United States Patent [19]
Dow

[11] 3,884,429
[45] May 20, 1975

[54] WARP BEAM FOR TRIAXIAL WEAVING

[75] Inventor: Norris F. Dow, Radnor, Pa.

[73] Assignee: N. F. Doweave, Inc., Philadelphia, Pa.

[22] Filed: Sept. 10, 1973

[21] Appl. No.: 395,529

[52] U.S. Cl. .............. 242/159; 28/37; 139/DIG. 1; 242/166; 242/176
[51] Int. Cl. .............. B65h 55/00
[58] Field of Search .......... 242/159, 166, 174, 176, 242/178; 28/32, 37; 139/DIG. 1, 11

[56] References Cited
UNITED STATES PATENTS

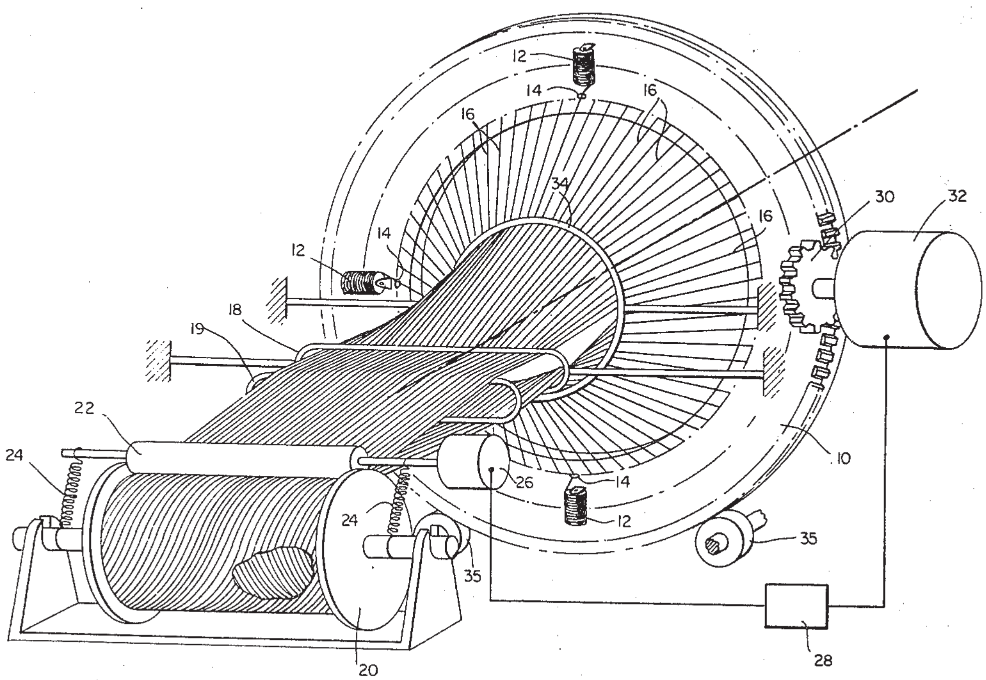
| | | | |
|---|---|---|---|
| 2,026,315 | 12/1935 | Kahlisch | 28/37 |
| 2,033,738 | 3/1936 | Reiners et al. | 28/37 |
| 2,066,888 | 1/1937 | Kahlisch | 28/37 |
| 2,972,796 | 2/1961 | Block | 242/166 X |

*Primary Examiner*—James Kee Chi
*Attorney, Agent, or Firm*—Miller, Frailey & Prestia

[57] ABSTRACT

A warp beam for triaxial weaving consists of a plurality of yarn courses forming a flattened sleeve wrapped spirally upon itself, the yarn courses being disposed in paths generally parallel to one another, and helical with respect to the longitudinal axis of the sleeve. Such a beam is formed by feeding a plurality of warp yarns to a beam take up while feeding the plurality of yarns from a creel with relative rotation of the creel and beam about a yarn path center line between them such that an individual warp yarn from its supply package on the creel rotates about the longitudinal center line of the warp yarn path from the creel to the take up apparatus, and therefore is wrapped helically about a sleeve formed collectively by the warp yarns from the plurality of supply packages on the creel. Triaxial weaving by first forming such a beam and then feeding from such a beam to a triaxial fabric loom whereby the warp yarn courses are made to traverse across the width of the fabric as they are unwound from the beam by virtue of their helical winding within the flattened sleeve of the warp beam is also within the scope of the present invention. Preferably, the helical angle of the individual warp yarns, with respect to the center line of the flattened sleeve along the center of one of the flat sides thereof, is approximately 30°, and preferably the yarn take off from the warp beam is synchronized with the weaving process such that end yarn transfer from above warps to below warps corresponds approximately to yarn take off from the appropriate flattened edge of the sleeve on the beam.

