

[54] MACHINE FOR FORMING TRIAXIAL FABRICS

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[52] U.S. Cl..... 139/11, 139/DIG. 1, 139/28, 139/191

[51] Int. Cl. D03d 41/00, D03d 13/00, D03d 49/60

[58] Field of Search..... 139/DIG. 1, 11, 191, 190, 139/188, 28; 140/3, 7

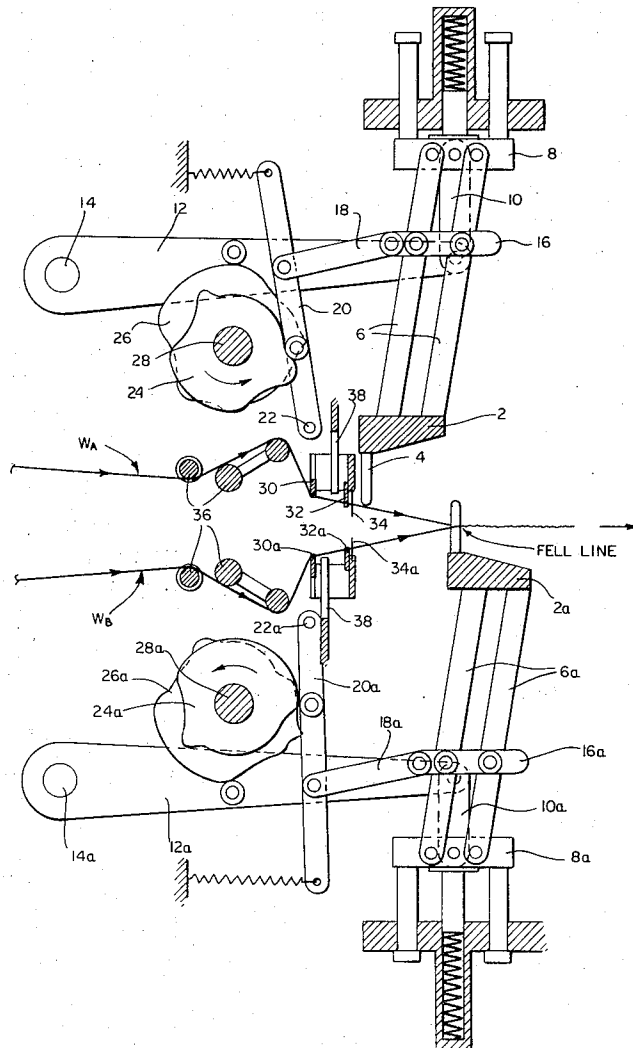
[57] **ABSTRACT**

Improved machine for forming triaxial fabric wherein a two beater combination and a single beat up movement in each fabric formation cycle are utilized to form a stable triaxial fabric more efficiently than has heretofore been possible.

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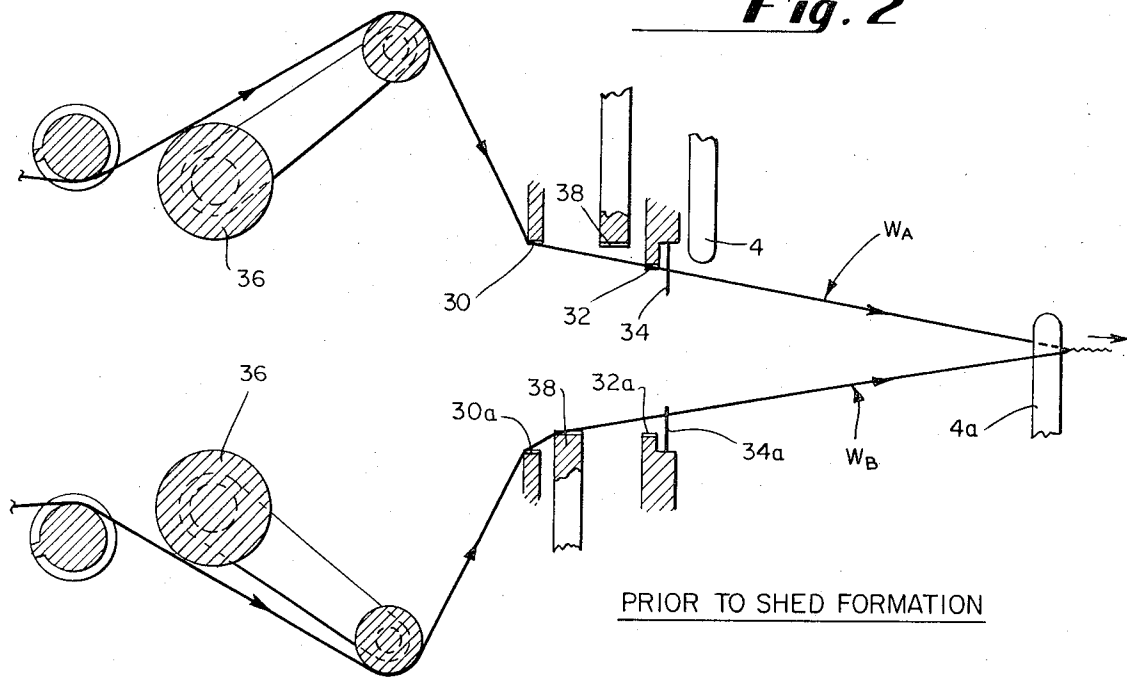
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**6 Claims, 13 Drawing Figures**

