

- [54] WEAVING MACHINE AND METHOD
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- [52] U.S. Cl. 139/16
- [51] Int. Cl. D03d 37/00
- [58] Field of Search 139/11, 1, 16

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Attorney—Gravely, Lieder & Woodruff

[57] ABSTRACT

A weaving machine for weaving a wrap thread into a multiplicity of longitudinal threads to create a tubular weave of substantial thickness includes means for sup-

porting a mandrel about which the weave is formed and for further anchoring the longitudinal threads so that they extend downwardly along the mandrel in a shed-like configuration. Located below and centered with respect to the mandrel is a transporting mechanism including a plurality of radial slideways, each of which supports a series of individual sliders which confine the longitudinal threads and are capable of shifting independently of one another to change the radial positions of the various longitudinal threads. The transporting mechanism positions the threads in groups corresponding to the various slideways with the threads in each group being spaced radially from one another due to the radial disposition of the slideways. By manipulating the sliders, any two of the threads of a group can be spaced further apart than the remaining threads to provide a shed opening in the group. An endless track encircles the shed formed by the longitudinal threads, and this track has radial slots for receiving the various groups of longitudinal threads. A feed assembly rides around the track, and this assembly is sized to fit through the shed openings in the various groups of longitudinal threads. The feed assembly carries a bobbin of wrap thread and lays this wrap thread into the portion of the shed opening adjacent to the mandrel as the feed assembly moves along the track, thus forming the tubular weave.

