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**United States Patent**  
**Kulczycki**

**4,046,173**  
**September 6, 1977**

Triaxial weaving machine with heddle shedding means

**Abstract**

A triaxial fabric weaving machine in which a plurality of elongate heddles for guiding warp yarns are arranged in weftwise rows and are shifted weftwise of the rows to thereby move the warp strands from one weftwise location to another. During weaving, heddles are supported by stationary guides and are moved longitudinally relative to the stationary guides for forming the warp strands into warp sheds in which wefts are inserted.

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**Current U.S. Class:** **139/48; 139/DIG1**  
**Intern'l Class:** D03C 013/00  
**Field of Search:** 139/11,46,48,54,DIG. 1

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## *Claims*

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That which is claimed is:

1. A weaving machine for making triaxial fabrics comprising a plurality of elongate heddles arranged in weftwise rows for guiding warp strands, each of said heddles having cutout means therein adapted to be engaged for imparting longitudinal movement thereto; means for shifting said heddles weftwise; stationary means extending weftwise of the weaving machine for guidingly supporting said heddles in said weftwise rows; and means movable to and from extended and retracted positions relative to said stationary means and engaging said cutout means of said heddles for moving said heddles longitudinally of themselves across said stationary means to and from extended and retracted positions for forming warp strands guided thereby into warp sheds.
2. A weaving machine according to claim 1 wherein said stationary means cooperates with said heddles for arranging said heddles in at least two substantially opposing rows.
3. A weaving machine according to claim 1 wherein said stationary means cooperates with said heddles for arranging said heddles in at least two rows spaced warpwise one from another.
4. A weaving machine according to claim 1 wherein said stationary means cooperates with said heddles for arranging said heddles in at least two rows and comprises first and second weftwise elongated guide means for respectively engaging heddles common to a first row and heddles common to a second row and further wherein said cutout engaging means comprises first and second weftwise elongated shedding bar members mounted for movement adjacent corresponding ones of said guide means for respectively engaging heddles common to the first row and heddles common to the second row.
5. A weaving machine according to claim 1 wherein each of said heddles has a longitudinal side edge and further wherein said stationary means comprises elongate plate means extending weftwise for slideable engagement with said longitudinal side edges of heddles in a common weftwise row.
6. A weaving machine according to claim 1 wherein each of said heddles has shoulder means formed thereon and further wherein said stationary means comprises a plurality of separator means spaced weftwise for guidingly receiving therebetween said shoulder means of heddles in a common weftwise row and for arranging said heddles in a parallel, weftwise spaced apart array.
7. A weaving machine for making triaxial fabrics comprising a plurality of elongate heddles for guiding warp strands, each of said heddles having a nose portion with a warp strand guide opening therethrough and at least a medial portion with a longitudinal side edge and cutout means therein adapted to be engaged for imparting longitudinal movement thereto; stationary means extending weftwise of the weaving machine for guidingly engaging said medial portions of said heddles and for arranging said heddles in at least two weftwise rows; shedding bar means including first and second bars mounted adjacent said stationary means for respectively engaging said cutout means of heddles in a first row and said cutout means of heddles in a second row; and drive means for moving said shedding bar means relative to said stationary means for thereby moving said heddles longitudinally of themselves across said stationary means to and from extended and retracted open shed positions and forming warp strands guided thereby into warp sheds.
8. A weaving machine according to claim 7 wherein said stationary means comprises elongate plate means extending weftwise for slideable engagement with heddles in a common weftwise row, and separator means

spaced warpwise from said plate means and spaced weftwise for guidingly receiving therebetween heddles in a common weftwise row, said stationary means arranging heddles in a common weftwise row in a parallel, weftwise spaced apart array.

9. A weaving machine according to claim 7 wherein said each of said first and second bars engages all those heddles common to the respective one of said rows.

10. A weaving machine according to claim 7 further comprising means for moving those heddles common to a respective one of said rows in unison weftwise along the corresponding one of said first and second bars, said shedding bar means and said means for moving heddles weftwise maintaining engagement of said bars and said cutout means during unison weftwise movement of heddles.

11. A weaving machine according to claim 10 wherein said means for moving heddles weftwise is operatively connected with said drive means for weftwise movement of heddles in timed relation with movement of said shedding bar means and while said heddles are in retracted open shed position.

12. A weaving machine for making triaxial fabrics comprising a plurality of elongate strip material heddles for guiding warp strands, each of said heddles having a nose portion with a warp strand guide opening therethrough and a rear portion remote from said nose portion and with a hookshaped projection defining a laterally opening cutout therein; stationary means for engaging said heddles medially of said nose portions and said rear portions and for arranging said heddles in at least two substantially opposing weftwise rows; shedding bar means including first and second ribbed bars mounted adjacent said stationary means for respectively engaging said cutouts of heddles in a first row and said cutouts of heddles in a second row; means for moving said shedding bar means relative to said stationary means for thereby moving said heddles longitudinally to and from extended and retracted open shed positions and forming warp strands guided thereby into warp sheds; means for moving heddles weftwise relative to said stationary means in timed relation with movement of said shedding bar means and while said heddles are in retracted open shed position; and means for transferring heddles from one end of one of said ribbed bars to an adjacent end of the other of said ribbed bars.

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### *Description*

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This invention relates to triaxial fabric weaving machines in which warp strands are guided by heddles arranged in weftwise rows and which are provided with means for moving heddles longitudinally and thereby forming the warp strands into warp sheds in which wefts are inserted.

More particularly, this invention relates to triaxial fabric weaving machines having elongate heddles shifted weftwise for moving warp strands guided thereby from one weftwise location to another. While triaxial weaving machines of this general type have been proposed heretofore, such proposals have suffered deficiencies with respect to supporting and guiding heddles in longitudinal shed forming movement while accommodating weftwise shifting of the heddles and maintenance of the heddles in predetermined spaced relation.

With the foregoing in mind, it is an object of the present invention to engage elongate heddles with stationary supports for guiding weftwise rows of heddles during longitudinal movement thereof to form warp strands guided thereby into warp sheds. In realizing this object of the present invention, certain difficulties and deficiencies of prior proposed triaxial fabric weaving machines are overcome in that the weaving machine of this invention accommodates movement of warp strands from one weftwise position to another while positively supporting heddles during longitudinal movement as warp sheds are formed.

A further object of this invention is to positively control positioning of a plurality of elongate heddles in a desired array of at least two weftwise rows in a triaxial fabric weaving machine, so as to control positioning of warp yarns during warp shed formation. In realizing this object of the present invention, stationary means engage medial portions of heddles and arrange the heddles in the predetermined array, while shedding bars mounted adjacent the stationary means engage the heddles common to respective rows and are moved relative to the stationary means for thereby moving the heddles longitudinally of themselves across the stationary means and to and from extended and retracted open shed positions.

