and responsive to interruption of energization of the drive motors **31** and **44**. By operation of the valve, the rod **73** is normally somewhat retracted from the path of travel of the ends of yarn Y (being held in the full line position of FIG. **4**). Upon stoppage of the associated textile machine **30**, air pressure is applied to cylinder **81** to pivot the links **77**, move the rod **73** across the normal paths of travel of ends of yarn Y (to the phantom line position of FIG. **4**) and displace the ends of yarn Y from the engagement with the oiling roller **68**.

An operating embodiment of the first form of apparatus **20** (as described) has been used to furnish yarns of wool and continuous filament synthetic yarns to multifeed circular knitting machines having a cylinder speed of 19 to 20 r.p.m. and yarn demand rates of approximately 450 feet per minute. In such application, the yarn engaging roll **42** had a diameter of 3 inches and was driven by direct connection with a motor running at 1750 r.p.m. Thus, the linear surface speed of the roll member **42** was approximately 1370 feet per minute and the ratio of tension reduction was found to be approximately 5 to 1.

It is to be noted that a number of factors contribute to establishing the particular ratio of reduction at which a given apparatus operates, including such consideration as the type and size of the yarn being supplied, the surface characteristic of the roll means, the extent of arcuate or circumferential wrap of the yarn about the roll means, and the ratio of lineal speeds at which yarn is demanded and the roll means is driven. Control over the particular ratio of tension reduction experienced in any given operating circumstance may be exercised by varying one or more of these factors as required or desired.

It has been discovered that woolen yarn may be run either with a roll having a matte chrome plated finish or with a roll having a highly polished chrome finish as discussed above. Continuous filament yarns have shown a greater tendency to lap up about the roll than have woolen yarns, and the higher polished roll surface has been found preferable with such yarns. Incorporation of a roll **42** having a highly polished surface into the apparatus **20** thus permits satisfactory operation with either type of yarn and avoids the necessity of changing rolls with changes in yarn. However, the present invention contemplates that such changes in the roll **42** as are required to accommodate particular yarns being used may be made within the scope of the present invention.

In operation of the apparatus **20** as described to this point, a number of packages P of yarn at least appropriate to provide the number of ends to be supplied to the associated textile machine are loaded onto the supporting table **39** and ends derived therefrom are threaded upwardly through the guiding grommets in the plate member **52** and the individual tension devices **50**. The ends of yarn are then passed about the roll **42**, through appropriate staggered guides, passed adjacent the oiling roller **68**, threaded through the stop motion switches **66**, and introduced to the instrumentalities of the knitting machine **30**.

On actuation of the knitting machine **30** and initiation of rotation of the roll **42**, a continuing transient frictional engagement occurs between each of the ends of yarn Y and the surface of the roll member **42**, depending upon the tension in the yarn upstream and downstream of the roll **42**, and the tension present in the yarn between the tension devices **50** and the roll **42** is reduced in a predetermined ratio. As the imbalance of the tensions becomes such that an individual end of yarn is drawn into frictional engagement with the roll **42**, sufficient force is exerted on that individual end of yarn by the roll **42** to return the yarn to the desired tension imbalance or ratio of tension reduction across the roll.

More particularly, the frictional gripping force between an end of yarn and the cylindrical surface of the roll **42** is determined by the difference between the tension in the yarn immediately preceding and immediately following the roll **42**. Upon the tension difference becoming more than a determinable amount, by, for example, the occurrence of a snag in the package, the force of engagement becomes such that the end is carried with the roll in its rotation at a linear speed in excess of that demanded by the associated textile machine. Immediately, the yarn is pulled free from the package; the difference in tensions becomes less; and gripping force between the yarn and the roll **42** is reduced. This fluctuation proceeds in such a manner as to appear normally as a steady state reduction at a predetermined ratio of the tension on passage of the ends of yarn about the rotating roll **42**, but is believed to result from transient engagement as just described.

In accordance with an important feature of the present invention, advantage is taken of the operation just described both to supply yarn to an associated textile machine such as the knitting machine **30** under controlled tension conditions and additionally to protect against the transmission of tension fluctuations which otherwise would adversely effect the proper operation of the machine. It is this protection against transmission of tension fluctuations, and particularly of tension peaks, which facilitates supply of yarn from packages from uneven density and release characteristics, such as directly from dye packages.