7 Claims, 14 Drawing Figures

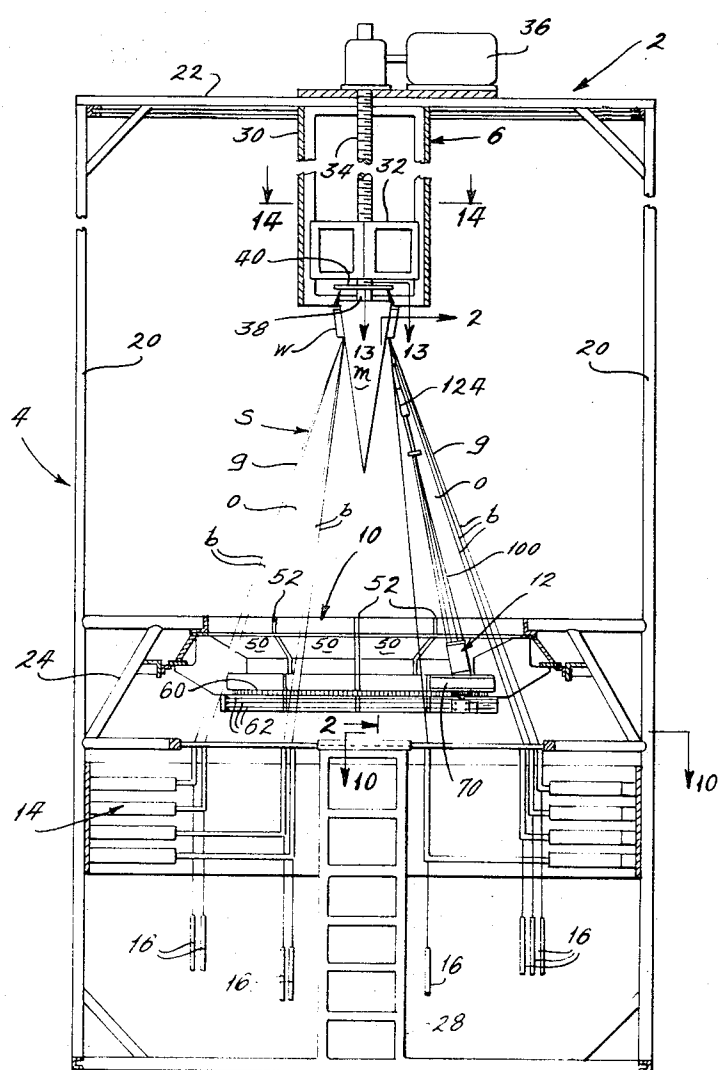
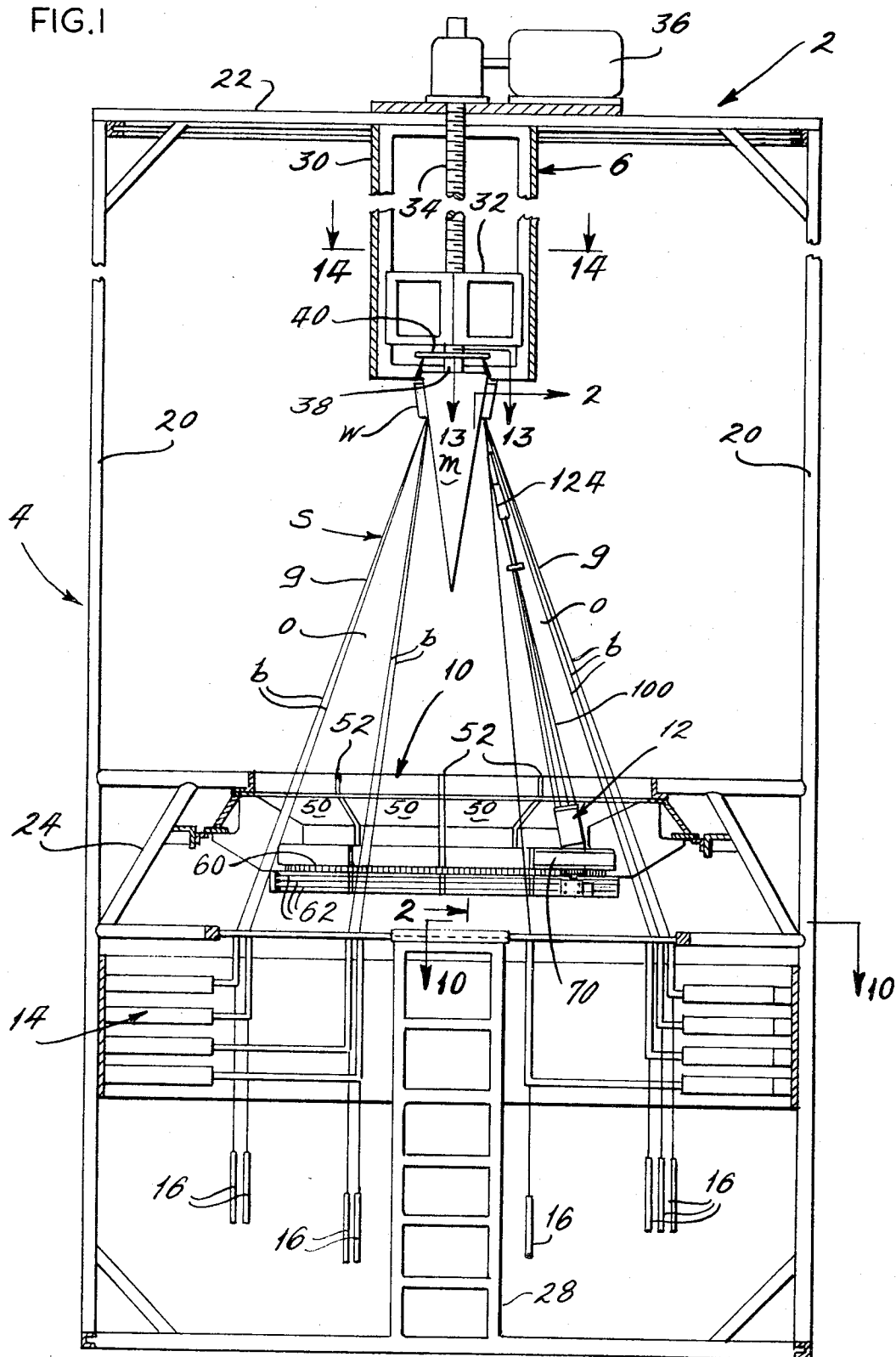