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

FIG. 1 is a schematic top plan view of a triaxial weaving machine in accordance with this invention;

FIG. 2 is a fragmentary end elevation view of the weaving machine of FIG. 1;

FIG. 3 is an enlarged perspective view, partly broken away, of portions of the weaving machine of FIGS. 1 and 2, particularly illustrating certain drive mechanisms;

FIG. 4 is a view similar to FIG. 3 illustrating additional drive mechanisms;

FIG. 5 is a perspective view of a heddle as used in the arrangements of FIGS. 1-4; and

FIG. 6 is an enlarged elevation view, partially in section, taken generally along the line 6--6 in FIG. 2.

Referring more specifically to the drawings, a weaving machine embodying the present invention has a plurality of elongate heddles arranged in weftwise rows for guiding, and forming warp sheds of, respective warp strands S (FIG. 2). The weaving machine may include any desired number of weftwise rows of heddles, just so long as at least one such row of heddles is provided on each side of the machine. By way of illustration, four weftwise rows of heddles A, A', B, B' are shown in FIG. 2. The upper rows A, A' constitute a first set or pair of substantially opposing weftwise rows of heddles, and the lower rows B, B' constitute a second set or pair of substantially opposing weftwise rows of heddles, with the two sets of heddles A, A', B, B' being disposed warpwise of each other. More specifically, it will be observed in FIG. 2 that the lower pair of substantially opposing weftwise rows of heddles B, B' are disposed closely adjacent to and in the direction of the fell 16 or downstream of the other pair of weftwise rows of heddles A, A'.

For the purposes of this disclosure, the left-hand weftwise rows of heddles A, B in FIGS. 1 and 2 will be referred to herein as the first rows in the respective first and second sets, and the right-hand weftwise rows of heddles A', B' will be referred to herein as the second rows in the respective first and second sets. It will be noted that both of the first rows of heddles A, B are supported adjacent one side of the path of the warp strands S to the fell 16 of the triaxial fabric F being woven, and both of the second rows of heddles A', B' are supported adjacent the other side of such path of the warp strands to the fell of the fabric being woven.

As is preferred, in the illustrated embodiment of the invention the weftwise rows of heddles occupy a substantially horizontal position with the heddles being moved horizontally during longitudinal shedding movements thereof. Consequently, a weft inserting means 17 inserts wefts in sheds being formed of the warp strands S in a horizontal plane and on a level spaced substantially below the level of the rows of heddles. Also, the fell 16 of the triaxial fabric F, being woven from the warp strands S and the wefts, extends substantially horizontally and is spaced substantially below the level of the rows of heddles A, A', B, B'. Thus, the fabric F at the fell 16 thereof moves downwardly in a substantially vertical path during weaving. Suitable beating-up means

serves to beat-up each successive inserted weft against the fell 16 and operates in timed relation to the operation of the rows of heddles A, A', B, B' and the weft inserting means, as is well known. An example of a suitable beating-up means is disclosed in Dow et al U.S. Pat. No. 3,799,209. Accordingly, a further more detailed description of the beating-up means is deemed unnecessary.

Although the rows of heddles, the supporting and controlling mechanisms therefor, and the fell 16 of the fabric F are illustrated as occupying horizontal positions, it is to be understood that they may occupy any desired position, such that the direction of movement of the fabric at the fell 16 during weaving may be in the upward direction or the horizontal direction or in any desired angular direction, without departing from the invention.

Each heddle may be of substantially the type disclosed in copending application Ser. No. 582,246, filed May 30, 1975 and owned in common with the present invention. Accordingly, it will be observed in FIG. 5 that each heddle is of elongate form; of relatively thin strip material and comprises an elongate body portion 21 of predetermined width, with an elongate narrow, reduced width frontal portion 22 extending forwardly from body portion 21. The reduced width frontal portion 22 may be about one-half as wide as body portion 21 and terminates in a substantially rounded or substantially semicircularly-shaped nose portion defining the front end of the respective heddle. Each heddle has a strand guide opening or eye 24 through the nose portion thereof for guidingly engaging the respective warp strand S. Thus, it will be observed in FIG. 2 that the warp strands S extend through the respective heddles to the fell 16 of the triaxial fabric being woven. The warp strands may be directed to the heddles from a suitable supply source, not shown, remote from the rows of heddles A, A', B, B'.

The heddles in each row A, A', B, B' may be arranged in any desired spaced relationship. It is preferred, however, that the distance between immediately adjacent heddles in each row is at least about equal to the thickness of each heddle so as to accommodate passage of the warp strands S through the heddles of each respective row and between those heddles which are immediately adjacent warpwise of the heddles through which particular warp strands extend. For this reason it also is preferred that the heddles in the upper rows A, A' be staggered weftwise relative to heddles in the lower rows B, B'. Desirably, the heddles are quite thin and the distance between immediately adjacent heddles in each weftwise row is about the same as the thickness of each heddle so as to permit weaving triaxial fabrics of high density from fine warp strands. Many of the heddles are omitted from each row in FIGS. 1, 3 and 4 for purposes of clarity.

In the particular illustrated embodiment, the heddles in the first rows A, B are disposed in offset relation with the respective heddles in the second rows A', B' and the heddles in the first set A, A' are also offset relative to the heddles in the second set B, B' (FIG. 6). Thus whenever any one of the rows of the heddles occupies an extended position, the substantially opposing row in the respective pair may occupy either a retracted position or an extended position. Such an arrangement accommodates production of a variety of forms of triaxial fabrics. Although the illustrated embodiment has the heddles of each row offset with relation to the heddles in other rows, it is to be understood that the heddles in each row may occupy a different position from that described with respect to the heddles in the other rows without departing from this invention.

Referring again to FIG. 5, it is preferred that the opposite longitudinal side edges of the heddle extend substantially parallel to each other and, since the elongate frontal portion 22 is of substantially less width than the body portion 21, the body portion defines a projecting shoulder portion on the heddle, which shoulder portion is adapted to be engaged by a shifting bar of a heddle shifting means for shifting each respective row of heddles weftwise during operation of the weaving machine. Each heddle also is provided with means adapted to be engaged for imparting longitudinal shedding movements thereto. To this end, the rear portion of each heddle, remote from the frontal portion 22 thereof, is provided with a laterally opening cutout 25 partially defined by a hook-shaped projection 26 on the rear end of the body portion 21 of each heddle.