In particular, the tension present in a running length of yarn intermediate the packages P and the tension devices **50** may very from substantially no tension to quite high tension levels. The function of the tensioning means is at least twofold, first as providing a back tension to assist in establishing transient frictional engagement of the individual ends of yarn with the roll **42** and secondly for establishing a minimum tension level immediately downstream of the roll **42**. That is, adjustment of one individual tension device **50** to provide a tension of, for example, 10 grams intermediate the tension device and the roll member **42**, in an apparatus where the ratio of tension reduction is approximately 5 to 1 will result in a tension immediately downstream of the roll **42** of approximately 2 grams. However, with a 5 to 1 reduction in tension occurring across the roll member **42**, a snag at the corresponding package P which causes the tension in the yarn to jump as high as, for example, 30 grams will still result in a variation from the 2 gram tension level downstream of the roll **42** only up to a tension level of approximately 6 grams. Thus, a tension fluctuation in the yarn leaving the package between 0 and 20 to 30 grams tension would screened and reduced by the apparatus **20** to a fluctuation of between about 2 and 6 grams at the associated textile machine. Fluctuations over this latter range may be satisfactorily accommodated by most textile machines while a fluctuation of from 0 to 30 grams of tension would be entirely unacceptable in most instances.

As illustrated in FIGS. **8**, **9** and **10**, the present invention contemplates a second or alternate form of yarn furnishing apparatus. The discussion to this point with respect to the first form of the invention is generally applicable to this second form and elements of this second form of apparatus, generally indicated by the reference character **120**, which correspond to elements described heretofore, will be identified by a similar reference character of the one hundred series. Thus, discussion here given will be limited to the points of distinction between the first form of apparatus **20** and the second form of apparatus **120**.

Several distinctive features are incorporated in the second form of apparatus **120**, each of which could be incorporated into the first form of the apparatus, if desired. These points include the use of a wheeled cart or dolly **139** to support a plurality of packages P for supplying ends of yarn. The wheeled package supporting base has a plurality of vertical package supports **140** secured thereon and extending generally upwardly therefrom, and permits loading of yarn packages P onto the dolly at a location remote from the apparatus **120**

and ready substitution of a loaded dolly for one from which the yarn supply has been exhausted. As shown, the package supports **140** are adapted to receive thereon a plurality of yarn packages P in order to accommodate the yarn usage characteristics of the associated textile machine to which yarn is supplied. Further, a plurality of packages stacked on a single support **140** are preferably tailed together, having the leading end of the yarn wound in one package tied to the trailing end of the yarn wound in the package positioned immediately above.

Another point of distinction is the provision of enclosure means normally positioned to extend entirely around the lower frame structure of the yarn furnishing apparatus. Such an enclosure means, preferably in the form of transparent plastic panels, insures that cross contamination of different colors of yarn being run on adjacent machines does not occur by the settling of lint onto the yarn being furnished to the machines.

In the second form of apparatus **120**, engagement between the plurality of ends of yarn and tension reducing means is attained by passing the yarn into engagement with a pair of counter rotating roll members **142** and **143**. By passing the ends of yarn along predetermined paths over roller **142** and then under roll **143**, an approximately 360° combined wrap is obtained. Of course, greater possibilities are presented for varying the degree of wrap if required to accommodate different characteristics of yarn or conditions.

In passing the ends of yarn to the roll members **142** and **143**, the ends of yarn additionally are passed through first and second individual tensioning devices **150** and **154**, providing a two-stage possibility for the imposition of a restraining force on each individual end. Thus, the range of adjustment provided for each individual end is more varied and the range of attainable tension downstream of the apparatus **120** is increased.

It is contemplated that the drive motor **144** from which motive force is applied to the yarn engaging rollers **142** and **143** will be directly connected to the roll **143**, with rotation being transmitted to the other roller **142** by a pair of intermeshing gears **146** and **147** (FIG. **10**). Further, it is contemplated that the motor **144** will be operated continuously, with the advancement of the ends of yarn by the rolls **142** and **143** being controlled by varying the extent of wrap of yarns thereabout. The extent of wrap is varied by movement of control rods **171** and **172** between the phantom line and full line positions of FIG. **10**, in response to energization of the solenoid coil controlling movement of the valve core **182** and thereby controlling the application of air pressure to control cylinders **179**, **180**, **181**. The operation of the yarn displacing rods **171**, **172** and **173** is similar to the operation described above with reference to the yarn displacing rod **73**.

In the drawings and specification, there have been set forth preferred embodiments of the invention, and although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation.