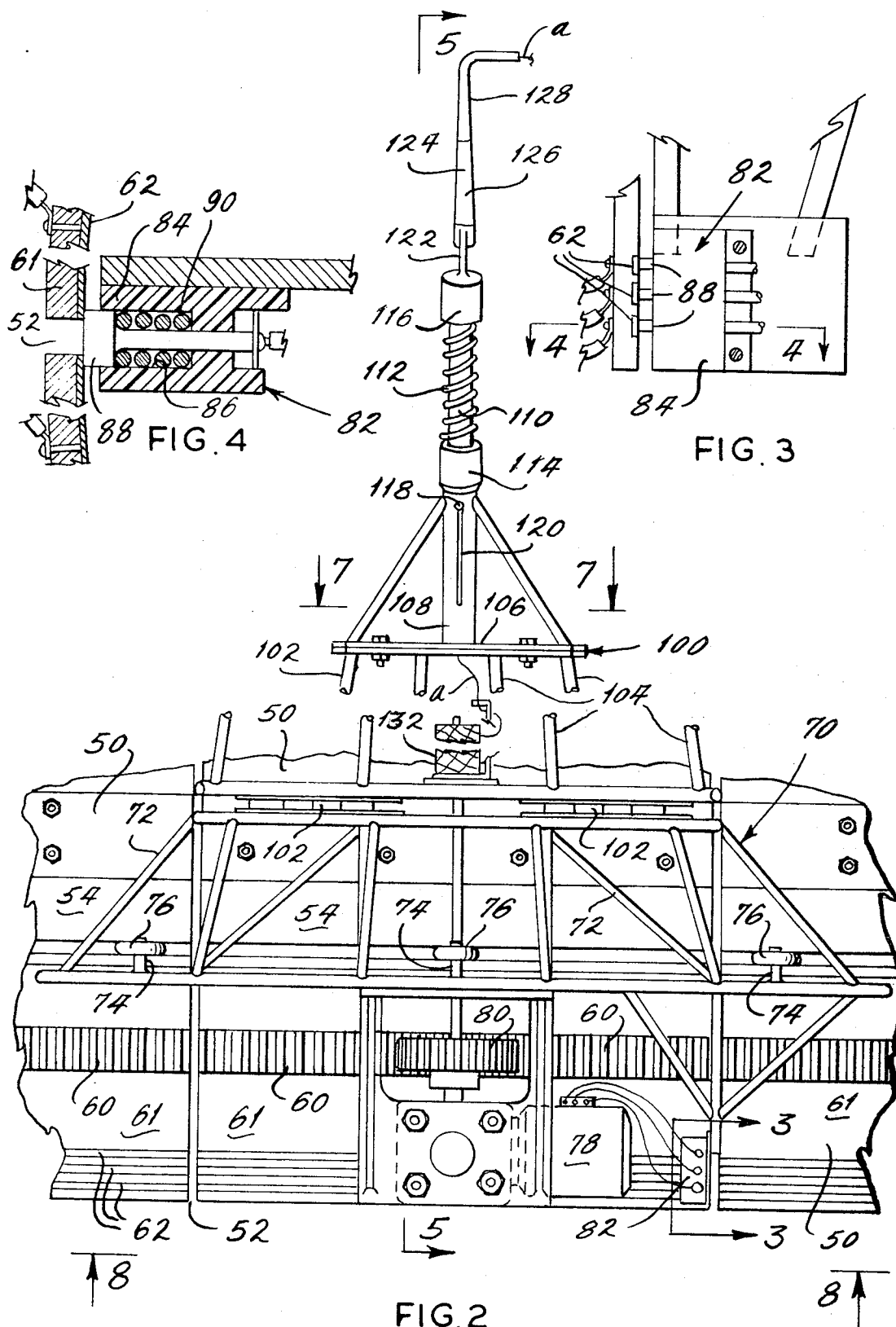
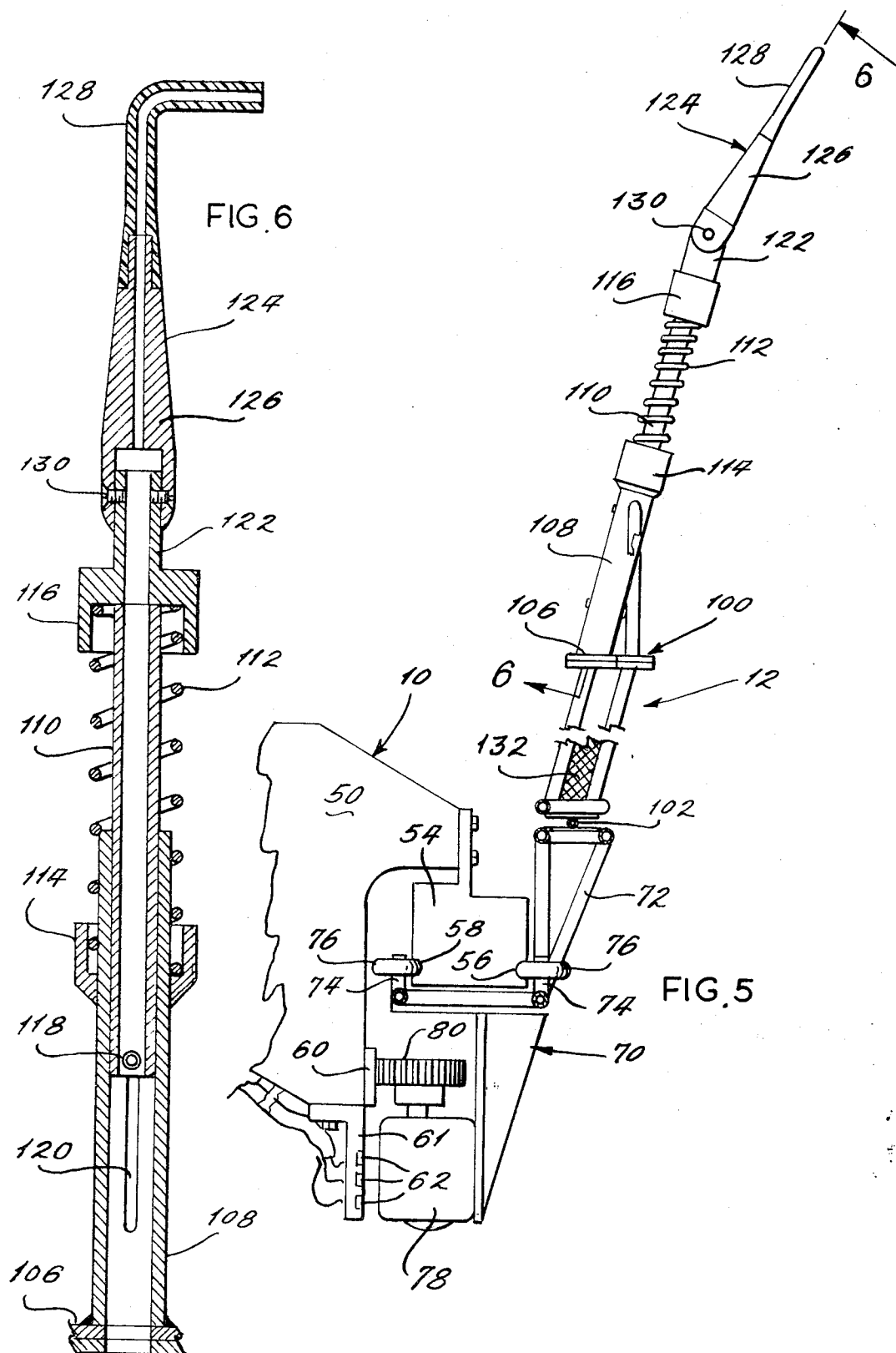
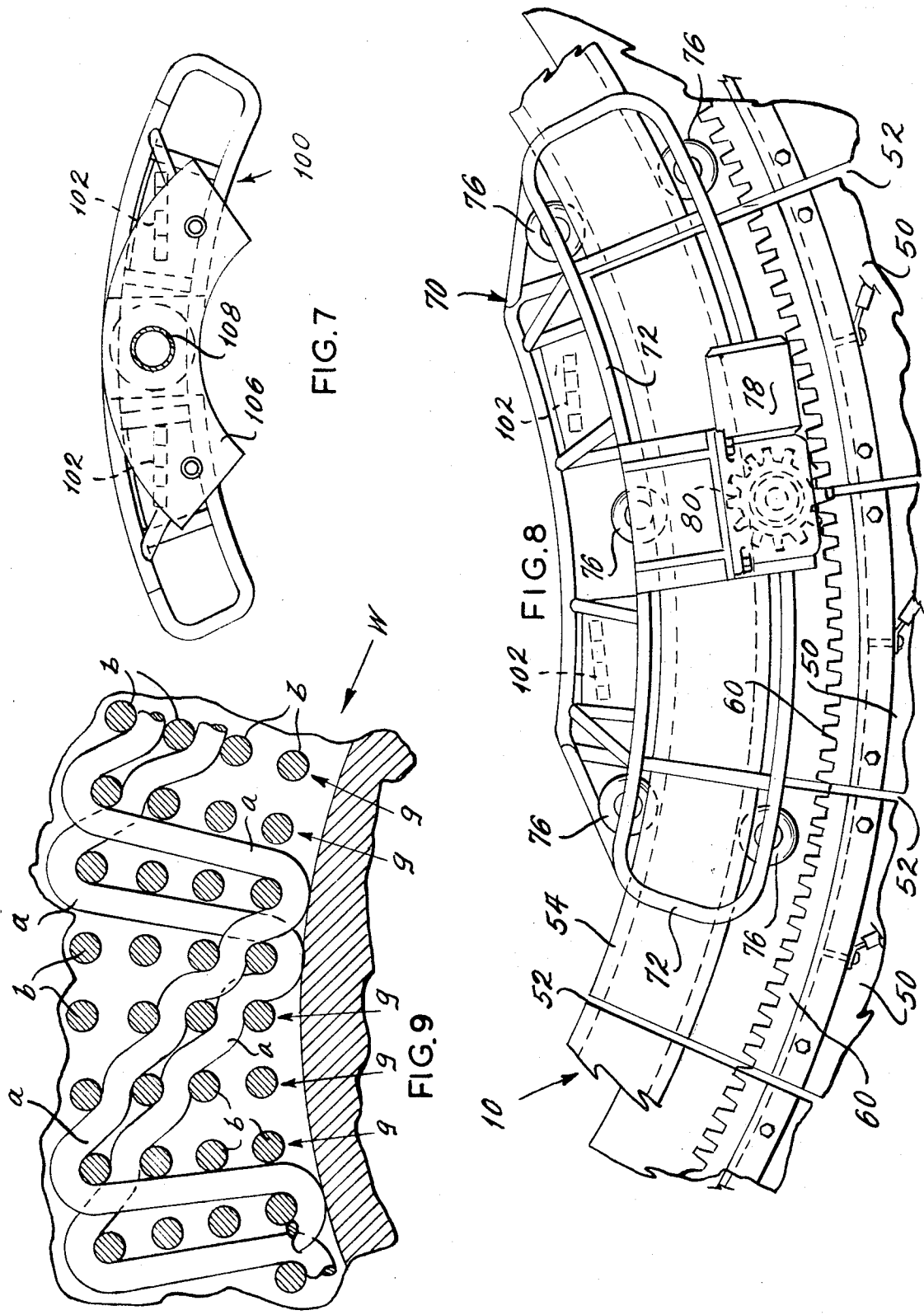