6 Claims, 10 Drawing Figures



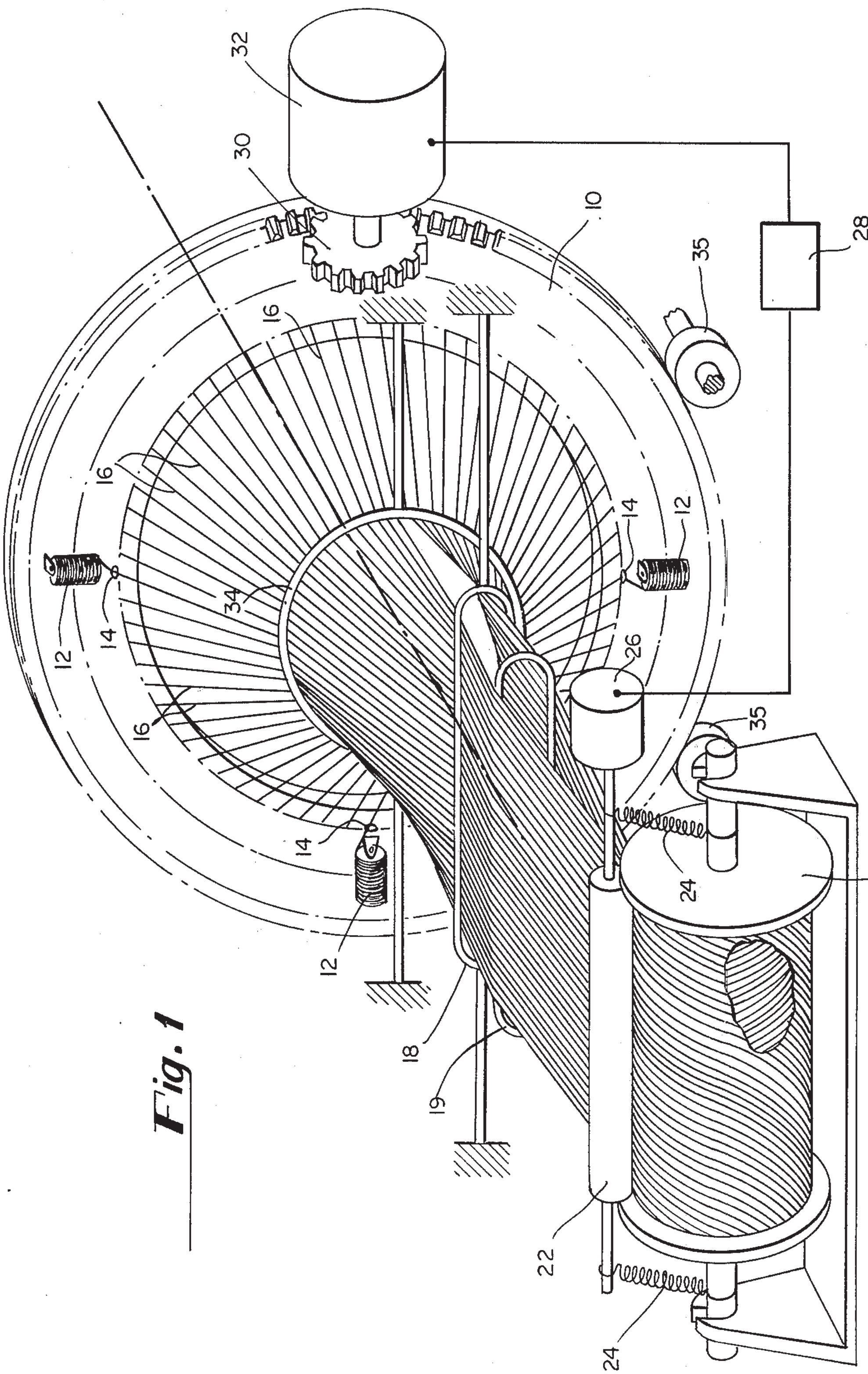



*Fig. 1*

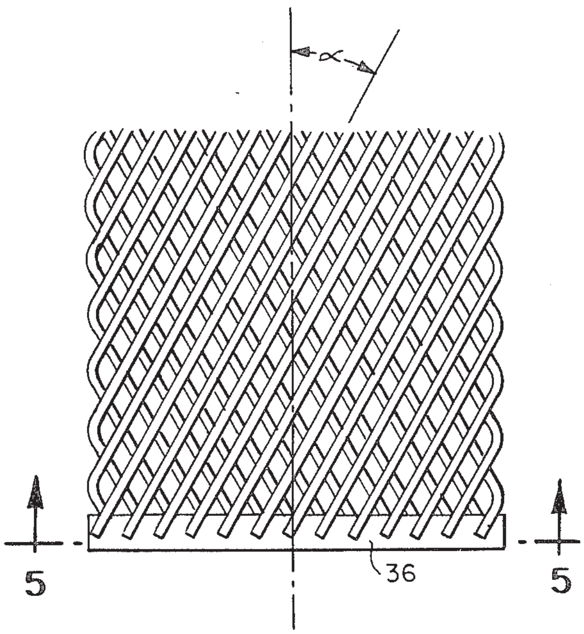



Fig. 4

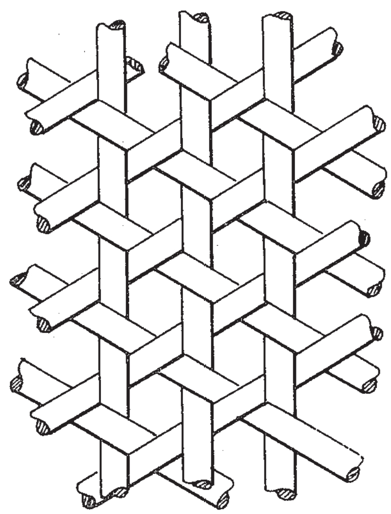


Fig. 8

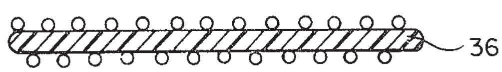



Fig. 5

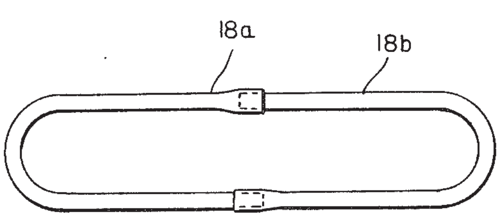



Fig. 3

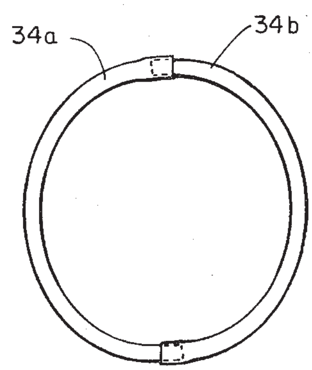



Fig. 2

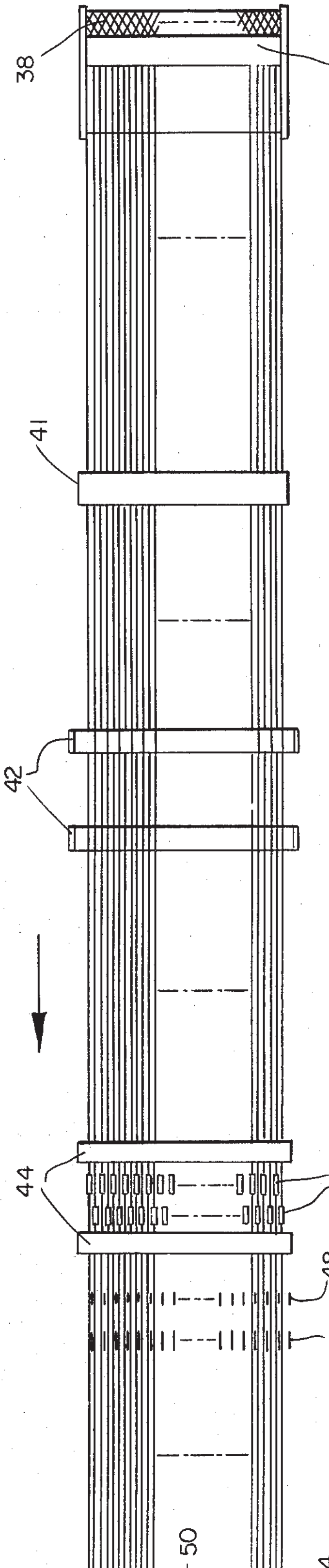



Fig. 6

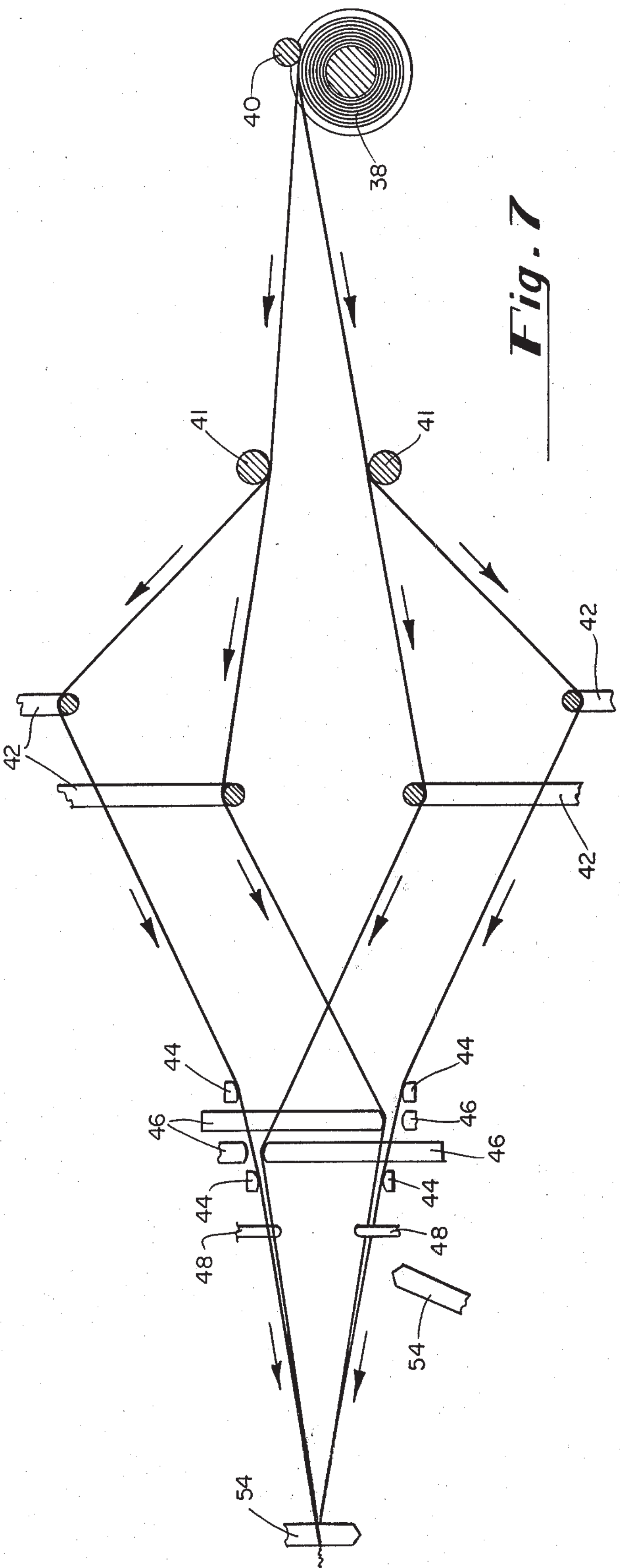
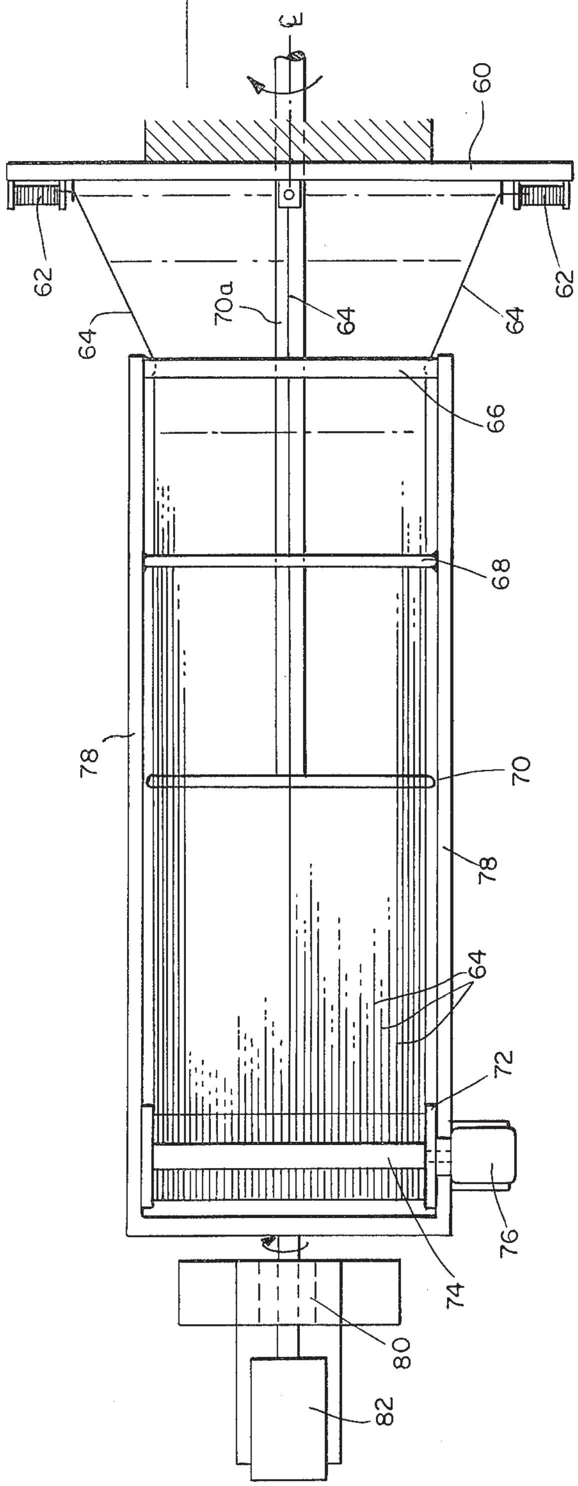
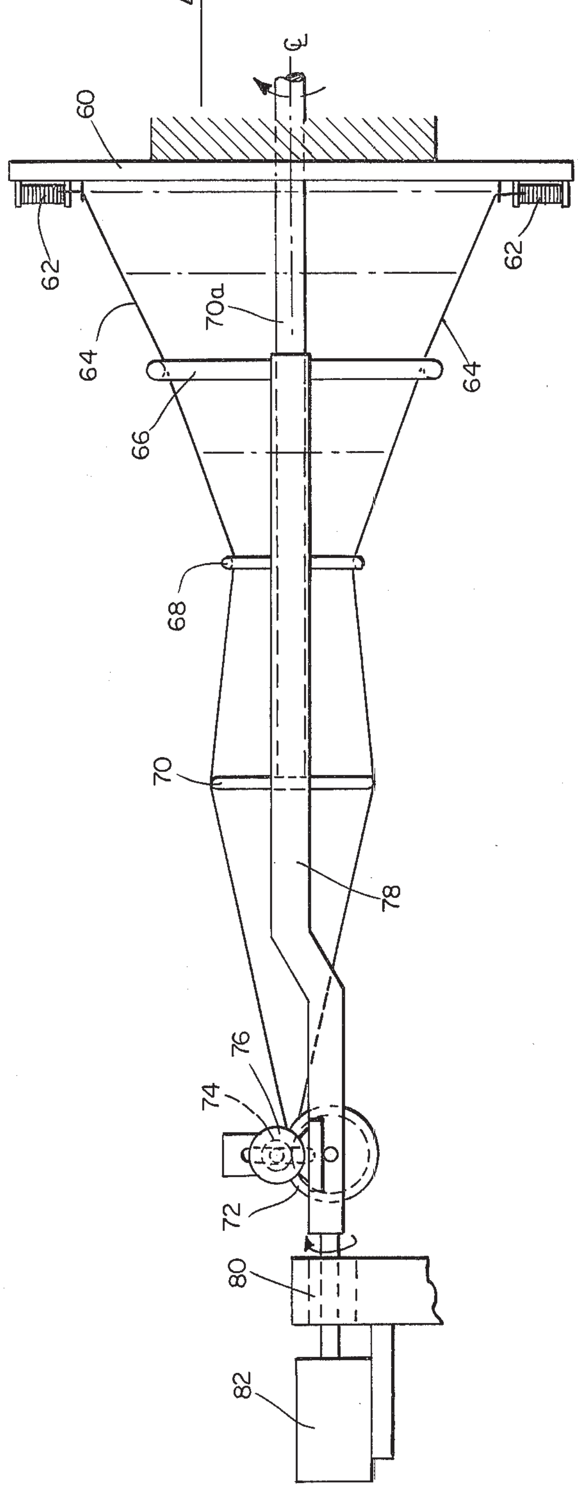



Fig. 7


60
62
62
64
64
64
70a
66
68
70
78
78
64
72
76
74
80
82
Fig. 9


60
62
62
64
64
70a
66
68
70
78
76
74
72
80
82
Fig. 10

## WARP BEAM FOR TRIAXIAL WEAVING

This invention relates to a method and apparatus for forming triaxial warp beams and to the beam product thereof and the method of triaxial weaving using such a beam. Further, this invention pertains to methods, apparatus and products which facilitate weaving triaxial fabrics, and particularly stabilized triaxial fabrics of the type disclosed and claimed in U.S. Pat. No. 3,446,251 — Dow. More particularly, this invention pertains to a warp beam wherein the disposition of warp yarn paths wrapped spirally about the beam is such as to provide transverse movement (with respect to the warp yarn paths) of the warp yarn courses as they are fed to a triaxial weaving machine to correspond to the requirements of the fabric forming machine for transverse motion and for transfer from above to below warps (and vice versa) at the edges of the fabric.

Triaxially woven fabrics, and particularly stabilized triaxially woven fabrics of the type disclosed and claimed in the above-referenced U.S. patent of common inventorship and assignment herewith, are becoming a product of commercial significance due to the inherent isotropy, strength-on-the-bias, and controllable variability of other physical characteristics of such weaves. A significant limitation in the technology relating to such weaves has been the novel and complex problems involved in designing commercially practical apparatus for producing such woven fabrics reliably and at reasonable cost and speed.