As shown in FIGS. 2 through 4, the cutouts 25 in heddles of each row A, A', B, B' are engaged by an elongate rib 31a of a respective shedding means 31, there being one of the shedding means 31 for moving each respective weftwise row of heddles A, A', B, B' longitudinally between the retracted position shown in solid lines in FIG. 2 and the extended position represented by rows A', B shown in broken lines in FIG. 2. In this regard, it will be noted that the proximal longitudinal side edges of the heddles common to respective ones of the first rows A, B slide against the respective upper and lower surfaces of a first stationary guide plate 32, and the proximal longitudinal edges of the heddles common to respective ones of the second rows A', B' slide against the respective upper and lower surfaces of a second stationary guide plate 32'. The stationary guide plates 32, 32' extend weftwise for a distance about equal to the width of the triaxial fabric F and the proximal edges of plates 32, 32' are spaced apart from each other (FIG. 1) to provide an adequate opening for the passage of the warp strands S therethrough and for the formation of the warp sheds thereof with the warp strand guide openings 24 in the heddles positioned forwardly beyond the proximal edges of the guide plates 32, 32'.

Each warp shedding means 31 may include a weftwise extending heddle shedding bar 31b, each of which is movable forwardly and rearwardly to and from extended and retracted positions relative to stationary means including the guide plates 32, 32' according to a predetermined pattern. Each bar 31b has an elongate weftwise extending projection or rib 31a thereon for engaging the cutouts 25 and hook-shaped projections 26 (FIGS. 2 through 4) of heddles common to a respective one of the rows of heddles A, A', B, B'. It is to be noted that the heddles in rows A, B are being moved from left to right and the heddles in rows A', B' are being moved from right to left in FIG. 2 whenever they are being moved forwardly to extended open shed positions. Also, whenever the heddles are being moved to the retracted open shed positions shown in solid lines in FIG. 2, the heddles are being moved rearwardly.

For the control of the heddles during formation of warp sheds and for shifting the heddles weftwise, means defining passageways are provided for guiding each row of heddles A, B, A', B'. The passageway defining means includes fixed means respectively designated at 34a, 34b, 34a', 34b', and movable means respectively designated at 35a, 35b, 35a', 35b'.

Each fixed means 34a, 34b, 34a', 34b' defines first passageway portions for guidingly receiving heddles upon warp shed forming movement thereof toward one of an extended position and a retracted position and may take the form of an elongate weftwise guide member or bar 40 (FIGS. 1 through 4) suitably supported so that its surface facing toward the corresponding guide plate 32, 32' is spaced from such guide plate a distance somewhat greater than the width of the reduced width frontal portions 22 (FIG. 5) of the corresponding heddles. The surface of each guide bar 40 adjacent the corresponding stationary guide plate 32, 32' is in the form of a plurality of projecting separators or wall members defining a weftwise row of passageways 41 (FIG. 4) for guiding the respective heddles in movement from and to the aforementioned open shed retracted and extended positions. The fixed passageway defining means 34a, 34b, 34a', 34b' and the plates 32, 32' together provide stationary means extending weftwise of the weaving machine for engaging medial portions of heddles and for guidingly supporting and arranging the engaged heddles in predetermined array in the weftwise rows. Heddles are moved longitudinally of themselves and across the stationary means by operation of the shedding bars as described above.

The movable means 35a, 35a', 35b, 35b' define second passageway portions for guidingly receiving heddles upon shedding movement thereof toward the other of the extended and retracted positions and are provided for moving the respective rows of heddles A, A', B, B' and warp strands S engaged thereby weftwise during weaving so as to shift each heddle in each row from one passageway to another and thereby move the warp strands from one weftwise location to another so that the warp strands may extend obliquely with respect to the wefts. Accordingly, each movable means comprises an elongate weftwise extending and weftwise movable

heddle shifting member or bar 45 positioned rearwardly of and in sliding engagement with, or in close proximity to, the respective heddle guide bar 40. Each heddle shifting bar 45 is provided with a weftwise row of closely spaced forwardly and rearwardly extending separators or wall members to define a weftwise row of passageways (similar to the fixed passageways 41) for guidingly receiving therein the shoulder portions defined by the body portions 21 (FIGS. 2 through 5) on the heddles in the respective row. The surfaces of the heddle shifting bars 45 facing toward the stationary guide plates 32, 32' are spaced from such guide plates to accommodate the shedding movements of the respective heddle shedding bars 31b in the space between bars 45 and plates 32, 32'.

Suitable control means 47 is shown schematically in the form of a block (FIG. 2) operatively connected to each heddle shifting bar 45 for imparting an active weftwise shifting movement or stroke to each heddle shifting bar 45 following each of, or certain of, the rearward or retracting movements of the respective shedding bars 31b. It is to be understood that successive active weftwise strokes of each heddle shifting bar 45 may be effected selectively in either weftwise direction with each such active stroke being effected for a distance substantially equal to an integral multiple of the distance between the centers of adjacent passageways 41. Such weftwise movement of the heddle shifting bars normally aligns the movable second passageway portions with the fixed first passageway portions so that the portions cooperate in guidingly receiving the heddles during their longitudinal movement. As to weftwise movement of heddles, the sum of all of the active weftwise strokes of each heddle shifting bar 45 normally makes the heddles in any given row subject to being transferred away from the same end of such given row to the adjacent end of another of the rows of heddles. Transfer means 50, 50' for accomplishing such movement has been indicated by blocks in FIG. 1, but forms no major portion of this invention and is subject to separate protection and accordingly is not here described in detail.

In the illustrated embodiment of the present invention it is to be assumed that successive heddles in the two first rows A, B are delivered to the ends of the rows A, B nearest the observer in FIG. 2 and that the successive delivered heddles are transferred by a first transfer means 50 to the adjacent ends of the respective second substantially opposing rows A', B'. Of course, it is apparent that the successive heddles are delivered to the other leading ends of the latter rows A', B' and are transferred to the adjacent trailing ends of the two first rows of heddles A, B by a second transfer means 50'. In any event, it is preferred that the control means 47 for each heddle shifting bar 45 imparts an inactive stroke to the respective heddle shifting bar 45 for returning the same to its original position following each active stroke thereof.

Following each active weftwise stroke of each heddle shifting bar 45, it is to be understood that the respective shedding means 31 moves all the heddles in the respective row forwardly to extended position so as to move the body portions 21 of the corresponding heddles forwardly out of engagement with the passageways in the respective heddle shifting bars 45, thus permitting the heddle shifting bars 45 to return to their original positions in an inactive stroke thereof without then being encumbered by, or imparting weftwise movement to, the respective heddles.