FIG. 1









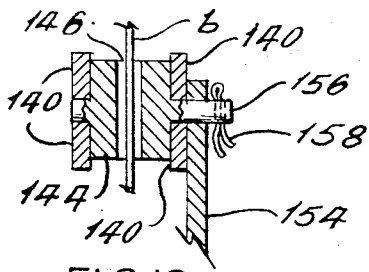


FIG. 12

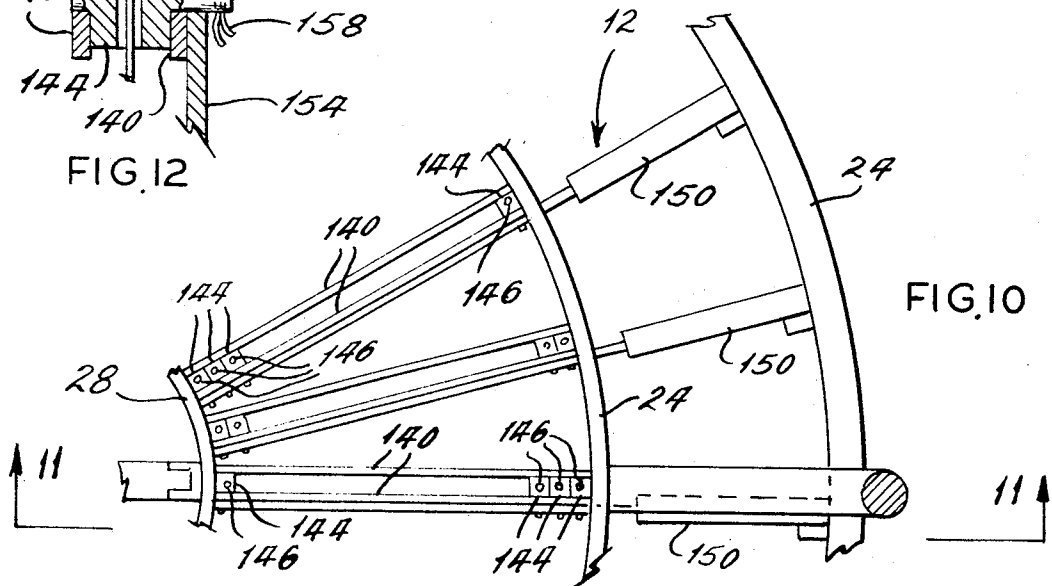


FIG. 10

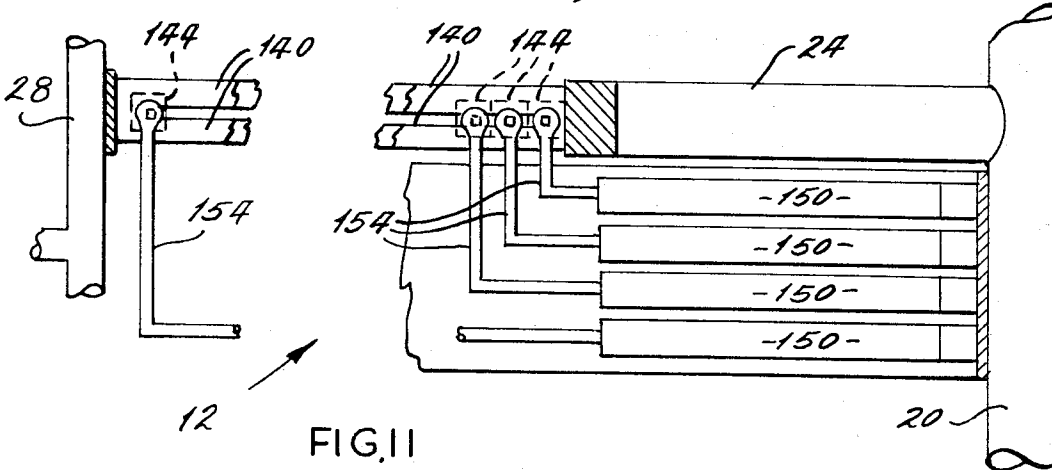


FIG. 11

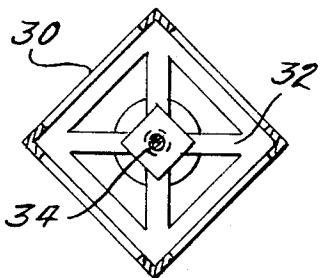


FIG. 14

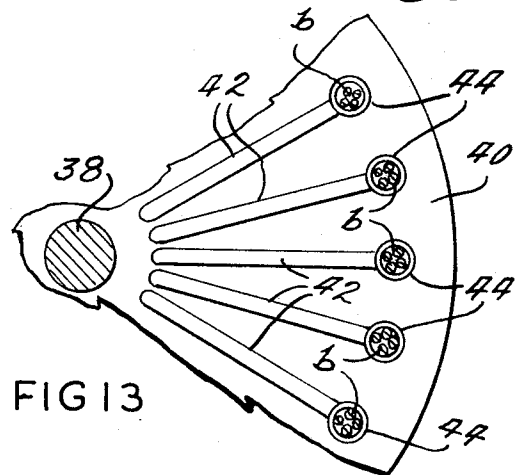


FIG. 13

WEAVING MACHINE AND METHOD

BACKGROUND OF THE INVENTION

This invention relates in general to weaving and more particularly to a weaving machine which produces a woven pattern of tubular configuration and to a method of weaving such a pattern.

So called ablative yarns, which are normally composed of carbon fibers, cannot be bent severely without causing at least some of the fibers in the region of the bend to fracture and thereby weaken the yarn. Consequently, extreme care must be exercised in weaving these yarns into useful configurations. Since most conventional weaving machines subject yarns to severe bends, they are not suitable for weaving ablative yarns.

Moreover, most ablative structures, such as the nose cones of rockets, possess a tubular or hollow configuration, and to convert ablative yarns into suitable ablative structures of a tubular nature necessitates a tubular weave having substantial thickness. In other words, it is desirable to have a three dimensional weave of a tubular configuration for ablative structures. Conventional weaving machines are incapable of producing weaves of a tubular pattern, much less weaves having substantial thickness.