A specific aspect of this problem has been the difficulty in transversely moving the multiplicity of warp yarn courses and the supply of yarn for such courses back and forth across the width of the woven fabric and transferring the end yarns at the edges of the fabric from above to below, or vice versa. Such problems are unique to triaxial, as opposed to biaxial, weaving.

Prior to the present invention, the general approach has been to mount warp yarns supplies in a movable carriage or rotating yarn supply package holder. See, for example, Preliminary Investigations of Feasibility of Weaving Triaxial Fabrics (Doweave) — Dow, *Textile Research Journal*, Vol. 40, No. 11, Nov. 1970, pages 986 – 998, and Triaxial Woven Fabrics: Their Structure and Properties—Skelton, *Textile Research Journal*, Vol. 41, No. 8, Aug. 1971.

Such warp feed supply means greatly complicates the triaxial weaving machine or loom since the warp yarn transfer requires coincidental movement of the various supply packages. The means for holding the supply packages and for moving the supply packages together with the warp yarn transfer mechanism tends to be very large, and expensive also, in any weaving apparatus of any practical size.

Further, the warp yarn courses are disposed in two generally parallel sets, each disposed in a planar array, one set (the "above" warps) above the other (the "below" warps). In addition to providing for the transverse movement of each yarn course across its planar array, synchronized means must be provided for transferring, at the proper stages in each weaving cycle, the end warp yarn from the above warp set to the below warp set, and the end warp yarn from the below set to the above set.

This further complicates the design, operation and maintenance of the weaving apparatus and generally increases the cost while impairing the reliability and speed of the weaving process.

It is therefore the general object of the present invention to provide a warp beam of numerous ends of warp yarn adapted to triaxial weaving.

More specifically, it is an object of this invention to provide such a warp beam which facilitates triaxial weaving by providing inherently for the lateral or transverse movement and the set-to-set transfer of warp yarns during the weaving process.

Another object of this invention is to provide apparatus for forming warp yarn beams specifically adapted to facilitate triaxial weaving, and further to provide a method of triaxial weaving by first delivering a plurality of warp yarns to a beam take up in such a manner that the weaving is subsequently accomplished by delivering the warp yarns from the previously formed beam to a conventional triaxial fabric loom.

These, and other objects which will become apparent in the course of the subsequent discussion, are met, briefly, by a triaxial weaving warp beam formed by taking up a plurality of warp yarn courses on a take up means together with a relative rotation of supply and take up as the warp yarn courses are fed to the take up means in paths generally parallel to and disposed about a warp yarn center line in a flattened sleeve-live configuration, thus causing the paths of the yarn courses to migrate transversely of the center line and about the periphery of the sleeve-like configuration. The warp beam of the present invention consists, therefore, of a plurality of yarn courses forming a flattened sleeve wrapped spirally upon itself with the individual yarn courses thereof being disposed in paths generally parallel to one another and helical with respect to the longitudinal axis (or warp yarn center line) of this sleeve.

Such a warp beam for triaxial weaving is formed, in accordance with the present invention, in apparatus which includes a creel means carrying a plurality of warp yarn supply packages, the creel means having the supply packages disposed about the warp yarn center line with warp yarns extended therefrom to a beam take up means. Either the take up means or the creel means is rotated, relative to the other, about the warp yarn center line. By imparting a relative rotation between supply and take up as the warp yarns are drawn from the supply, the individual warp yarns are moved about the warp yarn center line as the warp yarns are drawn from the supply packages and taken up on the take up means. This produces the helical effect of the warp yarns in the flattened sleeve on the take up means.

Preferably, the speed with which the yarns are moved about the warp yarn center line is maintained in a predetermined proportion with respect to the speed of the take up means so that a predetermined helical angle is maintained in the warp yarns on the take up means. The helical angle corresponds to the angle of warp yarns to the center line in the final triaxial weave. In most stabilized triaxial weaves of the type to which this invention is directed, this angle is preferably about 30°.

In all cases, the unit length in the flattened sleeve on the warp beam, i.e., the length of the sleeve in which an individual yarn course migrates transversely of the sleeve center line making one complete circumferential movement of the periphery of the sleeve, is the same as the length of finished woven fabric in which an individual yarn course migrates from one edge thereof to the opposite edge thereof and back to the first edge.

Generally, the present invention also consists of a method of weaving triaxial fabric wherein warp yarns from a bobbin supply or conventional warp beam or beams are delivered to and taken up by a take up means upon which a flattened sleeve-like configuration of warp yarns is taken up with the warp yarns parallel to one another and helically disposed with respect to the sleeve center line. In this method of weaving, the warp beam thus formed is thereafter used by unwrapping the sleeve and delivering the warp yarns therefrom to a triaxial fabric loom wherein the migration of warp yarn courses in the warp beam follows the desired warp yarn transfer mechanism in the loom to facilitate and simplify the supply of such warp yarns in such a loom. Thus, warp yarn supplies move transversely of the fabric, from edge to edge, synchronously with the corresponding transverse movement of warp yarns in the woven fabric. Further, each warp yarn supply reaches an edge of one set or array of warp yarns (either above or below) and is automatically transferred to the other set or array by virtue of its corresponding (and synchronized) change of position, and it is unwrapped from the warp yarn supply beam, from the top to the bottom (or vice versa) of the flattened sleeve-like configuration of warp yarns on the beam.