Suitable drive means for the heddle shifting bars 45 and the shedding means 31 may take the form illustrated in FIGS. 3 and 4, where a main drive shaft 51 has a plurality of control cams mounted thereon for operating corresponding cam follower arms. In driving the heddle shifting bars 45, a cam following crank arm 52 (FIG. 3) engages the surface of a cam 54 driven by a geared connection to the shaft 51. Oscillating movement of the follower arm 52 (indicated by arrows in FIG. 3) drives a connecting rod 55 and pivots a bell crank 56 mounted on a stationary portion of the weaving machine (as again indicated by arrows in FIG. 3). The end of the bell crank 56 remote from connection with the rod 55 is suitably connected with the bar 45 for row A' of heddles. As illustrated in FIG. 4, a similar arrangement of a follower arm 52, cam 64, connecting rod 65 and bell crank 66 drives the heddle shifting bar 45 for heddle row B'.

Longitudinal movement of the heddles is accomplished by operation of pairs of cams 71, 72, 73, 74 which cooperate with respective follower cranks 76, 77 to reciprocate drive links 78, 79 suitably connected with the shedding bars 31b.

In the drawings and specification, there has been set forth a predetermined embodiment 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.

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- [54] TRIAXIAL WEAVING MACHINE WITH HEDDLE SHEDDING MEANS 3,042,081 7/1962 MacIsaac ..... 139/46  
3,965,939 6/1976 Kulczycki et al. .... 139/DIG. 1
- [75] Inventor: Karol Kulczycki, Parsippany, N.J.
- [73] Assignee: Barber-Colman Company, Rockford, Ill.
- [21] Appl. No.: 687,012
- [22] Filed: May 17, 1976
- [51] Int. Cl.<sup>2</sup> ..... D03C 13/00
- [52] U.S. Cl. .... 139/48; 139/DIG. 1
- [58] Field of Search ..... 139/11, 46, 48, 54, 139/DIG. 1

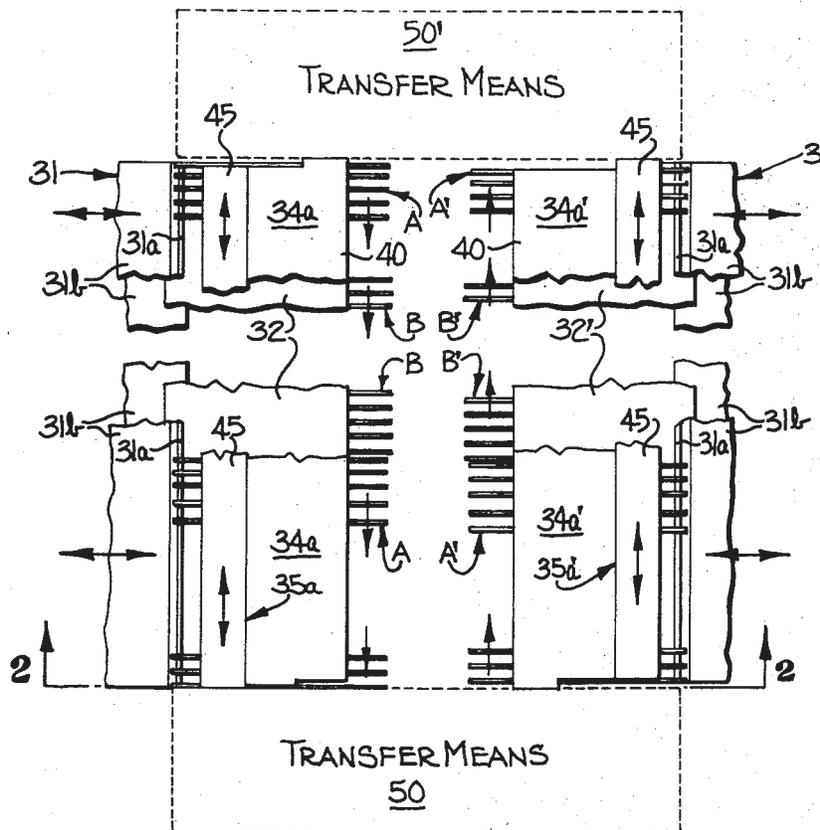
Primary Examiner—Henry S. Jaudon  
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[57] ABSTRACT

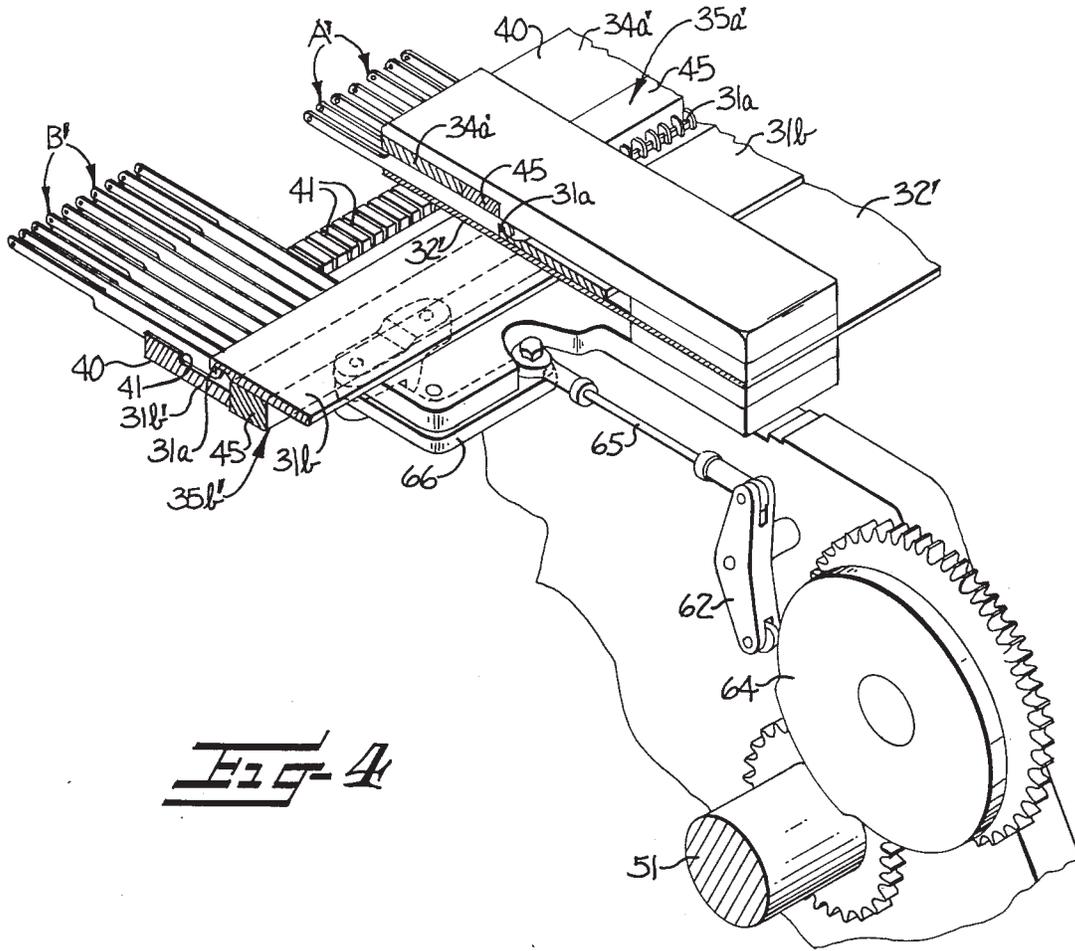
A triaxial fabric weaving machine in which a plurality of elongate heddles for guiding warp yarns are arranged in weftwise rows and are shifted weftwise of the rows to thereby move the warp strands from one weftwise location to another. During weaving, heddles are supported by stationary guides and are moved longitudinally relative to the stationary guides for forming the warp strands into warp sheds in which wefts are inserted.

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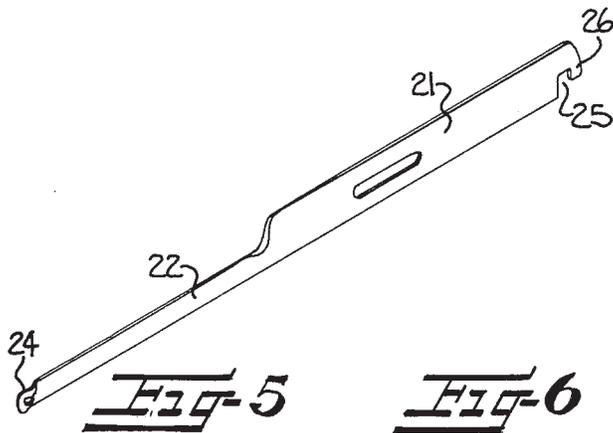
12 Claims, 6 Drawing Figures



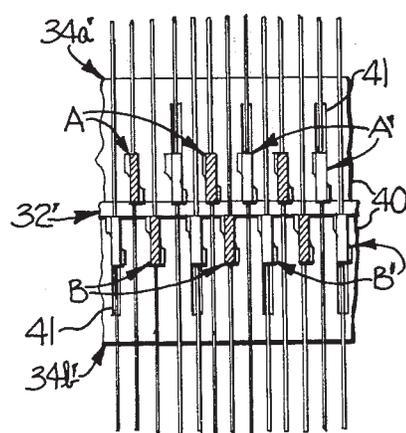




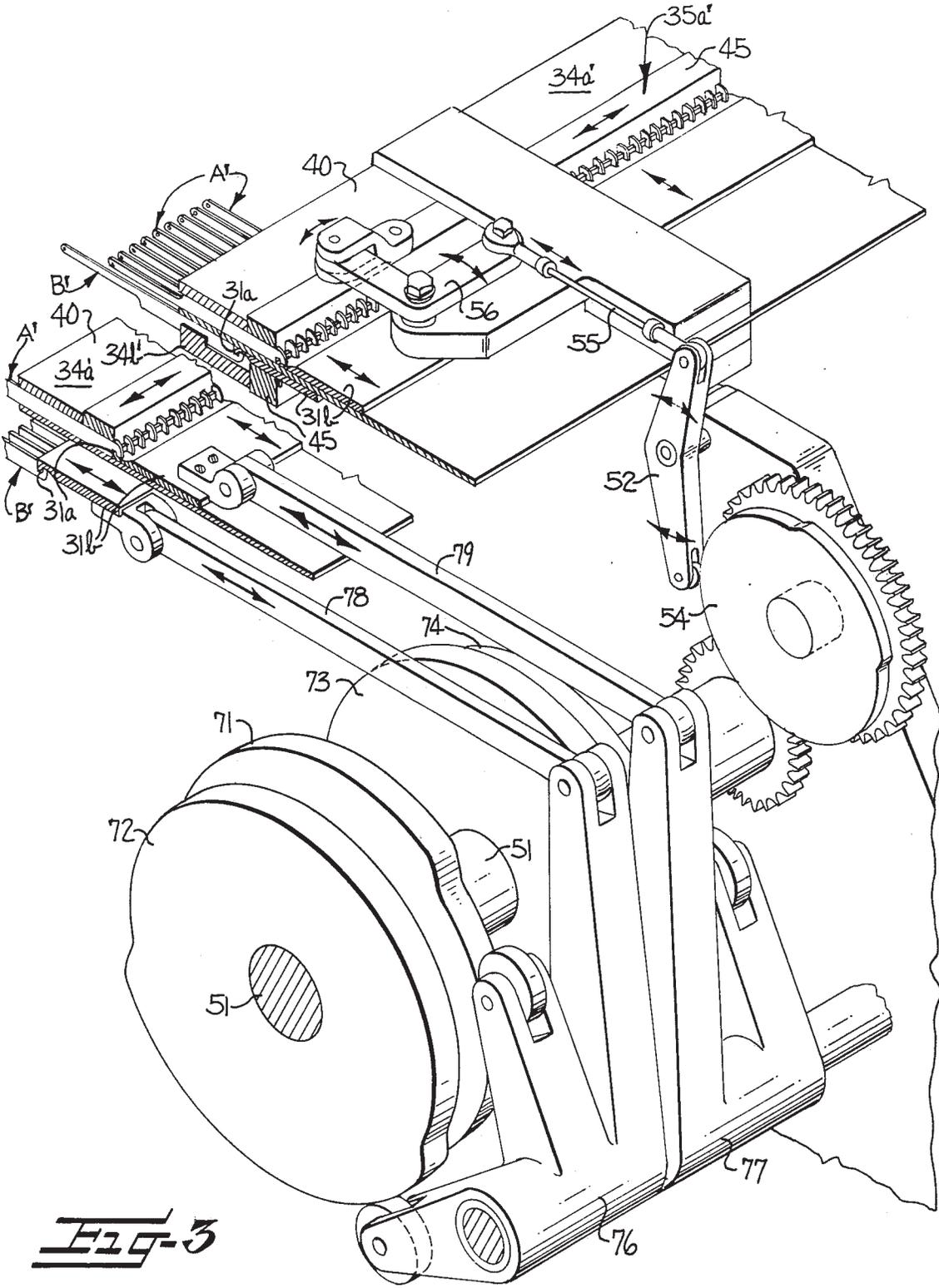
**Fig-4**



**Fig-5**



**Fig-6**



**FIG-3**

## TRIAxIAL WEAVING MACHINE WITH HEDDLE SHEDDING MEANS

This invention relates to triaxial fabric weaving machines in which warp strands are guided by heddles arranged in weftwise rows and which are provided with means for moving heddles longitudinally and thereby forming the warp strands into warp sheds in which wefts are inserted.

More particularly, this invention relates to triaxial fabric weaving machines having elongate heddles shifted weftwise for moving warp strands guided thereby from one weftwise location to another. While triaxial weaving machines of this general type have been proposed heretofore, such proposals have suffered deficiencies with respect to supporting and guiding heddles in longitudinal shed forming movement while accommodating weftwise shifting of the heddles and maintenance of the heddles in predetermined spaced relation.

With the foregoing in mind, it is an object of the present invention to engage elongate heddles with stationary supports for guiding weftwise rows of heddles during longitudinal movement thereof to form warp strands guided thereby into warp sheds. In realizing this object of the present invention, certain difficulties and deficiencies of prior proposed triaxial fabric weaving machines are overcome in that the weaving machine of this invention accommodates movement of warp strands from one weftwise position to another while positively supporting heddles during longitudinal movement as warp sheds are formed.

A further object of this invention is to positively control positioning of a plurality of elongate heddles in a desired array of at least two weftwise rows in a triaxial fabric weaving machine, so as to control positioning of warp yarns during warp shed formation. In realizing this object of the present invention, stationary means engage medial portions of heddles and arrange the heddles in the predetermined array, while shedding bars mounted adjacent the stationary means engage the heddles common to respective rows and are moved relative to the stationary means for thereby moving the heddles longitudinally of themselves across the stationary means and to and from extended and retracted open shed positions.

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

FIG. 1 is a schematic top plan view of a triaxial weaving machine in accordance with this invention;

FIG. 2 is a fragmentary end elevation view of the weaving machine of FIG. 1;

FIG. 3 is an enlarged perspective view, partly broken away, of portions of the weaving machine of FIGS. 1 and 2, particularly illustrating certain drive mechanisms;

FIG. 4 is a view similar to FIG. 3 illustrating additional drive mechanisms;

FIG. 5 is a perspective view of a heddle as used in the arrangements of FIGS. 1-4; and

FIG. 6 is an enlarged elevation view, partially in section, taken generally along the line 6-6 in FIG. 2.

Referring more specifically to the drawings, a weaving machine embodying the present invention has a plurality of elongate heddles arranged in weftwise rows for guiding, and forming warp sheds of, respective warp

strands S (FIG. 2). The weaving machine may include any desired number of weftwise rows of heddles, just so long as at least one such row of heddles is provided on each side of the machine. By way of illustration, four weftwise rows of heddles A, A', B, B' are shown in FIG. 2. The upper rows A, A' constitute a first set or pair of substantially opposing weftwise rows of heddles, and the lower rows B, B' constitute a second set or pair of substantially opposing weftwise rows of heddles, with the two sets of heddles A, A', B, B' being disposed warpwise of each other. More specifically, it will be observed in FIG. 2 that the lower pair of substantially opposing weftwise rows of heddles B, B' are disposed closely adjacent to and in the direction of the fell 16 or downstream of the other pair of weftwise rows of heddles A, A'.

For the purposes of this disclosure, the left-hand weftwise rows of heddles A, B in FIGS. 1 and 2 will be referred to herein as the first rows in the respective first and second sets, and the right-hand weftwise rows of heddles A', B' will be referred to herein as the second rows in the respective first and second sets. It will be noted that both of the first rows of heddles A, B are supported adjacent one side of the path of the warp strands S to the fell 16 of the triaxial fabric F being woven, and both of the second rows of heddles A', B' are supported adjacent the other side of such path of the warp strands to the fell of the fabric being woven.

As is preferred, in the illustrated embodiment of the invention the weftwise rows of heddles occupy a substantially horizontal position with the heddles being moved horizontally during longitudinal shedding movements thereof. Consequently, a weft inserting means 17 inserts wefts in sheds being formed of the warp strands S in a horizontal plane and on a level spaced substantially below the level of the rows of heddles. Also, the fell 16 of the triaxial fabric F, being woven from the warp strands S and the wefts, extends substantially horizontally and is spaced substantially below the level of the rows of heddles A, A', B, B'. Thus, the fabric F at the fell 16 thereof moves downwardly in a substantially vertical path during weaving. Suitable beating-up means serves to beat-up each successive inserted weft against the fell 16 and operates in timed relation to the operation of the rows of heddles A, A', B, B' and the weft inserting means, as is well known. An example of a suitable beating-up means is disclosed in Dow et al U.S. Pat. No. 3,799,209. Accordingly, a further more detailed description of the beating-up means is deemed unnecessary.

Although the rows of heddles, the supporting and controlling mechanisms therefor, and the fell 16 of the fabric F are illustrated as occupying horizontal positions, it is to be understood that they may occupy any desired position, such that the direction of movement of the fabric at the fell 16 during weaving may be in the upward direction or the horizontal direction or in any desired angular direction, without departing from the invention.

Each heddle may be of substantially the type disclosed in copending application Ser. No. 582,246, filed May 30, 1975 and owned in common with the present invention. Accordingly, it will be observed in FIG. 5 that each heddle is of elongate form; of relatively thin strip material and comprises an elongate body portion 21 of predetermined width, with an elongate narrow, reduced width frontal portion 22 extending forwardly from body portion 21. The reduced width frontal por-

tion 22 may be about one-half as wide as body portion 21 and terminates in a substantially rounded or substantially semicircularly-shaped nose portion defining the front end of the respective heddle. Each heddle has a strand guide opening or eye 24 through the nose portion thereof for guidingly engaging the respective warp strand S. Thus, it will be observed in FIG. 2 that the warp strands S extend through the respective heddles to the fell 16 of the triaxial fabric being woven. The warp strands may be directed to the heddles from a suitable supply source, not shown, remote from the rows of heddles A, A', B, B'.

The heddles in each row A, A', B, B' may be arranged in any desired spaced relationship. It is preferred, however, that the distance between immediately adjacent heddles in each row is at least about equal to the thickness of each heddle so as to accommodate passage of the warp strands S through the heddles of each respective row and between those heddles which are immediately adjacent warpwise of the heddles through which particular warp strands extend. For this reason it also is preferred that the heddles in the upper rows A, A' be staggered weftwise relative to heddles in the lower rows B, B'. Desirably, the heddles are quite thin and the distance between immediately adjacent heddles in each weftwise row is about the same as the thickness of each heddle so as to permit weaving triaxial fabrics of high density from fine warp strands. Many of the heddles are omitted from each row in FIGS. 1, 3 and 4 for purposes of clarity.

In the particular illustrated embodiment, the heddles in the first rows A, B are disposed in offset relation with the respective heddles in the second rows A', B' and the heddles in the first set A, A' are also offset relative to the heddles in the second set B, B' (FIG. 6). Thus whenever any one of the rows of the heddles occupies an extended position, the substantially opposing row in the respective pair may occupy either a retracted position or an extended position. Such an arrangement accommodates production of a variety of forms of triaxial fabrics. Although the illustrated embodiment has the heddles of each row offset with relation to the heddles in other rows, it is to be understood that the heddles in each row may occupy a different position from that described with respect to the heddles in the other rows without departing from this invention.

Referring again to FIG. 5, it is preferred that the opposite longitudinal side edges of the heddle extend substantially parallel to each other and, since the elongate frontal portion 22 is of substantially less width than the body portion 21, the body portion defines a projecting shoulder portion on the heddle, which shoulder portion is adapted to be engaged by a shifting bar of a heddle shifting means for shifting each respective row of heddles weftwise during operation of the weaving machine. Each heddle also is provided with means adapted to be engaged for imparting longitudinal shedding movements thereto. To this end, the rear portion of each heddle, remote from the frontal portion 22 thereof, is provided with a laterally opening cutout 25 partially defined by a hook-shaped projection 26 on the rear end of the body portion 21 of each heddle.

As shown in FIGS. 2 through 4, the cutouts 25 in heddles of each row A, A', B, B' are engaged by an elongate rib 31a of a respective shedding means 31, there being one of the shedding means 31 for moving each respective weftwise row of heddles A, A', B, B' longitudinally between the retracted position shown in

solid lines in FIG. 2 and the extended position represented by rows A', B shown in broken lines in FIG. 2. In this regard, it will be noted that the proximal longitudinal side edges of the heddles common to respective ones of the first rows A, B slide against the respective upper and lower surfaces of a first stationary guide plate 32, and the proximal longitudinal edges of the heddles common to respective ones of the second rows A', B' slide against the respective upper and lower surfaces of a second stationary guide plate 32'. The stationary guide plates 32, 32' extend weftwise for a distance about equal to the width of the triaxial fabric F and the proximal edges of plates 32, 32' are spaced apart from each other (FIG. 1) to provide an adequate opening for the passage of the warp strands S therethrough and for the formation of the warp sheds thereof with the warp strand guide openings 24 in the heddles positioned forwardly beyond the proximal edges of the guide plates 32, 32'.

Each warp shedding means 31 may include a weftwise extending heddle shedding bar 31b, each of which is movable forwardly and rearwardly to and from extended and retracted positions relative to stationary means including the guide plates 32, 32' according to a predetermined pattern. Each bar 31b has an elongate weftwise extending projection or rib 31a thereon for engaging the cutouts 25 and hook-shaped projections 26 (FIGS. 2 through 4) of heddles common to a respective one of the rows of heddles A, A', B, B'. It is to be noted that the heddles in rows A, B are being moved from left to right and the heddles in rows A', B' are being moved from right to left in FIG. 2 whenever they are being moved forwardly to extended open shed positions. Also, whenever the heddles are being moved to the retracted open shed positions shown in solid lines in FIG. 2, the heddles are being moved rearwardly.

For the control of the heddles during formation of warp sheds and for shifting the heddles weftwise, means defining passageways are provided for guiding each row of heddles A, B, A', B'. The passageway defining means includes fixed means respectively designated at 34a, 34b, 34a', 34b', and movable means respectively designated at 35a, 35b, 35a', 35b'.

Each fixed means 34a, 34b, 34a', 34b' defines first passageway portions for guidingly receiving heddles upon warp shed forming movement thereof toward one of an extended position and a retracted position and may take the form of an elongate weftwise guide member or bar 40 (FIGS. 1 through 4) suitably supported so that its surface facing toward the corresponding guide plate 32, 32' is spaced from such guide plate a distance somewhat greater than the width of the reduced width frontal portions 22 (FIG. 5) of the corresponding heddles. The surface of each guide bar 40 adjacent the corresponding stationary guide plate 32, 32' is in the form of a plurality of projecting separators or wall members defining a weftwise row of passageways 41 (FIG. 4) for guiding the respective heddles in movement from and to the aforementioned open shed retracted and extended positions. The fixed passageway defining means 34a, 34b, 34a', 34b' and the plates 32, 32' together provide stationary means extending weftwise of the weaving machine for engaging medial portions of heddles and for guidingly supporting and arranging the engaged heddles in predetermined array in the weftwise rows. Heddles are moved longitudinally of themselves and across the stationary means by operation of the shedding bars as described above.

The movable means 35a, 35a', 35b, 35b' define second passageway portions for guidingly receiving heddles upon shedding movement thereof toward the other of the extended and retracted positions and are provided for moving the respective rows of heddles A, A', B, B' and warp strands S engaged thereby weftwise during weaving so as to shift each heddle in each row from one passageway to another and thereby move the warp strands from one weftwise location to another so that the warp strands may extend obliquely with respect to the wefts. Accordingly, each movable means comprises an elongate weftwise extending and weftwise movable heddle shifting member or bar 45 positioned rearwardly of and in sliding engagement with, or in close proximity to, the respective heddle guide bar 40. Each heddle shifting bar 45 is provided with a weftwise row of closely spaced forwardly and rearwardly extending separators or wall members to define a weftwise row of passageways (similar to the fixed passageways 41) for guidingly receiving therein the shoulder portions defined by the body portions 21 (FIGS. 2 through 5) on the heddles in the respective row. The surfaces of the heddle shifting bars 45 facing toward the stationary guide plates 32, 32' are spaced from such guide plates to accommodate the shedding movements of the respective heddle shedding bars 31b in the space between bars 45 and plates 32, 32'.

Suitable control means 47 is shown schematically in the form of a block (FIG. 2) operatively connected to each heddle shifting bar 45 for imparting an active weftwise shifting movement or stroke to each heddle shifting bar 45 following each of, or certain of, the rearward or retracting movements of the respective shedding bars 31b. It is to be understood that successive active weftwise strokes of each heddle shifting bar 45 may be effected selectively in either weftwise direction with each such active stroke being effected for a distance substantially equal to an integral multiple of the distance between the centers of adjacent passageways 41. Such weftwise movement of the heddle shifting bars normally aligns the movable second passageway portions with the fixed first passageway portions so that the portions cooperate in guidingly receiving the heddles during their longitudinal movement. As to weftwise movement of heddles, the sum of all of the active weftwise strokes of each heddle shifting bar 45 normally makes the heddles in any given row subject to being transferred away from the same end of such given row to the adjacent end of another of the rows of heddles. Transfer means 50, 50' for accomplishing such movement has been indicated by blocks in FIG. 1, but forms no major portion of this invention and is subject to separate protection and accordingly is not here described in detail.

In the illustrated embodiment of the present invention it is to be assumed that successive heddles in the two first rows A, B are delivered to the ends of the rows A, B nearest the observer in FIG. 2 and that the successive delivered heddles are transferred by a first transfer means 50 to the adjacent ends of the respective second substantially opposing rows A', B'. Of course, it is apparent that the successive heddles are delivered to the other leading ends of the latter rows A', B' and are transferred to the adjacent trailing ends of the two first rows of heddles A, B by a second transfer means 50'. In any event, it is preferred that the control means 47 for each heddle shifting bar 45 imparts an inactive stroke to the respective heddle shifting bar 45 for returning the

same to its original position following each active stroke thereof.

Following each active weftwise stroke of each heddle shifting bar 45, it is to be understood that the respective shedding means 31 moves all the heddles in the respective row forwardly to extended position so as to move the body portions 21 of the corresponding heddles forwardly out of engagement with the passageways in the respective heddle shifting bars 45, thus permitting the heddle shifting bars 45 to return to their original positions in an inactive stroke thereof without then being encumbered by, or imparting weftwise movement to, the respective heddles.

Suitable drive means for the heddle shifting bars 45 and the shedding means 31 may take the form illustrated in FIGS. 3 and 4, where a main drive shaft 51 has a plurality of control cams mounted thereon for operating corresponding cam follower arms. In driving the heddle shifting bars 45, a cam following crank arm 52 (FIG. 3) engages the surface of a cam 54 driven by a geared connection to the shaft 51. Oscillating movement of the follower arm 52 (indicated by arrows in FIG. 3) drives a connecting rod 55 and pivots a bell crank 56 mounted on a stationary portion of the weaving machine (as again indicated by arrows in FIG. 3). The end of the bell crank 56 remote from connection with the rod 52 is suitably connected with the bar 45 for row A' of heddles. As illustrated in FIG. 4, a similar arrangement of a follower arm 52, cam 64, connecting rod 65 and bell crank 66 drives the heddle shifting bar 45 for heddle row B'.

Longitudinal movement of the heddles is accomplished by operation of pairs of cams 71, 72, 73, 74 which cooperate with respective follower cranks 76, 77 to reciprocate drive links 78, 79 suitably connected with the shedding bars 31b.

In the drawings and specification, there has been set forth a predetermined embodiment 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.

That which is claimed is:

1. A weaving machine for making triaxial fabrics comprising a plurality of elongate heddles arranged in weftwise rows for guiding warp strands, each of said heddles having cutout means therein adapted to be engaged for imparting longitudinal movement thereto; means for shifting said heddles weftwise; stationary means extending weftwise of the weaving machine for guidingly supporting said heddles in said weftwise rows; and means movable to and from extended and retracted positions relative to said stationary means and engaging said cutout means of said heddles for moving said heddles longitudinally of themselves across said stationary means to and from extended and retracted positions for forming warp strands guided thereby into warp sheds.

2. A weaving machine according to claim 1 wherein said stationary means cooperates with said heddles for arranging said heddles in at least two substantially opposing rows.

3. A weaving machine according to claim 1 wherein said stationary means cooperates with said heddles for arranging said heddles in at least two rows spaced warpwise one from another.

4. A weaving machine according to claim 1 wherein said stationary means cooperates with said heddles for arranging said heddles in at least two rows and com-

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prises first and second weftwise elongated guide means for respectively engaging heddles common to a first row and heddles common to a second row and further wherein said cutout engaging means comprises first and second weftwise elongated shedding bar members mounted for movement adjacent corresponding ones of said guide means for respectively engaging heddles common to the first row and heddles common to the second row.

5. A weaving machine according to claim 1 wherein each of said heddles has a longitudinal side edge and further wherein said stationary means comprises elongate plate means extending weftwise for slideable engagement with said longitudinal side edges of heddles in a common weftwise row.

6. A weaving machine according to claim 1 wherein each of said heddles has shoulder means formed thereon and further wherein said stationary means comprises a plurality of separator means spaced weftwise for guidingly receiving therebetween said shoulder means of heddles in a common weftwise row and for arranging said heddles in a parallel, weftwise spaced apart array.

7. A weaving machine for making triaxial fabrics comprising a plurality of elongate heddles for guiding warp strands, each of said heddles having a nose portion with a warp strand guide opening therethrough and at least a medial portion with a longitudinal side edge and cutout means therein adapted to be engaged for imparting longitudinal movement thereto; stationary means extending weftwise of the weaving machine for guidingly engaging said medial portions of said heddles and for arranging said heddles in at least two weftwise rows; shedding bar means including first and second bars mounted adjacent said stationary means for respectively engaging said cutout means of heddles in a first row and said cutout means of heddles in a second row; and drive means for moving said shedding bar means relative to said stationary means for thereby moving said heddles longitudinally of themselves across said stationary means to and from extended and retracted open shed positions and forming warp strands guided thereby into warp sheds.

8. A weaving machine according to claim 7 wherein said stationary means comprises elongate plate means extending weftwise for slideable engagement with heddles in a common weftwise row, and separator means spaced warpwise from said plate means and spaced

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weftwise for guidingly receiving therebetween heddles in a common weftwise row, said stationary means arranging heddles in a common weftwise row in a parallel, weftwise spaced apart array.

9. A weaving machine according to claim 7 wherein said each of said first and second bars engages all those heddles common to the respective one of said rows.

10. A weaving machine according to claim 7 further comprising means for moving those heddles common to a respective one of said rows in unison weftwise along the corresponding one of said first and second bars, said shedding bar means and said means for moving heddles weftwise maintaining engagement of said bars and said cutout means during unison weftwise movement of heddles.

11. A weaving machine according to claim 10 wherein said means for moving heddles weftwise is operatively connected with said drive means for weftwise movement of heddles in timed relation with movement of said shedding bar means and while said heddles are in retracted open shed position.

12. A weaving machine for making triaxial fabrics comprising a plurality of elongate strip material heddles for guiding warp strands, each of said heddles having a nose portion with a warp strand guide opening therethrough and a rear portion remote from said nose portion and with a hookshaped projection defining a laterally opening cutout therein; stationary means for engaging said heddles medially of said nose portions and said rear portions and for arranging said heddles in at least two substantially opposing weftwise rows; shedding bar means including first and second ribbed bars mounted adjacent said stationary means for respectively engaging said cutouts of heddles in a first row and said cutouts of heddles in a second row; means for moving said shedding bar means relative to said stationary means for thereby moving said heddles longitudinally to and from extended and retracted open shed positions and forming warp strands guided thereby into warp sheds; means for moving heddles weftwise relative to said stationary means in timed relation with movement of said shedding bar means and while said heddles are in retracted open shed position; and means for transferring heddles from one end of one of said ribbed bars to an adjacent end of the other of said ribbed bars.

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