SUMMARY OF THE INVENTION

One of the principal objects of the present invention is to provide a weaving machine capable of producing a tubular weave of substantial thickness. Another object is to provide a weaving machine which subjects the yarn woven therein to minimal angular deflections. An additional object is to provide a weaving machine which is ideally suited for weaving friable ablative yarn into ablative structures. A further object is to provide a method of weaving tubular structures. These and other objects and advantages will become apparent hereinafter.

The present invention is embodied in a weaving machine which includes anchoring means for securing longitudinal threads and positioning means for confining those longitudinal threads in circumferentially spaced groups with the threads of each group being spaced radially from one another. In addition, feed means are provided for laying a wrap thread through at least some of the groups of longitudinal threads. The invention further resides in the method of weaving employed by the machine. The invention also consists in the parts and in the arrangements and combinations of parts hereinafter described and claimed.

DESCRIPTION OF THE DRAWINGS

In the accompanying drawings which form part of the specification and wherein like numerals and letters refer to like parts wherever they occur.

FIG. 1 is an elevational view in section of a weaving machine constructed in accordance with and embodying the present invention;

FIG. 2 is a fragmentary sectional view taken along line 22 of FIG. 1 and shows the feed assembly forming part of the present invention;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2 and shows the electrical pick-up through which the electric current is transferred to the motor of the feed assembly;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3;

FIG. 5 is a sectional view taken along line 5—5 of FIG. 2 and shows the feed assembly and track on which it runs;

FIG. 6 is a sectional view taken along line 6—6 of FIG. 5;

FIG. 7 is a sectional view taken along line 7—7 of FIG. 2;

FIG. 8 is a fragmentary plan view taken along line 8—8 of FIG. 2 and shows the underside of the track and feed assembly;

FIG. 9 is a fragmentary sectional view of the weave formed by the weaving machine;

FIG. 10 is a fragmentary sectional view taken along line 10—10 of FIG. 1 and shows the transporting mechanism of the present invention;

FIG. 11 is a sectional view taken along line 11—11 of FIG. 10 and shows the transporting mechanism in elevation;

FIG. 12 is a sectional view of one of the sliders forming the present invention;

FIG. 13 is a fragmentary sectional view taken along line 13—13 of FIG. 1 and shows the anchor plate from which the longitudinal threads are suspended; and

FIG. 14 is a sectional view taken along line 14—14 in FIGS. 1 and 6 of the mandrel carrier of the present invention.

DETAILED DESCRIPTION

Referring now to the drawings, 2 designates a weaving machine (FIG. 1) which weaves a wrap or weft thread *a* into longitudinal or warp threads *b* to form a tubular weave *w* (FIG. 9) about a mandrel *m*. The machine 2 positions the longitudinal threads *b* around the mandrel *m* in radial groups *g* which in effect form a shed *s* of longitudinal threads *b* about the mandrel *m*. The machine 2 shifts the longitudinal threads *b* within each group *g* independently of one another in the radial direction, and by spacing any two adjacent threads *b* of a group *g* further apart than the remaining adjacent threads *b* of that group *g*, a shed opening *o* (FIG. 1) is created within the group *g*. Through such openings *o* in the various groups *g* the machine 2 lays the wrap thread *a* among the longitudinal threads *b* to form the weave *w*.

The weaving machine 2 basically includes (FIG. 1) a frame 4, a mandrel and anchor carrier 6 suspended from the frame 4 for supporting the mandrel *m*, a reed or slotted track 10 mounted on the frame 4, a thread feed assembly 12 which rides around the slotted track 10 and lays the wrap thread *a* into the longitudinal threads *b*, a transporting mechanism 14 for moving the longitudinal threads *b* of each group *g* to vary the position of the shed opening *o* in each group *g*, and tensioners 16 for maintaining the longitudinal threads *b* taut as they are shifted by the transporting mechanism 14 and as the wrap thread *a* is woven into them.

The frame 4 has (FIG. 1) upright members 20 which are interconnected at the upper ends by cross members 22. Intermediate their ends, the upright members 20 have a circular framework 24 secured to them, and this framework 24 supports the slotted track 10. Positioned within the circular framework 24 is a center support 28.

The mandrel and anchor carrier 6 includes (FIGS. 1 and 14) a square slide tube 30 which is welded at its upper end to the cross members 22 of the frame 4 and is large enough to receive the mandrel *m*. The slide

tube 30 projects downwardly from the cross members 22 and, while it is disposed above the track 10, is centered with respect thereto. Fitted into the tube 30 is a slide 32 to which a non-rotatable lead screw 34 is affixed. The lead screw 34 extends upwardly from the slide 32 and passes through a drive mechanism 36 located above and supported by the cross members 22. The drive mechanism 36 includes a nut (not shown) which is engaged with the threads of the lead screw 34 and is further rotated when the drive mechanism 36 is energized. This, of course, causes the slide 32 to rise or descend within the tube 30, depending on the direction of rotation imparted to the nut, and consequently the vertical position of the mandrel *m* is controlled by the drive mechanism 36.

The slide 32 also has a connecting rod 38 extending downwardly from it, and this rod is at its lower end engaged with the mandrel *m* for supporting the mandrel *m* in an elevated position above the track 10. The connecting rod 38 is threaded into both the slide 32 and the mandrel *m* and is therefore detachable from both. Thus, the mandrel *m* may be removed and replaced with another mandrel having a different configuration. The connecting rod 38 also carries an anchor plate 40 (FIG. 13) which is spaced from both the slide 32 and the mandrel *m* and has a plurality of radial slots 42 spaced at equal circumferential intervals around it. The slots 42 outwardly terminate at circular eyes 44 through which the longitudinal threads *b* are passed such that the longitudinal threads *b* of a single group *g* are confined within a single eye 44. The longitudinal threads *b* are secured to and suspend from the anchor plate 40.