This invention may be better understood by reference to the following detailed discussion thereof, taken in conjunction with the appended claims and the accompanying drawings, in which:

FIG. 1 is an isometric view of a simplified form of beaming apparatus for forming a warp beam peculiarly adapted to triaxial weaving, in accordance with the present invention;

FIGS. 2 and 3 are detailed views of certain warp yarn guides used in the apparatus of FIG. 1;

FIG. 4 is a top view of a plurality of warp yarns as they are disposed in the warp yarn beam of the present invention;

FIG. 5 is an end view of the plurality of warp yarns shown in FIG. 4, further showing a holding means to facilitate delivery of the warp yarns from the beam of the present invention;

FIG. 6 is a plan view of triaxial fabric weaving apparatus as warp yarns are supplied thereto from a triaxial warp beam in accordance with the present invention;

FIG. 7 is a side view of the apparatus shown in FIG. 6;

FIG. 8 is a plan diagrammatic view of stabilized triaxial woven fabric which may be produced in accordance with the present invention;

FIG. 9 is a schematic illustration in plan view of another form of apparatus for producing warp beams for triaxial weaving; and

FIG. 10 is a side view (in schematic) of the apparatus shown in FIG. 9.

Referring more specifically to FIG. 1, there is shown a creel 10 upon which is disposed a plurality of warp yarn supply packages either in the form of conventional warp beams or individual bobbins of which three typical such bobbins 12 are shown. Warp yarns from such supply packages are fed through individual guides, three typical such guides 14 being shown, and thence along yarn paths 16 disposed generally about a warp yarn path center line extending away from creel 10, the yarn paths 16 collectively defining an enclosed or tubular or sleeve-like configuration, subsequently modified by elongated inner and outer guides 18 and 19 into a flattened sleeve-like configuration such that the warp yarns therein are symmetrically disposed about a plane parallel to the axis of a take up means 20 upon which the flattened sleeve-like configuration formed of the plurality of warp yarn courses is wrapped spirally upon itself, the speed and movement of take up means 20 being controlled by a surface drive roller 22 held in engagement with the surface of the warp yarns being wound upon take up means 20 by spring means 24. Surface drive roller 22 is in turn driven by, for example, an electric motor 26 powered and controlled by drive control source 28.

A helical angle is imparted to warp yarns wrapped on take up means 20 by virtue of relative rotational motion, about the yarn path center line, of creel 10 and take up means 20. Warp yarn paths 16 from supply packages 12 on creel 10 to take up means 20 define an enclosed sleeve-like configuration disposed about the warp yarn center line. The relative rotational motion of creel 10 with warp yarn supply packages 12 thereon and take up means 20 is such that the warp yarn supply packages are moved through a closed path about that center line.

In the embodiment of this invention shown in FIG. 1, this is accomplished by virtue of geared engagement of creel 10 with the driving gear 30 in turn driven by a second electric motor 32 in turn powered and controlled by drive control source 28. Creel 10 is supported by idler rollers 35.

A second guide for the collective warp yarn paths, more specifically, a length compensating guide 34, is disposed between creel 10 and take up means 20 in order to equalize the length of yarn paths between their respective warp yarn supply packages on creel 10 and their respective positions at take up on take up means 20.

Guide means 34 and 18, respectively, are seen in more detail in FIGS. 2 and 3. Guide means 34 is shown schematically as elongated only in the vertical direction (so as to lengthen the path of yarn courses disposed near the horizontal ends of the tubular or sleeve-like configuration defined by the collective warp yarn courses). The exact actual shape of the guide means must, of course, be determined in detail to ensure that all yarn path lengths in the array thereof are equal. To facilitate set up, it will also be noted that guide means 34 consists of two separable segments 34*a* and 34*b*, the ends of which telescope into one another for easy assembly.

Similarly, guide means 28 (like guide means 19) is elongated horizontally in order to form the collective configuration of the warp yarn courses into a flattened sleeve configuration just prior to their take up on take up means 20. Guide means 18 also consists of separable sections 18*a* and 18*b* to facilitate set up. Guide means 19 is supported on a cantilever beam, not shown, fixedly mounted behind creel 10.

In FIG. 4, there is seen a top view of the plurality of warp yarns as they are wrapped spirally upon themself by take up means 20 or as they would appear as unwrapped from a warp yarn beam within the scope of the present invention, for delivery to a triaxial fabric weaving machine. In the flattened sleeve-like configuration collectively defined by the plurality of warp yarns shown in FIG. 4, it will be noted that each of the warp yarns migrates progressively, as it travels along the length of the warp yarn center line, from one edge of the flattened configuration to the other edge thereof, then from the bottom to the top (or vice versa) of the flattened sleeve and back to the first edge. This movement corresponds to the transverse and bottom warp to top warp (or vice versa) movement of each warp yarn in a triaxial fabric, and particularly in a stabilized triaxial fabric of the type disclosed and claimed in U.S. Pat. No. 3,446,251 – Dow.

In the triaxial weaving warp yarn beam of the present invention, as shown in FIG. **4**, all of the respective warp yarn paths are helically disposed about the warp yarn center line. What is referred to herein as the helical angle is the angle formed by each of the warp yarns in the flattened sleeve-like configuration with the warp yarn center line, viewed as shown in FIG. **4** and indicated as angle $\alpha$ in FIG. **4**.

An end view of the plurality of warp yarns as they are disposed when unwrapped from the triaxial warp beam of the present invention is seen in FIG. **5**. Also seen in FIG. **5** is a warp yarn end holder **36**, shown in section. Such a holder, which may be used to facilitate transfer of the ends of the warp yarn beam of the present invention to a triaxial fabric weaving machine, may consist, for example, of a flattened elongated plastic member with an adhesive surface thereon. Thus, each of the ends of warp yarns on the warp yarn beam may be transferred easily to a predetermined location in the set up of the triaxial fabric weaving machine. Alternatively, warp yarn end holder **36** may be circular rather than a flattened configuration, as seen in the end view cross-section, so that the warp yarn ends may be rotated to facilitate their transfer to predetermined locations in the set up of the triaxial fabric weaving machine. Used in this manner, a temple roll, or roller frictionally engaging the surface of the warp beam as the warp yarns are drawn therefrom maintains the angular disposition of the warp yarns thereon while the circular warp yarn holder is rotated about its axis as the warp yarns are drawn off the beam so that the warp yarns extending from the beam extend therefrom in parallel, non-helical relationship and are placed in predetermined positions in the warp yarn supply system of a triaxial fabric weaving machine, such as that seen in plan view in FIG. **6**.

As seen in FIG. **6**, triaxial warp beam **38** is set up to deliver warp yarns through a frictionally engaging roller **40** over tension adjustment bars **41** and tension compensators **42** through saw teeth warp yarn transverse transfer mechanisms **44**, passing over heddles **46** through weave guides **48** to a fell line **50** for weaving thereat into triaxial fabric **52**. Beaters **54** are intermittently inserted between warp yarns after the insertion of a pick or weft yarn therein by a shuttle mechanism, not shown, causing the weft yarn and any intersecting warp yarn courses between the beater and the fell line **50** to be beaten up into fell line **50**, to form a triaxial fabric **52** of the type seen, for example, in FIG. **8** (which corresponds to that shown in FIG. 1 of U.S. Pat. No. 3,446,251 ) and in FIG. 3 of U.S. Pat. No. 3,446,251. A typical shed formation for making the latter weave is seen in FIG. **7**, a side view of the apparatus shown in FIG. **6**. In FIG. **7** it will be seen that heddles **46** have formed some but not all of the warp yarn courses into a shed at a particular stage of the weaving cycle of fabric **52** such that the pick passes over and under selected yarn courses of both the upper and lower sets of warp yarn courses as they are delivered in a flattened sleeve-like configuration from beam **38** to fell line **50**.



In the operation of the apparatus as shown in FIG. **1** and in the methods illustrated in FIGS. **1**, **6**, and **7**, a plurality of warp yarn supply packages delivers warp yarn through a plurality of warp yarn paths **16**, the path collectively being disposed about the warp yarn center line and defining a closed tubular configuration converted by elongated guides **18** and **19** into a flattened sleeve configuration to be taken up onto a beam by take up means **20**. Relative rotation between creel **10** upon which supply bobbins **12** are mounted and take up means **20** (more specifically, rotation of creel **10** in the apparatus shown in FIG. **1**) causes the respective warp yarn paths to migrate transversely of each of the paths and generally about the periphery of the closed path of the supply packages about the warp yarn center line thus imparting a helical angle about the warp yarn center line to the warp yarns as they are delivered to the take up means **20**. The proportional control of the rate of speed of take up means **20** and of the relative rotation between creel **10** and take up means **20** imparts a predetermined helical angle to warp yarns taken up by take up means **20**. In the apparatus shown in FIG. **1**, drive control source **28** or an integrated common drive means for take up means **20** and rotating creel **10** are designed and precisely controlled so as to produce a specified constant predetermined helical angle to the warp yarns. This angle, as measured by the angle which each of the warp yarn forms with the warp yarn center line in a plan view of the flattened sleeve configuration is preferably 30° (although it may deviate slightly therefrom). This angle corresponds to the angle of warp yarns in most triaxial fabrics, the formation of which is accomplished by the use of the triaxial warp beam of the present invention.

As warp yarns are taken up in their flattened sleeve-like configuration by take up means **20**, they of course assume a relationship generally parallel to one another as well as helical with respect to the center line of the generalized warp yarn paths, and more specifically the center line of the flattened sleeve-like configuration of the yarns as they are taken up by take up means **20**. Moreover, this flattened sleeve-like configuration may be described as being defined by a plurality of warp yarn paths disposed symmetrically about a central plane parallel to the axis of take up means **20**.

As seen in FIGS. **6** and **7**, warp beam **38** is then transferred to a triaxial fabric weaving machine wherein the warp yarns are taken off beam **38** in a direction parallel to the warp yarn center line and over various tension control means, transverse transfer means, and heddles to the fell line of the triaxial weaving machine. The upper half of warp yarns in the flattened sleeve-like configuration of warp yarns on the beam becomes the upper warps in the triaxial weaving machine while the lower half of the sleeve becomes the lower warps. In the course of weaving, the woven fabric is intermittently advanced and the warp yarn courses extending from warp beam **38** to fell line **50** are transferred, or caused to migrate, a predetermined distance transverse of the warp yarn paths. This is accomplished by virtue of the transverse migration of warp yarns in the helically wound flattened sleeve-like configuration of yarns on beam **38** as beam **38** is unwrapped for delivery of warp yarns to the weaving machine, and the simultaneous transfer or movement of warp yarn transfer elements, such as upper and lower sawteeth **44.** The upper warp yarns are, of course, transferred in one direction and the lower warp yarns are transferred in the opposite direction. Thus, the parallel configuration of the warp yarns is maintained during the transfer movement. In addition, and coincidentally therewith, warp yarns at the extreme ends of the warp yarn sets disposed above one another in the flattened sleeve-like configuration on the beam and in the upper and lower warp yarn arrays in the weaving machine are transferred from the top to bottom or bottom to top alternately in each warp yarn transfer movement. Generally, the distance of the transfer movement is governed by warp yarn spacing in the weave and the nature of the weave itself.

Also intermittently, weaving sheds are formed, by upper and lower heddles **46,** of the various warp yarn courses (some or all of the upper warps being forced downward and some or all of the lower warps being forced upward) and weft yarns inserted therein.

After the transverse transfer, each upper warp intersects a lower warp (as seen in plan view). The shed is then formed and the weft yarn is inserted behind (on the supply, as opposed to the fell line, side of) these intersections. One set of beaters **54** (either upper or lower depending on the stage of the weaving cycle) are then inserted between the adjacent warp yarns and moved toward the fell line **50** to snugly compact and to beat up the warp yarn intersections and weft yarn into woven fabric **52** of stable triaxial configuration.

As described above, the helical angle of warp yarns in beam **38** corresponds to the angle of warp yarns in the final triaxial woven fabric, and for most triaxial fabrics, it is approximately 30° with some slight deviation therefrom due to the tortuous path of warp yarns in the weave after being "snugly compacted" for optimum mechanical properties. In addition, the spacing of warp yarns in the flattened sleeve-like configuration of beam **38** also corresponds to the spacing of warp yarns in the final fabric **52** and the unit length of the flattened sleeve-like configuration of warp yarns in beam **38** also corresponds to the unit length of warp yarns in fabric **52.** For purposes of the present invention, unit length is defined as the length of the flattened sleeve as well as the length of fabric in which an individual warp yarn migrates either about the periphery of the sleeve coming back to its original position, or migrates from one edge thereof, as in the fabric, to the other edge thereof and back to the first edge.

For weaving a particular triaxial fabric, the triaxial warp beam of the present invention must, of course, maintain a preselected and constant unit length throughout its total length. In the beaming operation of the present invention, the plurality of warp yarns is generally wrapped about a central spool which is usually but not necessarily cylindrical.

This invention has been defined to include apparatus for producing a warp beam for triaxial weaving, the apparatus including a creel having a plurality of warp yarn supply packages mounted thereon, disposed about a warp yarn path center line, from which warp yarns are delivered to a beam take up, the apparatus further including means for providing relative rotation of creel and beam take up about the warp yarn path center line. It has been described previously with reference primarily to the apparatus illustrated in FIG. **1** wherein the rotating creel is provided to impart the necessary relative rotational movement of creel and beam take up. An alternative apparatus within the scope of the present invention is shown schematically in FIGS. **9** and **10,** plan and side views respectively of the apparatus. More specifically, a fixedly mounted creel **60** has mounted thereon a plurality of warp yarn supply packages **62,** two of which are shown in each view. Warp yarn paths **64** form a closed tubular configuration about warp yarn path center line as they extend from warp yarn supply packages **62** through yarn path length compensating guide **66** flattened sleeve configuration forming guides **68** and **70** to beam take up means **72,** drawn by surface drive roller **74,** which is in turn driven by motor **76,** surface drive roller **74** being urged into engagement with the warp yarns being taken up by take up means **72** by a means not shown. Take up means **72,** together with surface drive roller **74** and motor **76,** and guides **66** and **68** are mounted on extended support members **78,** which are in turn rotatably supported in bushing **80** and connected therethrough to a second motor **82.** Inner guide **70** is supported on a cantilever beam **70***a* which is rotated in unison with support members **78.**

In the operation of the apparatus shown in FIGS. **9** and **10,** motor **74** and surface drive roller **76** take warp yarns supplied by warp yarn packages **62** and wrap it spirally upon beam take up means **72** in a flattened sleeve configuration formed by guides **68** and **70** while motor **82** causes the entire assembly of beam take up means **72,** surface drive roller **74,** motor **76,** support members **78,** and guides **66** and **68** to be rotated, relative to creel **60** and warp yarn supply packages **62** at a predetermined rate proportional to the take up rate of take up means **72.** Thus, a helical angle is imparted to the warp yarns being taken up in a flattened sleeve-like configuration on take up means **72** in accordance with the present invention.

Generally, guides **66, 68,** and **70** may be similar to perform corresponding functions to guides **18, 19,** and **34** in the apparatus illustrated in FIG. **1.**

Obviously, other means may be used to form the warp yarns collectively into a flattened sleeve-like configuration for take up by the take up means in the beaming apparatus of the present invention. For example, movable individual guides for each of the warp yarns may be disposed in an elongated oval path and carried about that path, which corresponds to the periphery of the flattened sleeve-like configuration of warp yarns prior to take up, by means of mounting on sprocket chain elements or in some form of track device. Thus, a sprocket chain suitable mounted and driven in an elongated elliptical path supported by a member from the back of creel **10** in the apparatus of FIG. **1** and through the center of the tubular configuration of warp yarns may carry a plurality of small pigtail guides for positively positioning each of the warp yarns in the flattened sleeve-like configuration prior to beam take up for positively positioning and positively controlling the migration of each of the warp yarns in and about the flattened sleeve-like configuration of warp yarns.

While this invention has been described with respect to particular embodiments thereof, and, for purposes of simplification, has been described and illustrated with respect to warp yarn beams and weaving apparatus utilizing relatively limited numbers of warp yarns, it should be understood that the present invention may be utilized in a great variety of other forms and embodiments, and in much more complicated forms of apparatus and with larger numbers of warp yarn courses in the beam. It should also be understood that the appended claims are intended to encompass all forms and embodiments of the present invention, whether described or not, to the extent that such forms and embodiments are considered to be within the true spirit and scope of the present invention.

I claim:

1. A warp beam for triaxial weaving consisting of a plurality of yarn courses forming a flattened sleeve wrapped spirally upon itself, said yarn courses being disposed in paths generally parallel to one another and helical with respect to the longitudinal axis of said sleeve.

2. A warp beam, as recited in claim 2, wherein said flattened sleeve has a predetermined constant unit length throughout its total length, said unit length consisting of the length of said flattened sleeve in which each of said yarn courses makes one complete traverse of the periphery of said sleeve and returns to its original position.

3. A warp beam, as recited in claim 1, wherein said flattened sleeve is wrapped about a cylindrical spool at the center thereof.

4. A warp beam, as recited in claim 1, wherein said spirally wound flattened sleeve is fastened at its outer longitudinal end to a retainer adapted to hold all of the yarn courses thereof in their proper position with respect to one another, and to facilitate transfer of said yarn courses to a triaxial loom warp feed system.

5. A warp beam, as recited in claim 1, wherein said paths have a helical angle of approximately 30°.

6. A warp beam, as recited in claim 2, wherein said flattened sleeve is wrapped about a cylindrical spool at the center thereof.

* * * * *