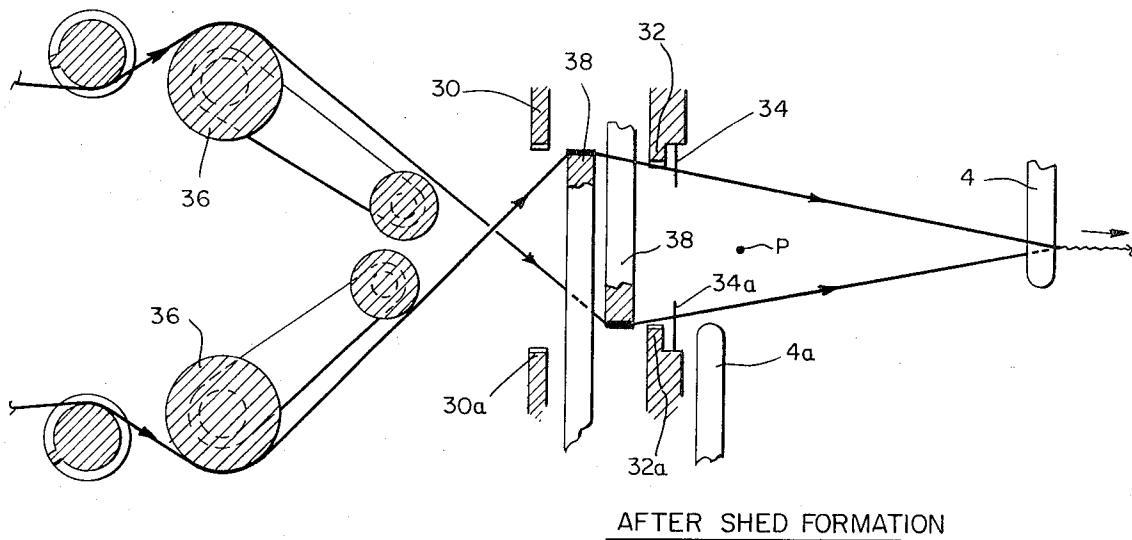




**Fig. 2**

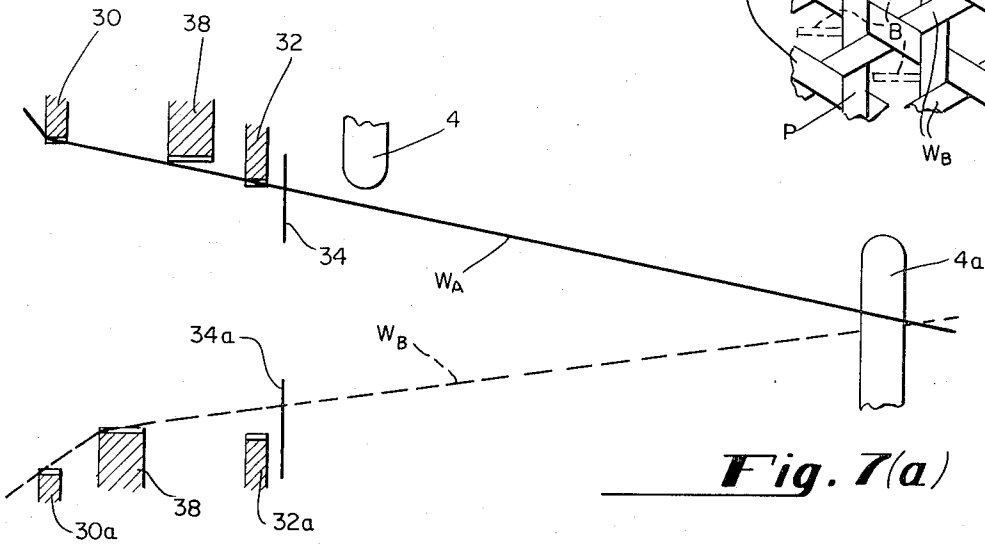
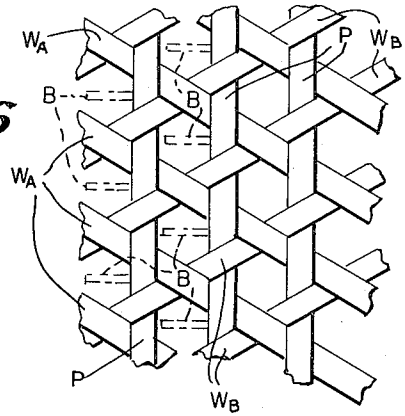


**Fig. 3**

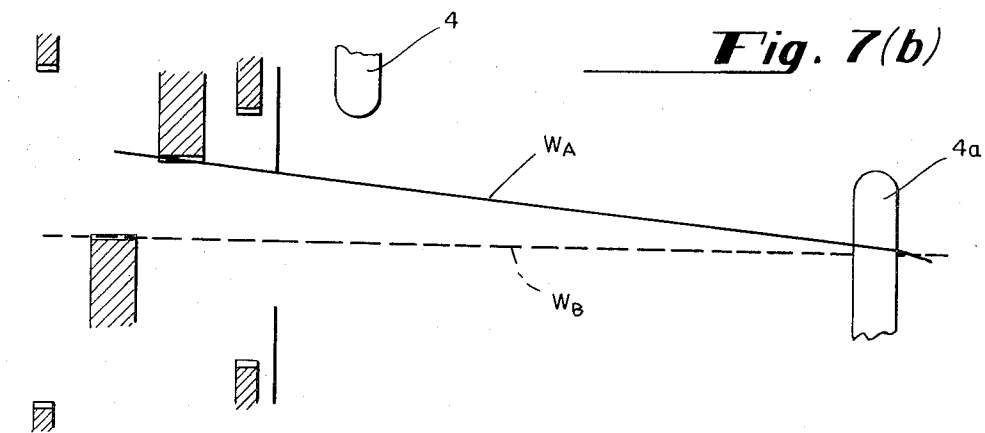




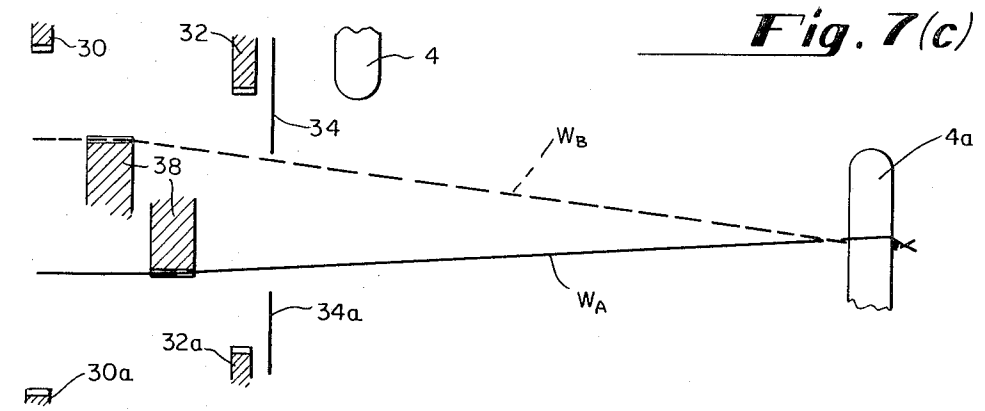
**Fig. 6**



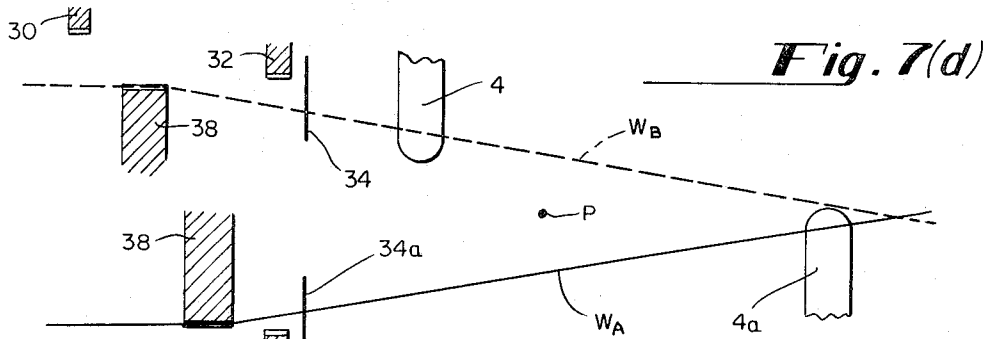
**Fig. 7(a)**



**Fig. 7(b)**



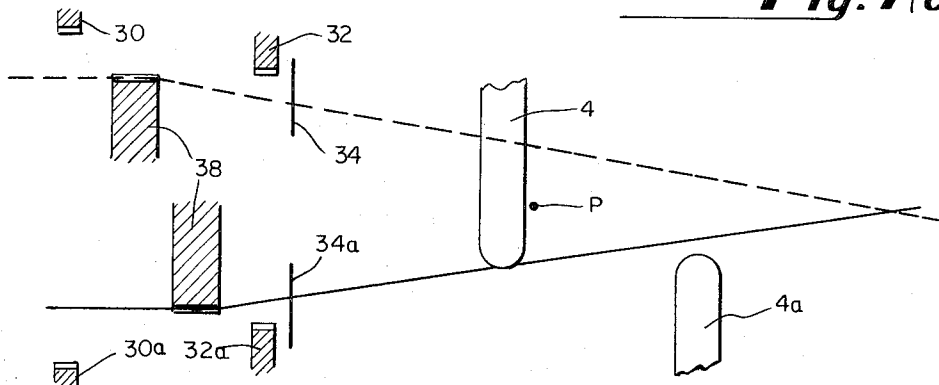
**Fig. 7(c)**



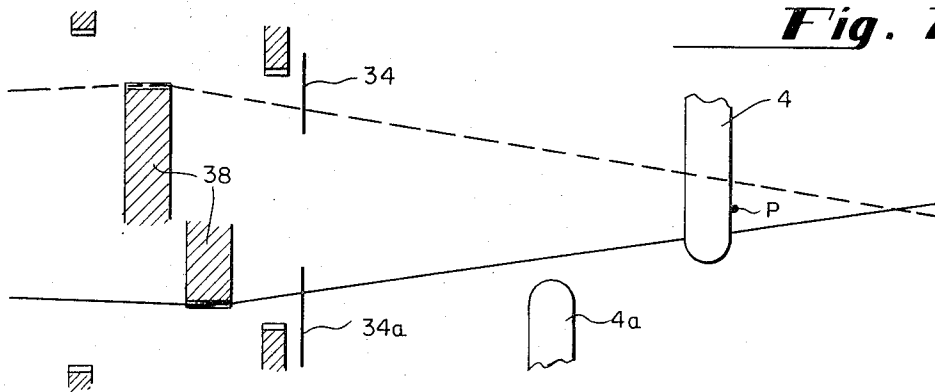
**Fig. 7(d)**



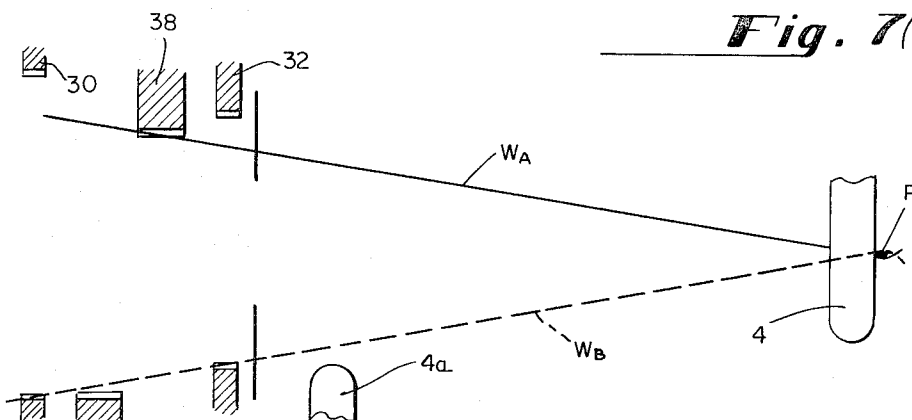
**Fig. 7(e)**



**Fig. 7(f)**



**Fig. 7(g)**



## MACHINE FOR FORMING TRIAXIAL FABRICS

This invention pertains to an improved machine for forming triaxial fabric and more particularly to such a machine incorporating a single pair of beaters operative to stabilize the weave with a minimum of delay to the weaving cycle.

Stable, generally isotropic triaxial fabric, as disclosed in U.S. Pat. No. 3,446,251 — Dow, is relatively new. Mechanically, as contrasted with manually, forming such fabric is necessarily complicated. See, for example, *Preliminary Investigations of Feasibility of Weaving Triaxial Fabrics (DOWEAVE)*, Dow, Textile Research Journal, Volume 40, No. 11, November 1970, pages 986-998. With reference only to the fabric shown in FIG. 1 of U.S. Pat. No. 3,446,251, warp traversal may be accomplished in a manner similar to that disclosed in U.S. Pat. Nos. 550,068 and 1,368,215. Shed formation and pick insertion for fabrics of this type may be accomplished in a manner similar to that used in conventional orthogonal weaving. All of these elements have heretofore been combined in a relatively efficient prototype machine.

A major delay factor in the prototype machine as it existed prior to the present invention was in the beaters or beat up system. As is evident in the journal article referred to above, it has heretofore been considered necessary to employ either more than two beaters with at least two of the beaters operating in each fabric formation cycle or a single pair of beaters with multiple beat up strokes in each fabric formation cycle.

This was thought to be necessary to stabilize the yarns by positively beating, in separate motions, the warp yarn intersections and the transversely inserted woof yarn or pick. Such multiple beating motions contributed significantly to the elapsed time required for each fabric formation cycle and added to the complexity of the machine, providing, among other things, greater opportunity for defective fabric formation due to misalignment of beaters, improper beater operation, etc.

In view of these problems, it is the general objective of the present invention to provide a machine for forming stable triaxial fabric, simplified and improved by the incorporation therein of a simple, effective and efficient beat up system.

A more specific object of this invention is to provide an effective beater arrangement for a triaxial machine, which arrangement facilitates more efficient fabric formation by reducing the number of beater motions per fabric formation cycle without appreciable sacrifice of fabric stability.

These and other objects are met in accordance with the present invention by triaxial machine beat-up system consisting of an above beater and a below beater both positioned transversely of the fabric so that the beater members approximately coincide with the transverse positions of warp yarn intersections in the fabric in alternate fabric formation cycles. Beater control means, such as paired cams and connecting members, simultaneously move one of the beaters from a second rest position at the fell line to an intermediate position out of the transverse planes of the warp yarns and the other of the beaters from a first rest position away from the fell line and out of the transverse planes of the warp yarns through a first intermediate position wherein the beater members project through the transverse planes of the warp yarns as the formed shed is

being unformed, then moving further to its first rest position while the second beater advances to its second rest position at the fell line, beating into the fell both the pick and the warp yarn intersections formed prior to shed formation and partially advanced by the shed formation movement.

In the preferred form of the present invention the intermediate positions of the beaters are displaced primarily vertically from the preceding rest position and the first rest position of the beaters is longitudinally adjacent the warp traversal means to facilitate beater alignment and insertion.

Further, with respect to the preferred form of the present invention, the precise longitudinal and vertical movement of the beaters is effected and controlled by separate cams, mounted on a common shaft, each associated with cam rollers pivotally connected to linkage members, one end of each of which is pivotally connected through other linkage members to one of the beaters of this invention and the other end of each of which is pivotally connected to one of two fixed pivot points displaced vertically and longitudinally, respectively, from the cam roller connected to the linkage member pivoting about such point.

For a better understanding of the present invention, reference is made to the following detailed description of the invention taken in conjunction with the appended drawings, in which:

FIG. 1 is a simplified side elevation, in section, showing the primary operative features in the improved machine of the present invention;

FIGS. 2 and 3 are sequential side elevation views of the improved machine of the present invention, illustrating the primary mechanical members thereof in schematic cross section;

FIGS. 4 and 5 are more precise illustrations of the beater paths and the relative beater positions at various points along those paths in the apparatus illustrated in FIGS. 1, 2 and 3.

FIG. 6 is a plan view of the triaxial fabric showing the beaters positions in successive fabric formation cycles; and

FIGS. 7 (a) to 7 (g) are sequential schematic side views of the fabric formation process showing the positions of the beaters with reference thereto.

Referring more specifically to FIG. 1 there is shown an above beater 2, having a plurality of parallel downwardly extending members 4, attached to linkage members 6 which are in turn pivotally connected to a vertically movable downwardly urged plate member 8. Plate member 8 is also pivotally connected, through arm 10 to cam controlled operator 12 pivotally connected at fixed point 14. Linkage members 6 are also connected, through pivotal connecting means and additional linkage members 16 and 18 to a second cam controlled operator 20 pivotally connected at fixed point 22 and urged toward cam 24. Operators 12 and 20 are in turn controlled by cams 24 and 26 mounted on a common shaft 28.

Because of the importance of the vertical and longitudinal positions of the beaters at various stages of the fabric formation cycle (as described more fully hereinafter), the mechanism for effecting the beater movement in the preferred embodiment of the present invention is an important feature thereof. As shown in FIG. 1, this mechanism comprises cams 24 and 26, mounted on common shaft 28, engaging cam rollers on

connecting members 12 and 20. Horizontal motion is imparted to beater 2 by virtue of the generally vertical displacement between fixed pivot point 22 of connecting member 20 and the cam roller mounted thereon. Similarly, vertical motion results from the horizontal displacement between fixed pivot point 14 of connecting member 12 and the cam roller mounted thereon.

A further feature of this mechanism is the parallelogram arrangement of linkage member 6, plate 8 and beater 2. The pivotal connection of parallel member 6 to plate 8, which is permitted to move only vertically, prevents any rotational movement of beater 2, thus maintaining beater members 4 in a downwardly directed orientation for optimum engagement of, and disengagement from, warp yarn lines and of the pick yarn.

At the beginning of alternate fabric formation cycles, traversing guide means 30, 32 and 34 advance upper warp yarn strands in the path  $W_A$ , by altering that path in a direction transverse thereto, a distance approximately equal to that between adjacent warp yarns at that point. Similar movement of warp yarn strands in the path  $W_B$  is effected by transversing guide means 30a, 32a and 34a at the beginning of intervening fabric formation cycles.

Tensioning means 36 is provided to maintain tension in the warp yarn strands when said yarn strands are in the shed unmade position, as shown in FIG. 1. Heddle means 38 are provided to form the shed by guiding the upper group of warp yarn strands downwardly and the lower group of the warp yarn strands upwardly.

Finally, there is seen in FIG. 1 the below beater system, which is substantially identical to the above beater described above, the below beater system including corresponding elements to those described with respect to the above beater, each having a reference numeral differing from that of the corresponding element by the addition of the letter *a* thereto.

FIGS. 2 and 3 show the essential elements of the apparatus of FIG. 1 in greater detail and in two significant stages of the fabric formation cycle, namely, prior to shed formation in one fabric formation cycle and after shed formation, in a successive fabric formation cycle, respectively.

FIG. 4 shows the paths of the beaters in the preferred forms of the present invention and FIG. 5 illustrates the relative position of the above and below beaters at any given point along their paths. It will be noted that both beaters move cyclically from a first rest position 1 and 10a, respectively, to a second rest position 1a and 10, respectively, and then back to the first rest position and that one beater is always at one rest position when the other beater is at the other rest position. Finally, it should be noted that both beaters pass through critical intermediate points at approximately 4 and 4a practically simultaneously. These critical intermediate points occur in the first stage of the beater beat up movement and the beater withdrawal movement and are preferably displaced primarily vertically from the preceding beater rest position.

Beater members 4 and 4a are located at the fell line (the line of previously formed fabric) in their second rest position 1a and 10 and, preferably, near (or longitudinally adjacent) the warp traversal means 30, 32, 34, 30a, 32a, 34a and shed forming means, i.e., heddles 38, at their first rest position 1 and 10a, respectively. Further, beater members 4 and 4a do not project

through the transverse planes of the warp yarn strands at first position 1 and 10a respectively, and the critical intermediate position 4a and 11 following the second rest position 10 and 1a. Beater members 4 and 4a do, however, project through said planes at the second rest position 1a and 10 and the remaining critical intermediate point 4 and 11a. The purpose of this arrangement is to hold the beater at the fell line as long as possible into the subsequent fabric formation cycle and then to withdraw it from the warp yarn strands quickly so as not to interfere with the advancement of the warp yarn intersections and the pick by the other beater. At the same time the other beater is inserted quickly into the warp yarn strands as the shed is formed to ensure proper alignment, to ensure that the beater enters the shed behind the pick which it must pick up, and to assist the shed formation action in advancing the warp yarn intersections ahead of the pick.

Referring now to FIG. 6, there is shown, in plan view, a triaxial fabric consisting of a first set of warp yarn strands  $W_A$ , a second set of warp yarn strands  $W_B$ , and transverse, woof yarn strands or picks P. Also seen are the beater positions B necessary for effective coordinated beat up of warp yarn intersections and picks. It will be noted that the warp yarn intersections are transversely off-set from one another in successive fabric formation cycles (each pick defining a fabric formation cycle).

To accomplish this transverse beater positioning, the beater members of the present invention and the warp yarn strands are disposed as follows. The warp yarn strands, in a conventional manner for triaxial fabric formation, extend longitudinally from a warp supply means disposed on a circularly moving mount and are divided into upper and lower warp yarn groups, the yarn strands in each of these groups being generally parallel and spaced equidistant from adjacent strands, the upper yarn strands being transversely disposed intermediate the lower yarn strands and vice versa. The parallel, downwardly extending beater members 4 are also spaced equidistant from adjacent members by a distance corresponding to that between adjacent warp yarn strands as are the parallel, the upwardly extending beater members 4a. Moreover, upper beater members 4 are transversely disposed intermediate lower beater members 4a and all of the beater members 4 and 4a define imaginary planes, in the course of their travel, as illustrated in FIG. 4. These imaginary planes are generally parallel to one another, perpendicular to the transverse planes of the warp yarn strands, the plane of each beater member also being disposed intermediate an upper and a lower warp yarn strand which are transversely adjacent one another.

The beaters are situated so that upon traversal by one set of warp yarn strands (either the upper or lower group), such as by transverse movement of 30, 32 and 34 or 30a, 32a and 34a, approximately a distance corresponding to the spacing between adjacent warp yarn strands in the group, each of the warp yarn strands thereof passes through first one and then a second imaginary plane defined by the paths of specific beater members, the beater member and associated beater defining the first of these planes being positioned at the time of warp yarn traversal in its second rest position and the beater member and associated beater defining the second of these planes being in its first rest position.



Following warp traversal by one of the groups of warp yarn strands in one transverse direction, the other group of warp yarn strands is traversed in the opposite direction in the subsequent fabric formation cycle. Means are also provided to transfer, following each warp traversal movement, the leading edge warp yarn strand from its group to the corresponding edge of the other group. Because these warp traversal and transfer means are not part of the present invention, they are not illustrated herein.

Operation of the improved machine of the present invention may best be described with reference to the schematic sequential drawings of FIGS. 7a to 7g wherein the primary mechanisms are shown for cam shaft positions of 0°, 20°, 30°, 122 ½°, 127 ½°, 135° and 180° thus defining a single fabric formation cycle. (Alternate fabric formation cycles, with the cam shaft rotating from 180° to 360° differ only in that the opposite beater and warp traversing means are involved).

The fabric formation cycle begins with beater members 4 in the first rest position and beater members 4a in the second rest position and upper yarn strands W<sub>A</sub> and lower yarn strands W<sub>B</sub> in their respective shed unmade positions. At this point warp traversal of upper warp yarn strands W<sub>A</sub> is accomplished by transverse movement of guides 30, 32 and 34 one warp yarn space and transfer of the leading edge strand (the strand on the edge of the group toward which the traverse movement is directed) to the corresponding edge of the lower yarn strands W<sub>B</sub>.

Heddles 38 then function to form the shed, as shown in FIGS. 7 (b) and 7(c), in so doing advancing the transverse intersection of adjacent upper and lower warp yarn strands, caused by the warp traverse movement, toward the fell line and beater 4a. As the shed reaches its fully formed position, and the pick is inserted, FIG. 7 (d), beater members 4 and 4a begin their movement induced by the beater control means, or more specifically, the cam shaft, cams and linkage described above, quickly passing through the critical intermediate positions which are preferably primarily vertically displaced from their preceding rest positions, to the positions shown in FIG. 7 (e) wherein beater members 4a are withdrawn from the warp yarn strands and beater members 4 are extended through the shed and are advancing pick P and the warp yarn intersections which precede it toward the fell line while also combing warp yarns W<sub>A</sub> and W<sub>B</sub>. At the completion of the fabric formation cycle, FIG. 7 (g), the beater motion is complete and lower warp yarn strands W<sub>B</sub> are seated in traversing guides 30a, 32a and 34a ready for the traversal movement at the start of the next cycle.

While this invention has been described with reference to specific embodiments thereof, it should be understood that various other embodiments and modifications, all within the true spirit and scope of the present invention, may be developed by those skilled in the art. Similarly, functionally similar mechanisms may be substituted for those shown and the overall disposition of the machine, with respect to horizontal and vertical directions, may be varied. Still further the warp yarn strands may be transversely spread, at the point where shed formation, warp traversal and beater insertion is accomplished, and convergent from that point to the fell line. Such a configuration may facilitate beater insertion and guide, heddle and warp yarn strand align-

ment. A variety of other similar changes will be apparent to those skilled in the art.

It should also be noted that while this invention has been described with reference to the formation of a particular triaxial fabric, many of the elements of this invention, as well as the inventive concept itself, may be adapted to facilitate formation of other fabrics, particularly triaxial configurations such as those disclosed both generally and specifically in the U.S. Pat. No. 3,446,251.

We claim:

1. In a machine for forming triaxial fabric consisting of:

- a. means for supplying a plurality of warp yarn strands said strands being divided into upper and lower groups, the strands in each of said groups being generally parallel and equally spaced from adjacent strands, the strands of said upper group being transversely spaced intermediate the positions of said strands of said lower group, said warp yarn strands extending longitudinally from said supply means to a fell line at which is located a fabric take-up means,
- b. means for transversely advancing first one of said warp strand groups, a distance equal to the spacing between adjacent yarn strands in a given transverse direction and then the other of said warp strand groups at the point of supply thereof the same distance in the opposite direction,
- c. means for transferring, following each such transverse movement, a yarn strand from the edge of said transversely moved yarn strand group toward which said transverse movement occurs to the corresponding edge of the other yarn strand group, and
- d. means, following each such transverse movement and yarn strand transfer, for altering the paths of said warp yarn strands at a particular longitudinal position by guiding said lower yarn strands upwardly and said upper yarn strands downwardly to form a shed and for inserting a wool yarn strand in said shed transverse of said warp yarn supply strands,
- e. the improvement consisting of a beat up means for stabilizing fabric produced in said machine, said beat up means consisting of
  - i. an above beater, disposed above and transverse of said warp yarn strands, comprising a plurality of parallel downwardly extending members, said members being spaced from adjacent members by a distance corresponding to that between adjacent warp yarn strands in said warp yarn strand groups, said above beater further including an above beater control means for moving said above beater from a first rest position through a first intermediate position to a second rest position, at the fell line, and thence through a second intermediate position back to said first rest position in a predetermined path,
  - ii. a below beater, disposed below and transverse of said warp yarn strands, comprising a plurality of parallel upwardly extending members, said members being transversely spaced intermediate the transverse positions of said above beater members, said below beater further including a below beater control means for moving said below beater from a first rest position through a first in-

intermediate position to a second rest position, at the fell line, and thence through a second intermediate position back to said first rest position in a predetermined path, the paths of all of said members of said above and said below beaters lying in imaginary planes generally parallel to each other and to said warp yarn strands, said beater members extending through said warp yarn strands in said first intermediate position and in said second rest position and not extending through said warp yarn strands in said first rest position and said second intermediate position,

iii. said above and below beaters being positioned such that in the transverse movement of said groups of warp yarn strands, each of said strands of said transversely moving group passes first through one of said imaginary planes defined by the path of one beater member of one of said beaters, which beater is in the second rest position thereof at the time of said transverse movement, and second through another of said imaginary planes defined by the path of a second beater member of the other of said beaters, the other of said beaters being in said first rest position at the time of said transverse movement and until said shed formation,

iv. said beater control means adapted to move said above beater from said first rest position to said first intermediate position to said second rest position to said second intermediate position and thence back to said first rest position simultaneously with the movement of said below beater from said second rest position through said second intermediate first rest and first intermediate position and back to said second rest position, said beaters reaching said intermediate positions simultaneously as said shed is formed.

2. An improved machine for forming triaxial fabric, as recited in claim 1, wherein the path of said beaters from said rest positions to said intermediate positions is primarily vertical.

3. An improved machine for forming triaxial fabric, as recited in claim 1, wherein said first rest position of said beaters is located longitudinally adjacent said warp traverse means.

4. An improved machine for forming triaxial fabric, as recited in claim 1, wherein said beater control means comprise paired cams on a common shaft engaging separate cam rollers mounted on separate connecting members, said cam rollers being urged toward said cams, the first of said connecting members being (I) pivotally connected at a first fixed point displaced vertically from the cam roller mounted thereon and (II) pivotally connected to said beater, the second of said connecting members being (III) pivotally connected at a second fixed point displaced horizontally from the cam roller mounted thereon and (IV) pivotally connected to said beater.

5. An improved machine for forming triaxial fabric, as recited in claim 4, wherein said beater is directly attached to parallel third and fourth connecting members which are in turn connected, pivotally, at their opposite ends to a plate member movable in the vertical direction only, said plate member being pivotally connected to said second connecting member and both of said third and fourth connecting members being pivotally connected to a horizontal fifth connecting member in turn pivotally connected to said first connecting member.

6. In a machine for forming triaxial fabric consisting of

a. means for supplying a plurality of warp yarn strands from a supply source thereof to a fell line at which said warp yarn strands are formed into triaxial fabric,

b. means for selectively transversely displacing some of said warp yarn strands relative to other of said warp yarn strands such as to produce intersections between said transversely moved groups of strands as viewed in plan view,

c. means, activated following activation of said warp transversal means, for selectively temporarily displacing at least some of said warp yarn strands at a point along the length thereof, relative to other of said warp yarn strands so as to form a weaving shed therein, and

d. means for inserting a weft yarn strand into said weaving shed in a path generally perpendicular to said warp yarn strands,

e. the improvement consisting of

i. an above beater, disposed above and transverse of said warp yarn strands, comprising a plurality of parallel downwardly extending members,

ii. a below beater, disposed below and transverse of said warp yarn strands, comprising a plurality of parallel upwardly extending members,

iii. said upwardly extending members of said below beater being transversely displaced from said downwardly extending members of said above beaters so as to prevent interference therebetween, and

iv. beater control means for alternately causing one and then the other of said beaters to be moved along said warp yarn strands to said fell line, with the extending members extending between adjacent warp yarn strands and behind said weft yarn, to remain at said fell line until the next subsequent beater movement of the alternate beater is initiated and then to be moved back to its starting position and beater actuation means for actuating said beater control means following actuation of said shed forming means whereby said beater causes both said weft yarn strand and said intersecting warp yarns to be snugly compacted simultaneously at the fell line.

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