The circular framework 24 supports the slotted track 10 (FIGS. 2, 5, and 8) including a plurality of track segments 50, which are bolted to the framework 24 and are separated from one another by radial slots 52. Each track segment 50 has a rail segment 54 bolted to it, and adjoining rail segments 54 are likewise separated by the radial slots 52. While the rail segments 54 are bolted to the track segments 50, they are for the most part spaced from the track segments 50 (FIG. 5). In particular, the rail segments 54 are suspended from the track segments 50, and the suspended portions have inwardly and outwardly opening grooves 56 and 58. The grooves 56 and 58 of adjacent rail segments 54 align so as to create a pair of oppositely opening annular grooves around the track 10. In addition, each track segment 50 below its rail segment 54 has (FIGS. 2, 5, and 8) a gear segment 60 attached to it, and adjacent gear segments 60 are also spaced apart by the radial slots 52. The gear segments 60 align with one another and the spacing between adjacent gear segments 60, that is the space across the slot 42, substantially equals the width of one tooth so that the individual gear segments 60 in effect form a continuous circular rack around the track 10. Finally, the track segments 50 below their gear segments 60 have (FIGS. 2-5) dielectric segments 61, each of which is provided with several vertically spaced contact strips 62 which are insulated from one another and also from the track segments 50. The strips 62 of adjacent track segments 50, like the rail segments 54 and gear segments 60, are separated by the radial slots 52, but nevertheless align, thus forming several electrified rails around the track 10. The circular rack and electrified rails face inwardly. It should be noted that the radial slots 52 receive the longitudinal threads *b* with

each group *g* of longitudinal threads *b* being confined in a separate slot 52.

The thread feed assembly 12 is supported on and follows the endless track 10. It includes (FIGS. 2 and 5) a carriage 70 having a frame 72 which possesses an arcuate contour conforming to the contour of the track 10 at the rail segments 54 thereon. The frame 72 lies primarily along the underside and the inside faces of the rail formed by the rail segments 54 and is long enough to completely span and project circumferentially beyond two of those rail segments 54. The frame 72 is provided with six spindles 74 arranged in three pairs on each side thereof. One spindle 74 of each pair projects upwardly adjacent the inside face of the rail formed by the rail segments 54, while the other spindle 74 of each pair projects upwardly along the outside face. These spindles 74 form the journals for wheels 76 which project into the inwardly and outwardly opening grooves 56 and 58 of the rail segments 54 so that the carriage 70 is confined to the track 10 and cannot be displaced from it. The three pairs of spindles 74 are spaced such that the wheels 76 of the leading and trailing pairs will always be engaged with the grooves 56 and 58 of different rail segments 54.

The carriage frame 72 projects downwardly past the circular rack formed by the gear segments 60 and the electrified rails formed by the contact strips 62, and bolted to this portion of the frame 72 is a gear motor 78 (FIGS. 2, 5, and 8), the output shaft of which is fitted with a pinion gear 80. This gear meshes with the circular rack formed by the gear segment 60.

The motor 78 is connected by electrical wires to an electrical pickup assembly 82 (FIGS. 2-4) which is also mounted on the downwardly projecting portion of the frame 72 and is positioned opposite the electrified rails formed by the contact strips 62. In particular, the pickup assembly 82 includes a housing 84 formed from a dielectric material. The housing 84 has three bores 86 opening outwardly toward the track 10, and each bore 86 aligns with a separate contact strip 62. Each bore 86 further contains a brush 88 and a coil spring 90, the latter urging the former outwardly and into engagement with one of the electrified rails formed by the contact strips 62. Each brush 88 contacts a different electrified rail and is further connected to the gear motor 78 through a separate wire. The diameter of the brushes 88 exceeds the width of the slots 42 to enable the brushes 88 to pass from one aligned contact strip 62 to the next.

The carriage frame 72 also projects upwardly along the inside face of the rail formed by the rail segments 54, and this portion of the frame 72 supports a mast 100 (FIGS. 1, 2, and 5) which projects upwardly through the shed openings *o* formed in the groups *g* of longitudinal threads *b*. The mast 100 is furthermore connected to the carriage frame 72 by a hinge 102 having its axis perpendicular to the radius of the circular track 10. Consequently, the mast 100 is free to swing inwardly and outwardly a limited distance with respect to the circular track 10 to compensate for changes in the position of the shed opening *o*. The mast 100 includes a plurality of upright members 104 which converge toward and are connected at their upper ends to an arcuate plate 106 (FIG. 7). Attached rigidly to the arcuate plate 106 and projecting upwardly therefrom (FIGS. 5 and 6) is a tube 108 into which another tube 110 is fitted such that the latter telescopes relative to

the former. Both tubes 108 and 110 are encircled by a coil spring 112 having its lower end positioned and a cup 114 fitted securely on the lower tube 108 and its upper end fitted into another cup 116 fitted into the shiftable upper tube 110. Therefore, the spring 112 urges the shiftable tube 110 upwardly. This upward movement is limited, however, as is the downward movement also, by pin 118 (FIG. 6), which is fitted to the shiftable tube 110, and moves within a slot 120 in the fixed tube 108. When the pin 118 engages either end of the slot 120, telescopic movement of the shiftable tube 110 is no longer possible. The disposition of the pin 118 in the slot 120 further prevents the shiftable tube 110 from rotating with respect to the lower tube 108 and the mast 110. The upper cup 116 has (FIGS. 2, 5, and 6) a tab 122 projecting upwardly from it, and mounted on this tab 122 is a thread insertion tube 124 comprising a rigid body portion 126 and a flexible end portion 128. The rigid body portion 126 is bifurcated at its lower end where it receives the tab 122 on the upper end of the shiftable tube 110, and the bifurcated lower end and the tab 122 are connected by means of a pivot pin 130 (FIGS. 5 and 6) which enables the insertion tube 124 to pivot a limited amount relative to the remainder of the mast 100. Indeed, the axis of the pin 130 parallels the axis of the hinge 102 so that the insertion tube 124 also moves to compensate for changes in the size and configuration of the shed opening *o*. The flexible end portion 128 is formed from a flexible plastic material and turns rearwardly intermediate its ends so that its upper end opens rearwardly relative to the direction of movement for the carriage 70.

Finally, the mast 100 carries a bobbin grows (FIGS. 2 and 5) the feed is mounted at the base thereof and contains the wrap thread *a*. This thread extends from the bobbin 132 (FIG. 2) upwardly along the mast 100 and the tube plate 106 passes into the fixed lower tube 108. From path fixed tube 108, the thread *a* passes into the shiftable upper tube 110 and thence into the insertion tube 124, from which it extends rearwardly through the flexible end portion 128 of the insertion tube 124, the shiftable

The transporting mechanism 14 is also mounted on the frame 4 and extends between the circular framework 24 and center support 28 thereof. The transporting mechanism 14 includes (FIGS. 10-12) radially extending bars 140 which are arranged in pairs to form slideways 142 within the frame 4. These slideways 142 are spaced at equal circumferential intervals, and each slideway 142 lies in the same vertical plane as a slot 42 of the track 10 and an eye 44 of the anchor plate 40. The slideways 142 retain individual sliders 144 which move inwardly and outwardly thereon. A separate slideway 142 exists for each group *g* of longitudinal threads *b*, and a separate slider 144 exists on each slideway 142 for each thread *b* of the group *g*. To confine the longitudinal threads *b*, the sliders 144 are provided with vertical guide holes 146 (FIG. 12), through which the longitudinal threads *b* extend.