We claim:

1. In combination with a textile machine having yarn takeup means for taking up a plurality of yarns at predetermined demand rates; apparatus for supplying yarns to said takeup means under controlled tension conditions comprising:

a. creel means for supporting a plurality of yarn packages of uneven density and yarn release characteristics such that the tension in yarns being withdrawn therefrom varies along the length thereof;

b. tensioning means positioned intermediate said creel means and said yarn takeup means for applying an individually predetermined tensioning force to each of the yarns to provide a predetermined minimum amount of tension therein and to compensate at least partially for the varying amount of tension in the yarns due to the uneven density and yarn release characteristics of the yarn package; and

c. tension reducing means disposed between said yarn takeup means and said tensioning means and adapted to engage the plurality of yarns for feeding the yarns at a linear rate greater than said predetermined demand rates of said yarn takeup means to reduce the amounts of tension therein by a predetermined ratio to compensate further for, and reduce the amount of variations in, the tension in the yarns.

2. The combination according to claim **1** wherein said tension reducing means (c) comprises:

1. roll means adapted to engage all of the yarns; and

2. drive means connected to said roll means for rotating the same with a linear surface speed greater than said predetermined demand rates of said yarn takeup means, the area of engagement of said roll means with each yarn, the surface characteristics of said roll means and the linear surface speed at which said roll means is driven being correlated so as to provide a predetermined controlled amount of slippage between the roll and yarns and thereby provide said predetermined ratio of tension reduction.

3. The combination according to claim **2** further comprising (d) stop motion means disposed between said tension reducing means and said yarn takeup means and responsive to the amounts of tension in the yarns as the same pass to said yarn takeup means and operatively connected to said textile machine for interrupting operation of said textile machine upon occurrence of an improper amount of tension in the yarns.

4. The combination according to claim **3** wherein said stop motion means is operatively connected to said drive means (c) (2) of said tension reducing means (c) for interrupting the driving of said roll means (c) (1) upon occurrence of an improper amount of tension in the yarns and wherein the combination further comprising (e) brake means operatively connected to said stop motion means (d) and to said roll means (c) (1) for braking said roll means to a standstill promptly on interruption of driving thereof and thereby avoiding excessive slackening of the yarns.

5. The combination according to claim **1** wherein said yarn supplying apparatus further comprises (d) yarn treating means for applying a treatment fluid to the yarn during passage thereof to said yarn takeup means and in preparation for subsequent yarn manipulation.

6. The combination according to claim **1** wherein said yarn tensioning means (b) of said yarn supplying apparatus comprises a number of individual tensioning devices at least equal to the number of said plurality of yarns being supplied to said yarn takeup means, each of said tensioning devices applying force to a respective one of said yarns.

7. The combination according to claim **6** wherein each of said individual tensioning devices is independently and individually adjustable for setting the tensioning force exerted thereby on said respective yarns.

8. In combination with a textile machine having yarn takeup means for taking up a plurality of yarns at predetermined demand rates; apparatus for supplying yarns to said takeup means under controlled tension conditions comprising:

a. creel means for supporting a plurality of yarn packages of uneven density and yarn release characteristics such that the tension in yarns being withdrawn therefrom varies along the length thereof;

b. tensioning means positioned intermediate said creel means and said yarn takeup means for applying tensioning force to the yarns to provide a predetermined minimum amount of tension therein and to compensate at least partially for the varying amount of tension in the yarns due to the uneven density and yarn release characteristics of the yarn packages;

c. tension reducing means disposed between said yarn takeup means and said tensioning means and adapted to engage the yarns for feeding the yarns at a linear rate greater than said predetermined demand rates of said yarn takeup means to reduce the amounts of tension therein by a predetermined ratio to compensate further

for, and reduce the amount of variations in, the tension in the yarns, said tension reducing means comprising:

1. roll means adapted to have a predetermined portion of its periphery engage the yarn,
2. drive means connected to said roll means for rotating the same with a linear surface speed greater than said predetermined demand rate of said yarn takeup means, and
3. the area of engagement of said roll means with the yarn, the surface characteristics of said roll means and the linear surface speed at which said roll means is driven being correlated so as to provide a predetermined controlled amount of slippage between the roll and yarn in engagement therewith and thereby provide said predetermined ratio of tension reduction; and

d. yarn treating means disposed between said tension reducing means and said yarn takeup means for applying a treatment fluid to the yarn during passage thereof to said yarn takeup means.

9. The combination according to claim 8 further comprising:

e. stop motion means disposed between said tension reducing means and said yarn takeup means and responsive to amounts of tension in the yarns as the same pass to said yarn takeup means and operatively connected to said textile machine for interrupting operation of said textile machine upon occurrence of an improper amount of tension in the yarns; and
f. yarn displacing means operatively connected to said stop motion means and operatively associated with said yarn treating means for displacing the yarns and for interrupting fluid treatment thereof upon occurrence of an improper amount of tension in the yarns.

10. In combination with a knitting machine having yarn takeup means for taking up a plurality of yarns at predetermined demand rates; apparatus for supplying yarns to said takeup means under controlled tension conditions comprising:

a. creel means standing independently of and spaced from the knitting machine for supporting a plurality of yarn packages of uneven density and yarn release characteristics such that the tension in yarns being withdrawn therefrom varies along the length thereof;
b. tensioning means mounted on said creel means and positioned intermediate said packages supported thereby and said yarn takeup means for applying tensioning force to the yarns to provide a predetermined minimum amount of tension therein and to compensate at least partially for the varying amount of tension in the yarns due to the uneven density and yarn release characteristics of the yarn packages; and
c. tension reducing means mounted on said creel means and disposed between said yarn takeup means and said tensioning means and adapted to engage the yarns for feeding the yarns at a linear rate greater than said predetermined demand rates of said yarn takeup means to reduce the amounts of tension therein by a predetermined ratio to further compensate for, and reduce the amount of variations in, the tension in the yarns, said tension reducing means comprising:
   1. at least one roll adapted to have a predetermined portion of its periphery engage the yarn,
   2. drive means connected to said roll for rotating the same with a linear surface speed greater than said predetermined demand rate of said yarn takeup means, and
   3. the area of engagement of said roll with the yarn, the surface characteristics of said roll and the linear surface speed at which said roll is driven being correlated so as to provide a predetermined controlled amount of slippage between the roll and yarn in engagement therewith and thereby provide said predetermined ratio of tension reduction.

11. Apparatus for supplying yarns under controlled tension conditions to a knitting machine having yarn takeup means for taking up a plurality of yarns at predetermined demand rates, the apparatus comprising:

a. creel means for supporting a plurality of yarn packages of uneven density and yarn release characteristics such that the tension in yarns being withdrawn therefrom varies along the length thereof;
b. tensioning means mounted on said creel means and positioned to receive yarns being withdrawn from the yarn packages for applying an individually predetermined tensioning force to each of the yarns to provide a predetermined minimum amount of tension therein and to compensate at least partially for the varying amount of tension in the yarn due to the uneven density and yarn release characteristics of the yarn packages; and
c. tension reducing means mounted on said creel means and disposed to receive yarns passing from said tensioning means and adapted to engage the plurality of yarns for feeding the yarns at a linear rate greater than said predetermined demand rates of said yarn takeup means to reduce the amounts of tension therein by a predetermined ratio to further compensate for and reduce the amount of variations in the tension in the yarns, said tension reducing means comprising:
   1. roll means adapted to engage all of the yarns,
   2. drive means connected to said roll means for rotating the same with a linear surface speed greater than said predetermined demand rates of said yarn takeup means, and
   3. the area of engagement of said roll means with each yarn, the surface characteristics of said roll means and the linear surface speed at which said roll means is driven being correlated as to provide a predetermined controlled amount of slippage between the roll means and yarns and thereby provide said predetermined ratio of tension reduction.

12. Apparatus according to claim 11 wherein said roll means (c) (1) comprises one roll adapted to have a predetermined portion of its periphery engage all of the yarns.

13. Apparatus according to claim 12 arranged for guiding each of the yarns being supplied to a textile machine into wrapping engagement of approximately 360° extent about said one roll.

14. Apparatus according to claim 11 wherein said roll means (c) (1) comprises a pair of rolls each adapted to have a predetermined portion of its periphery engage all of the yarns.

15. Apparatus according to claim 14 arranged for guiding each of the yarns being supplied to a textile machine into a total wrapping engagement of approximately 360° extent about said pair of rolls.

16. A method of supplying yarns under controlled tension conditions to a textile machine having yarn takeup means for taking up a plurality of yarns at predetermined demand rates and comprising the steps of:

directing yarn from a plurality of yarn packages of uneven density and yarn release characteristics along predetermined paths of travel to the textile machine while applying a predetermined tensioning force to each of the yarns to provide at least a predetermined minimum amount of tension therein and to at least partially compensate for the varying amounts of tension in the yarns due to the yarn package characteristics; and

slippingly feeding each of the tensioned yarns at a linear speed greater than the predetermined demand rates while pulling the yarn from the corresponding one of said packages to the textile machine and while reducing the amount of tension in each of the tensioned yarns in a predetermined ratio to further compensate for, and reduce the amount of variations in tension in the yarns by slipping the yarns in a predetermined, controlled manner.

17. A method according to claim 16 and further comprising the step of subjecting the yarns to a fluid treatment during

passage thereof from said packages to the textile machine being supplied, in preparation for a subsequent process to which the yarn is to be subjected.

18. The combination, with a textile machine having operating instrumentalities including means for positively feeding a plurality of ends of yarn to other operating instrumentalities of the machine at a predetermined demand rate, of apparatus for controlling the tension of each end of yarn at a predetermined tension level as such ends are moved along predetermined paths of travel to said positive yarn feeding means, said apparatus comprising:

means spaced from said textile machine operating instrumentalities for supporting a plurality of yarn supply packages;

yarn engaging roll means disposed in said predetermined paths of travel intermediate said package support means and said yarn feeding means for engagement with each end of yarn moving along said predetermined paths;

yarn tensioning means disposed intermediate said package support means and said roll means for exerting a determinable restraining force on each of said ends of yarn and including means guiding each of said ends for removal thereof from said respective package in a direction substantially alined with the longitudinal axis of said package;

means for driving said roll means in rotation with a linear surface speed greater than said predetermined demand rate to reduce the tension in each of said ends of yarn from that resulting from said yarn tensioning means restraining force to said predetermined tension level and to maintain a predetermined imbalance therebetween by advancing each end of yarn along said predetermined paths upon such end being drawn into transient frictional engagement with said roll means; and

said roll means, tensioning means and driving means cooperating with each other to maintain substantially constant tension in said plurality of ends of yarn at said yarn feeding means even during fluctuation of tension therein between said yarn supply packages and said tensioning means.

19. The combination according to claim 18 and wherein said yarn tensioning means comprises a number of tensioning devices corresponding to the number of said ends of yarn, each of said tensioning devices exerting on a respective end of yarn a restraining force correlated to the frictional engagement characteristics of said roll means, the linear surface speed of said roll means and said predetermined tension level.

20. The combination according to claim 18 and further comprising stop means operatively connected with said textile machine and responsive to an improper operating condition such as excessive tightness of any of said ends of yarn intermediate said roll means and said yarn feeding means for stopping said textile machine and yarn disengaging means operatively connected with said textile machine and associated with said roll means for displacing said ends of yarn from said predetermined paths of travel upon stopping of said textile machine and thereby lessening the engagement of said ends of yarn with said roll means during interruption of operation of said textile machine.

21. The combination according to claim 18 and further comprising yarn treatment applying means disposed in said predetermined paths of yarn travel intermediate said roll means and said yarn feeding means for applying a treatment liquid to said ends of yarn as the same are moved along said predetermined paths, said treatment applying means including a treatment liquid reservoir and an applicator roll for contacting said ends of yarn and dispensing treatment liquid thereonto from said reservoir.

22. The combination, with a knitting machine having operating instrumentalities including means for positively feeding a plurality of ends of yarn to knitting instrumentalities of the machine at a predetermined demand rate correlated to the production of fabric by the machine, of apparatus for controlling the tension of each end of yarn at a predetermined tension level as such ends are moved along predetermined paths of travel to said positive yarn feeding means, said apparatus comprising:

means for supporting a plurality of yarn supply packages;

a pair of yarn engaging roll members disposed in said predetermined paths of travel intermediate said package support means and said yarn feeding means, each of said roll members having a cylindrical yarn engaging surface of predetermined frictional characteristics, said roll members being disposed relative to said predetermined paths of travel for engagement with each end of yarn moving therealong by wrapping of such ends about a predetermined portion of the peripheries of said roll members;

a number of yarn tensioning devices disposed intermediate said package support means and said yarn engaging roll members, each of said tensioning devices exerting on a respective end of yarn a determinable restraining force correlated to the frictional characteristics of said roll member surfaces and to said predetermined tension level;

means for driving said yarn engaging roll members in rotation with a linear surface speed greater than the demand rate of said yarn feeding means and correlated to said frictional characteristics of said roll member surfaces and to said predetermined tension level to reduce the tension in each of said ends of yarn from that resulting from said yarn tensioning means restraining force to said predetermined tension level and to maintain a predetermined imbalance therebetween by advancing each end of yarn along said predetermined paths upon such end being drawn into transient frictional engagement with said yarn engaging roll members; and

said roll members, tensioning devices and driving means cooperating with each other to maintain substantially constant tension in said plurality of ends of yarn at said yarn feeding means even during fluctuation of tension therein between said yarn supply packages and said tensioning means.