The sliders 144 are shifted inwardly and outwardly along the slideways by pneumatic cylinders 150 (FIG. 11) which also form part of the transporting mechanism 14. These cylinders 150 have piston rods 152 which are attached to the sliders 144 by links 154. In particular, each link 154 flares outwardly at its upper end where it is provided with an eye which receives an actuating pin 156 projecting from one of the sliders

144. The link 154 is retained on the pin 156 by a cotter pin 158 (FIG. 12). Thus, a separate pneumatic cylinder 150 operates each slider 144. The cylinders 150 are connected to a source of high pressure air through pneumatic lines having valves in them, and the cylinders 150 are actuated by operating the valves. Thus, a separate valve must be altered to cause a cylinder 150 to move its slider 144 along the slideway 142 for that slider 144. The valves in turn are controlled from a remote location and that control facility can be a manual control board, a magnetic tape, a punched tape, or a computer. In lieu of the pneumatic cylinders 150, the sliders 144 may also be shifted by other suitable motion imparting mechanisms such as solenoids.

The tensioners 16 (FIG. 1) are merely weights attached to the lower ends of the longitudinal threads *b*.

OPERATION

To prepare the weaving machine 2 to produce the three dimensional weave *w* of tubular configuration, the longitudinal threads *b* are separated into groups *g*, and each group *g* is passed through a separate eye 44 in the anchor plate 40. To facilitate threading in this instance the connecting rod 38 and along with it the anchor plate 40 should be detached from both the slide 32 of the mandrel and anchor carrier 6 and the mandrel *m*. The longitudinal threads *b* are in effect suspended from the anchor plate 40, preferably by knotting the threads *b* of each group *g* beyond the eye 44 through which the group *g* extends. This prevents the threads *b* from slipping through the anchor plate 40. The threads *b* may be supported at lesser radii to bring them closer to mandrels of smaller size by passing them through the slots 42 instead of through the eyes 44. Next the connecting rod 38, to which the anchor plate 40 is affixed, is fastened to the slide 32, and mandrel *m* possessing the desired shape of the weave *w* is attached to the lower end of the rod 38. Next the drive mechanism 36 of the mandrel carrier 6 is energized to align the upper end of the thread insertion tube 124 with the portion of the mandrel *m* at which the weave *w* is to commence.

Thereafter, the threads *b* of each group *g* are extended past a slot 42 in the track 10 and toward a different slideway 142 where they are inserted through the guide holes 146 of the sliders 144 on that slideway 142, with each thread *b* passing through a different slider 144. In other words, each thread *b* of a group *g* is confined by a separate slider 144 of a single slideway 142. In this connection, it should be noted that the slideway 142, the radial track slot 42, and the anchor plate eye 44 for each group *g* are in the same radial position or plane so that the threads *b* of each group *g* extend upwardly without any twist or interference with the threads *b* of adjacent groups *g*. Finally, the tensioners 16 are attached to the lower end of the longitudinal threads *b*.

Thus, the longitudinal threads *b* will be suspended from the anchor plate 40 and will extend downwardly past the mandrel *m* to form a generally conical shed *s* about the mandrel. The threads *b* in each group *g* are spaced radially from one another since radial spacings exist between the vertical guide holes 146 of the sliders 144 for each slideway 142. Those threads *b* forming groups *g* which during the installation of the longitudinal threads *b* are located in the vicinity of the thread feed assembly 12 are positioned such that they do not

interfere with the thread feed assembly 12. This may be achieved by manipulating the sliders 144 for the groups *g* of threads in that vicinity such that they are all at the inside or outside of their slideways 142, in which case no shed opening *o* will exist, or such that some threads *b* are at the inside and some are at the outside of their respective slideways 142, in which case a shed opening *o* large enough to accommodate the thread feed assembly 12 will exist.

The bobbin 132 is loaded with the wrap thread *a*, and a small amount of this thread is withdrawn to form a leader (FIG. 2). This leader is brought upwardly along the mast 100 and at the arcuate plate 106 it is inserted into the fixed lower tube 108. The leader is further extended into the shiftable upper tube 110 and thence into the insertion tube 124, from which it is withdrawn at the flexible end portion 128 thereof. The short segment of leader emerging from the rearwardly disposed end of the flexible end portion 128 is tied to the anchor plate 40.

Once the longitudinal threads *b* are properly installed and the wrap thread *a* is threaded through the insertion tube 124 and attached to the anchor plate 40, the longitudinal threads *b* in the groups *g* immediately preceding the feed assembly 12 are positioned such that the shed opening *o* for those groups are in the proper location for the commencement of the weaving operation, and this positioning is achieved by operating the pneumatic cylinders 150 which shift the sliders 144 for those threads *b*. In this connection, it should be noted that the sliders 144 on each slideway 142 should either be all at the inside or outside ends of the slideway 142 or else split into two bunches, one of which is disposed at the inner end and the other at the outer end. The latter arrangement creates a shed opening *o* in the longitudinal threads *b* of the group *g* and the exact position of the shed opening *o* within the group *g* depends on how many sliders 144 are bunched at the inner and outer ends respectively of the slideway 142 (FIG. 10).

The threads *b* passing through the sliders 144 at the inner end of the slideway 142 will be disposed inwardly from the track 10, whereas the threads *b* confined by the sliders 144 at the outer end of the slideway 142 will be passed through one of the radial slots 42 in the track 10. The former are in the in-shed position and the latter are in the out-shed position. In any event, when the sliders 144 of a single slideway 142 are positioned to create a shed opening *o*, that opening *o* is large enough to accommodate the entire thread feed assembly 12 including its carriage 70 and mast 100. Moreover, when all of the sliders 144 are positioned either at the inner end of the slideway 142 or its outer end, in which case no shed opening *o* will exist, they are disposed beyond the path of the thread feed assembly 12 and will not interfere with it.

After the longitudinal threads *b* in the groups *g* located immediately ahead of the thread feed assembly 12 are correctly positioned, the contact strips 62 located on the track 10 are energized. Since the brushes 88 wipe these contact strips 62, the gear motor 78 is energized. This, of course, rotates the pinion gear 80 and inasmuch as the pinion gear 80 meshes with the circular rack formed by the gear segments 60, the thread feed assembly 12 will propel itself through the shed openings *o* in the groups *g* of longitudinal threads *b* located immediately ahead of it, or if no shed openings exist in any of those groups *g*, then past the inner or

outer threads *b* of such groups *g*. The engagement of the carriage wheels 76 with the grooves 56 and 58 in the rail segments 54 of the track 10, retains the carriage 70 on the track 10 and keeps it from deviating from the circular path defined by that track 10.

As the thread feed assembly 12 advances around the track 10, the wrap thread *a* is withdrawn from the bobbin 132 and deposited by the flexible end 128 of the insertion tube 124 in the narrowest parts of shed openings *o*, that is, in the apex adjacent to the mandrel *m*. Since the mast 100 pivots about the hinge 102 and the insertion tube 124 pivots relative to the shiftable tube 110, and further in view of the fact that the end portion 128 of the insertion tube 124 is flexible, the feed assembly 12 easily adjusts to changes in the position and configuration of the shed openings *o* as it moves from one group *g* of longitudinal threads *b* to the next.

The gear motor 78 operates continuously so that the feed assembly 12 makes one revolution after another around the track 10. Usually at least some of the pneumatic cylinders for each slideway 142 are activated once the carriage 70 and insertion tube 124 pass beyond the group *g* of threads *b* extended through that slideway 142 so that the shed opening *o* is in a different position during the next revolution of the feed assembly 12. Considering the numerous groups *g* and the number of threads *b* in each group *g*, many combinations are available and intricate weaves may be produced (FIG. 9).

The weave *w* of course grows with each revolution of the feed assembly 12 around the track 10, and in time will cover a substantial portion of the outer surface of the mandrel *m*. The telescopic mounting of the tube 110 enables the insertion tube 124 to assume a lower part as the weave *w* grows, and consequently the wrap thread *a* is always fed into the juncture of the longitudinal threads *b* with the completed weave *w* is longer than the distance the shiftable tube 110 will retract into the fixed tube 108, the mandrel *m* may be elevated at periodic intervals by energizing the drive mechanism 36 of the mandrel carrier 6.

Since the threads *b* experience very little angular deflection during the weaving operation, the machine 2 is ideally suited for weaving brittle ablative yarns.

When the weave *w* is completed, the mandrel *m* is detached from the mandrel carrier. Thereafter, the weave may be immersed in a resin to form a high strength rigid structure of extremely light weight, once the resin cures. If the threads are ablative yarn, this structure may be employed as an ablator.

This invention is intended to cover all changes and modifications of the example of the invention herein chosen for purposes of the disclosure which do not constitute departures from the spirit and scope of the invention.

What is claimed is:

1. A weaving machine for weaving a wrap thread into a plurality of longitudinal threads to form a weave of generally tubular configuration; said weaving machine comprising: anchoring means for securing the ends of the longitudinal threads in a generally fixed position; a circular track below the anchoring means, the track being concentric about a center axis and having slots which extend radially with respect to and open inwardly toward the center axis; positioning means for engaging the longitudinal threads and positioning them in circumferentially spaced groups aligned with the

slots in the track and with the threads of each group being aligned radially with respect to the center axis and with respect to one another; a mandrel above the track and surrounded by the circumferentially spaced groups of longitudinal threads; shifting means associated with each group of longitudinal threads for moving the longitudinal threads in the radial direction between in-shed and out-shed positions to space two adjacent longitudinal threads of the group further apart than other adjacent longitudinal threads of the group whereby a shed opening is formed in the group, the longitudinal threads when in the in-shed position being located inwardly from the track and when in the out-shed position being located within the radial slots of the track; a carriage mounted on and movable around the track, the carriage having a bobbin containing the wrap thread and an insertion device extending generally in the direction of the center axis and terminating adjacent to the mandrel for directing the wrap thread into the top of the shed opening so that the wrap thread is laid into the shed opening as the carriage moves around the track, whereby the weave is formed about the mandrel.

2. A weaving machine according to claim 1 wherein the insertion device on the carriage comprises an insertion tube through which the wrap thread is discharged into the portion of the shed openings located adjacent to the completed weave, and mounting means supporting the insertion tube on the carriage, the mounting means urging the tube toward the completed weave but being yieldable to compensate for growth of the weave.

3. A weaving machine according to claim 2 wherein

the mounting means includes a pair of tubes which telescope relative to each other and are urged away from each other by a spring to urge the insertion tube toward the completed weave, whereby a tight weave is formed.

4. A weaving machine according to claim 1 wherein the portion of the insertion tube from which the wrap thread is laid into the shed opening is flexible.

5. A weaving machine according to claim 1 and further characterized by means for maintaining the longitudinal threads taut as the wrap thread is woven into them.

6. A weaving machine according to claim 1 and further characterized by means for drawing the completed weave upwardly away from the track as the weave grows.

7. A method of weaving comprising: arranging longitudinal threads in circumferentially spaced groups about a center axis with the threads of each group being aligned radially with respect to one another and to the center axis, spacing two adjacent threads in at least some of the groups further apart than the remaining adjacent threads in those groups to create shed openings in the groups, the shed openings terminating at apexes located adjacent to the completed portion of the weave; passing a bobbin containing a wrap thread around the center axis and through the shed openings in the groups, playing the wrap thread out of the bobbin and laying into the apexes of the shed openings as the bobbin moves around the center axis; and changing the position of the shed openings with succeeding revolutions of the bobbin about the center axis.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,750,714 Dated August 7, 1973
William W. Weaver
Inventor(s) Harry A. Holman, Jr., Albert W. Kallmeyer, Jr., and

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Line 60, column 1, should be line 2-2 instead of line 22.

Line 58, column 2, memebers should be members.

Starting at Line 33, column 5, the paragraph should read as follows:

"Finally, the mast 100 carries a bobbin 132 (Figs. 2 and 5) which is mounted at the base thereof and contains the wrap thread a. This thread extends from the bobbin 132 (Fig. 2) upwardly along the mast 100 and at the arcuate plate 106 passes into the fixed lower tube 108. From the fixed tube 108, the thread a passes into the shiftable upper tube 110 and thence into the insertion tube 124, from which it extends rearwardly through the flexible end portion 128 of the insertion tube 124."

Signed and sealed this 20th day of November 1973.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents