July 18, 1967 W. D. ALLERS 3,331,178

WIRE MAT

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Fig. 1.

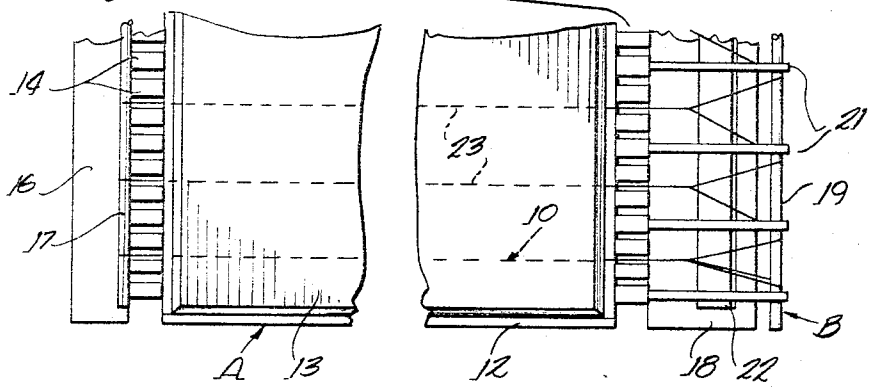


Fig. 2.

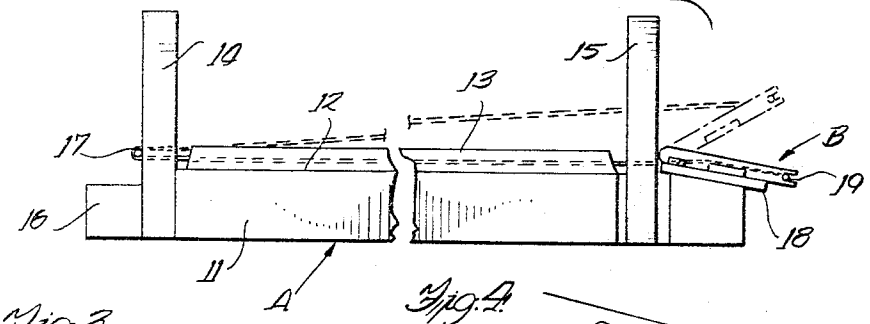


Fig. 3.

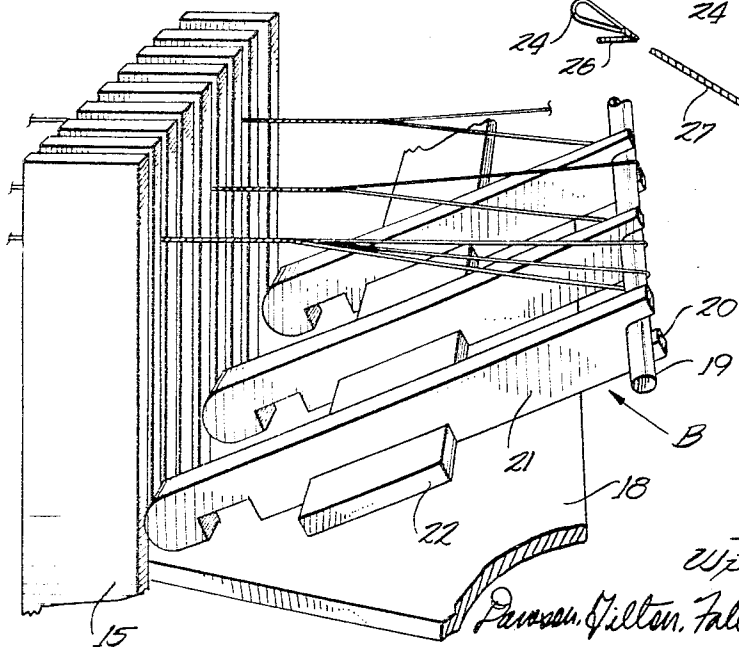
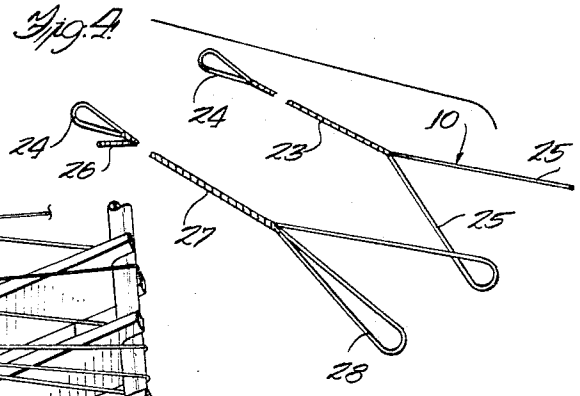


Fig. 4.



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Fig. 5.

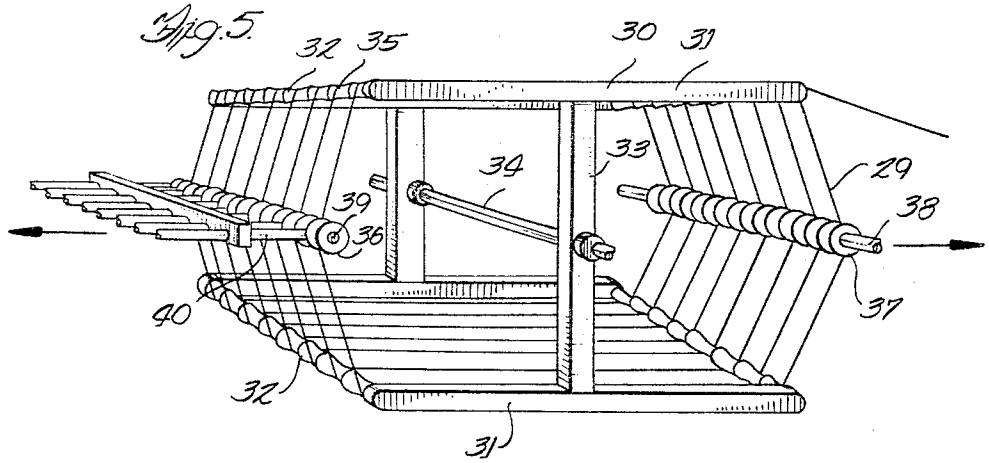


Fig. 6.

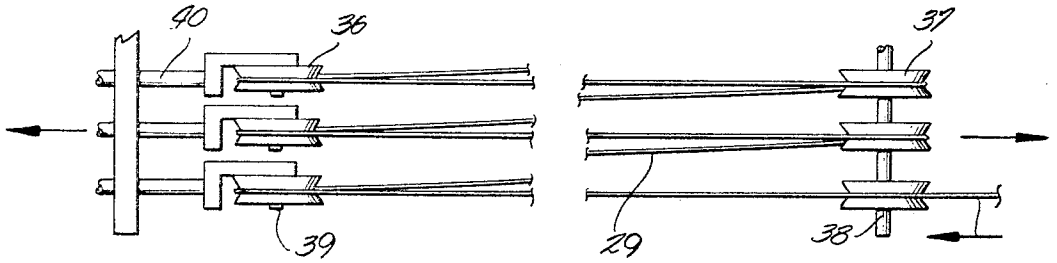
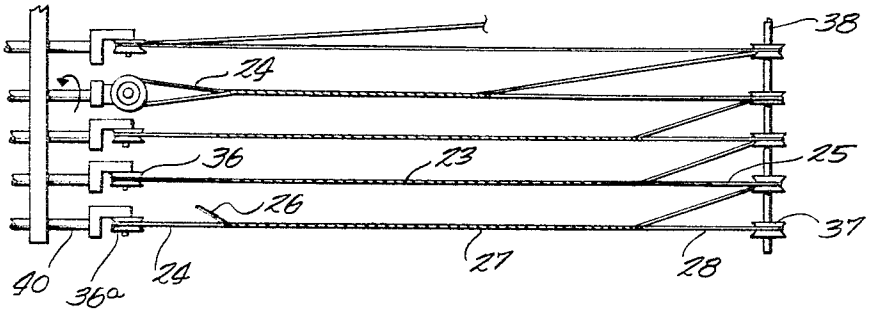


Fig. 7



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Fig. 8.

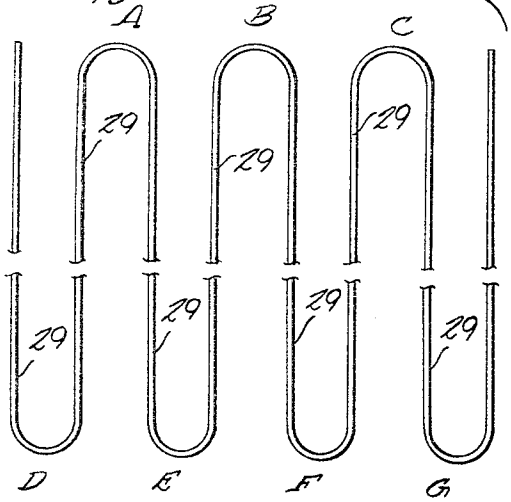


Fig. 9.

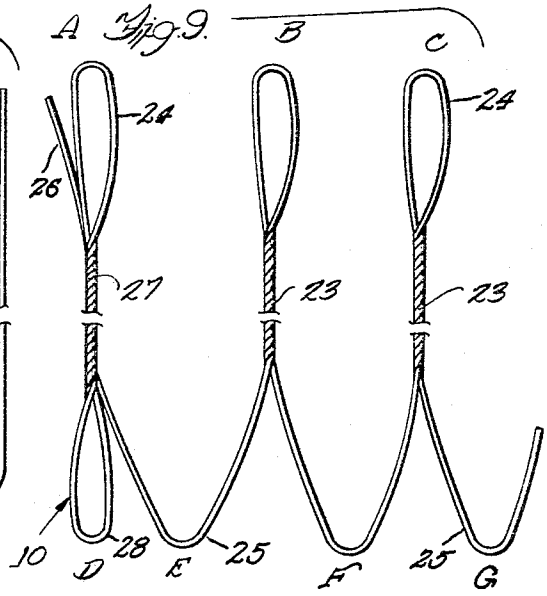


Fig. 10.

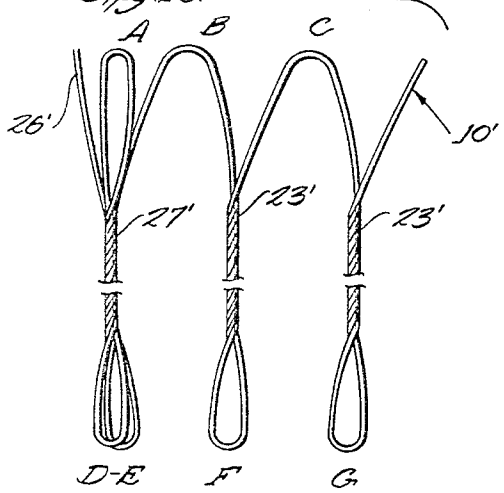
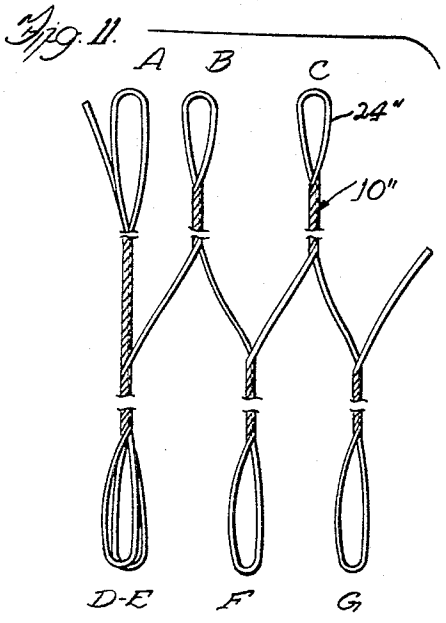


Fig. 11.



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3,331,178

WIRE MAT

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9 Claims. (Cl. 52—660)

This invention relates to a wire mat particularly suitable for use in prestressing concrete sheets and other members, and to the method of forming such a mat.

In Patent No. 3,084,910, issued Apr. 9, 1963, a method and apparatus are disclosed for forming prestressed concrete sheets. An arrangement of tensors is provided for tensioning a plurality of wires over a bed, each tensor in its preferred form comprising a horizontal rod carried by a plurality of arms or shoes which pivot at their ends about a horizontal pivot line parallel with but spaced from the axis of the rod. A power-operated lever is connected to the tensor for slowly pivoting it to shift the horizontal rod downwardly and outwardly away from the bed, thereby stretching and tensioning the wires which are looped about the rod and which span the bed. When the self-locking tensor is fully lowered and the wires have reached maximum predetermined tension, a layer of wet concrete is applied to the bed and, after the concrete has fully hardened, the tensor is disconnected from the exposed ends of the imbedded wires.

For effective stressing of the concrete sheet or other member, it is essential that the stretched and highly-tensioned wires be securely anchored within the concrete. Otherwise, the wires would contract as soon as they are cut or disconnected from the tensor and the concrete in which such wires are imbedded would not be stressed. It is for this reason, among others, that multiple strand twisted wire is preferred; the uneven contour of such wire plays an important part in achieving a secure interlock between that wire and the surrounding concrete.

Despite its important advantages, twisted wire has significant disadvantages which makes it difficult, expensive, and even dangerous to use in forming prestressed concrete members. A particular problem concerns the wide range and dangerously unpredictable level of maximum tension which such wire is capable of withstanding depending upon whether it is tensioned along a straight or curved line. Where the wire curves sharply, as where it is looped around the horizontal rod of a tensor, the different radii of curvatures for the various strands at any given point of contact with the tensor rod results in unequal stressing of the strands. The outermost strand at any given point is under greater stress and tends to cut into the strand or strands in contact with the surface of the tensor rod. Should one strand be severed by an adjacent strand, a type of chain reaction occurs with many strands breaking, often at the same point, and the wire, with its tension suddenly relieved, lashing or whipping about. It should be noted that if any slippage or relative movement occurs between the wire and the smooth surface of the tensor rod during the tensioning step, such relative movement significantly increases the possibility of the self-severing action of the twisted wire.

Another problem relates to the difficulty of determining the stress limits of twisted wire because of the slight stretchability which inherently results from its twisted character. Even where such wire is cut into precisely equal lengths and each length is provided with its own terminals on opposite sides of the bed, the variations in the stress limits of each stretch of wire over the bed may give rise to breakage problems. Where a single piece of twisted wire is strung back and forth over the bed to form an integral wire mat, the danger of breakage is substantially greater because of the tendency of the various

stretches to equalize their tension, and thereby slip over the smooth rounded surface of the tensor rod, as the tensor is shifted downwardly into its wire-tensioning position.

Accordingly, it is a principal object of the present invention to overcome the aforementioned defects and disadvantages in the wires and wire mats used in forming prestressed concrete members. Another object is to provide a wire mat for use in forming prestressed concrete members which has all of the important advantages of twisted wire without the above-described disadvantages thereof. A further object is to provide a mat of twisted wire which may be used in conjunction with the prestressing apparatus and method disclosed in the aforementioned copending application without danger that one strand will tend to sever another against the outer surface of the tensor rod.

Another object of the present invention is to provide a one-piece wire mat which does not require reuse of conventional terminals and which therefore eliminates the disadvantages and problems inherent in the use of such terminals.

Other objects will appear from the specification and drawings in which:

FIGURE 1 is a broken top plan view of a bed and wire tensioning apparatus, the apparatus holding in fully tensioned state a wire mat embodying the present invention;

FIGURE 2 is a side elevational view of the bed, apparatus and mat shown in FIGURE 1;

FIGURE 3 is an enlarged broken perspective view illustrating in detail the relationship between the tensor of the apparatus and the wire mat;

FIGURE 4 is a broken perspective view illustrating the structural details of the mat;

FIGURE 5 is a perspective view of an apparatus for use in forming the mat shown in FIGURE 4;

FIGURE 6 is an enlarged broken top plan view illustrating an intermediate step in the formation of the mat;

FIGURE 7 is a top plan view similar to FIGURE 6 but of reduced scale and illustrating a subsequent twisting step in the formation of the mat;

FIGURE 8 is a broken and somewhat diagrammatic plan view of a wire mat prior to the twisting of adjacent stretches thereof;

FIGURE 9 illustrates one way in which the wire shown in FIGURE 8 may be twisted to form a completed mat;

FIGURE 10 illustrates a second way in which the wire of FIGURE 8 may be twisted to form a completed mat;

FIGURE 11 illustrates a third way in which the wire of FIGURE 8 may be twisted to form a completed mat.

Referring to FIGURES 1–11 of the drawings, the numeral **10** generally designates a mat which embodies the present invention and which is formed from a single piece of wire or other filament. The word "wire" is here used to mean a filament formed of metal or any other material having the requisite characteristics of strength and durability. While in most instances the wire is preferably formed of steel or other suitable metal, it is to be understood that the "wire" may alternatively be formed of nylon or other plastics.

In FIGURES 1, 2 and 3 the mat is shown in use in conjunction with a bed A and tensor B of the type generally disclosed in Patent No. 3,084,910 to which reference has previously been made. The bed consists essentially of a slab **11** having a top surface **12** in the shape of a concrete member **13** to be formed thereon. In the illustration given, surface **12** is flat and member **13** constitutes a thin concrete sheet. On opposite sides of the bed are upstanding posts **14** and **15**. Posts **14** bear against

one side of slab 11 and brace the foundation 16 as well as the horizontal rod 17 which is held tightly against the posts by the highly tensioned wires looped thereabout.

The series of spaced upstanding posts 15 along the opposite side of the slab are interposed between that slab and an inclined platform 18. The platform is horizontally elongated and slants transversely upwardly towards the series of posts 15 to provide an inclined supporting surface for tensor B.

The tensor consists essentially of a horizontal rod 19 which is rotatably supported in the end notches 20 of a plurality of inwardly extending pivot arms or shoes 21. All of the spaced parallel arms are rigidly interconnected by a connecting bar 22 and the inner ends of the arms are rounded (in vertical planes) and bear against posts 15 and platform 18. Thus, the tensor B is capable of pivoting about a pivot line parallel with and spaced inwardly with respect to the axis of tensor rod 19, the range of pivotal movement being represented in FIGURES 2 and 3 by the raised position of FIGURE 3 (also shown in broken lines in FIGURE 2) and the lowered position of FIGURE 2.

When the tensor is in its fully lowered position, the axis of rod 19 is spaced below the pivot line of the tensor and the tension of the stretched wire mat effectively locks the tensor in place. During the wire-tensioning operation, as the tensor is pivoted downwardly, rod 19 is free to rotate about its own axis and within the notches 20 of the pivot arms, thereby eliminating or reducing slipping contact between the wire and the rod. Downward pivoting movement of the tensor is most easily accomplished by connecting a suitable lever extension (not shown) to the tensor to increase the mechanical advantage of the applied force. Such a lever assembly and a form of winch used in connection with its operation are fully disclosed in the aforesaid copending application and, since they form no part of the present invention, need not be described in detail herein.

Mat 10 consists of a single strand of wire which extends between the stationary horizontal rod 17 and tensor rod 19. With the exception of the terminal stretches, all of the stretches of wire which extend back and forth between the stationary rod and the tensor rod are of substantially identical length. Since the rod 17 extends along the same horizontal plane as the uppermost edge portion of platform 18, the stretches of fully tensioned wire extend in the same horizontal plane between spaced points along a pair of spaced parallel lines.

Referring to FIGURES 4, 9 and 1, it will be observed that adjacent stretches of the wire have their intermediate portions twisted together to provide a plurality of parallel double-strand intermediate sections 23. At one end of each intermediate section is a single-strand loop 24 which, in the illustrations given, is fitted over stationary rod 17. At the opposite ends of the intermediate sections (and along the opposite side of the mat) are a plurality of single-strand loops 25 which interconnect adjacent intermediate sections of the mat. In contrast to bridging loops 25, each of the loops 24 is closed and extends to only a single intermediate section.

The terminal stretch of wire 26 returns to the terminal intermediate section 27 so that such section differs from the other intermediate sections 23 in being formed of three strands twisted together. As a result of such construction, closed loops 24 and 28 are provided at opposite ends of each terminal intermediate section 27. The extreme end of terminal stretch 26 may be affixed to the remaining strands of the intermediate portion 27 by any suitable connecting means; however, it has been found that if the mat is of sufficient size and the terminal intermediate portion 27 is sufficiently twisted, no additional connection between the three strands of the section 27 is required.

Each of the two-strand intermediate sections 23 has an identical number of twists. The terminal intermediate

portions 27 may have one or more fewer twists to compensate for their greater thickness. The result is a mat having a plurality of integral elements (each element consisting of end and intermediate sections) of substantially identical overall or total length.

The mat 10 is formed from a single strand of wire by the method illustrated in FIGURE 5 through 7. The single-strand wire is commercially available on large spools and, as a preliminary step in the formation of the mat, the wire 29 is unwound from the spool (not shown) onto reel 30. The reel may be generally H-shaped composed of a plurality of interconnected side, end, and intermediate members 31, 32, and 33, respectively. The reel is rotatably mounted upon a horizontal shaft 34 which passes through the centers of intermediate members 33, thereby facilitating the winding of the wire 29 under generally uniform tension upon the reel. End members 32 are all parallel with each other and are preferably provided with a series of spaced-apart arcuate recesses 35, each of the recesses being adapted for slidably supporting only a single coil of the wire 29 wrapped about the reel. The wire is wound about the spool with a degree of resistance sufficient to place equal lengths of wire about each turn of the reel.

After the wire is fully wound upon the reel but has not been severed from the supply spool, two series of pulleys 36 and 37 are brought into contact with the inner surfaces of the coils of wire as shown in FIGURE 5. The two sets of pulleys 36 and 37 are rotatable about axes which are parallel with each other and with the end members 32 of the reel. Each pulley is independently rotatable about its own axis, and at least one of the sets is constructed so that the pulleys thereof may also be rotated about the axes of their mountings. In the illustration given, the pulleys of set 36 are independently rotatable about the axle 39 of individual mounting elements 40, although it is to be understood (for reasons which will appear hereinafter) that the pulleys of set 37 may be similarly mounted, rather than being mounted upon a single shaft 38. It will also be noted that the spacing between the pulleys of each set corresponds with the spacing between the recesses 35 of each end member 32. Therefore, as the two sets of pulleys are drawn outwardly in opposite directions, the groove of each pulley receives a portion of a single coil of the wire 29 wound about the reel 30.

The particular carriage means used to support each set of pulleys for outward movement with respect to the reel may vary considerably depending upon the size, location and capacity of the particular installation. Whatever the design of the particular carriage means, it is essential in forming a rectangular mat that the axes of the two sets of pulleys remain at all times in parallel relation with each other. Since the wire 29 remains connected to the supply spool (not shown), and since the wire is freely slidable within the recesses 35 of end members 32, outward movement of the two sets of rollers produces longitudinal sliding movement of the wire 29 about the reel. Additional wire, as it is required, is provided by the supply spool. Outward movement of the pulleys is continued until the stretches of wire extending back and forth between the parallel rolls of pulleys are of a preselected length. The wire is severed from the supply spool and, with opposite ends of the wire entrained about the pulleys anchored securely in place, a predetermined outward force is applied to the two sets of pulleys 36 and 37 to produce uniform tension in all of the stretches 29 of wire.

Where only a relatively small mat is desired, the wire may be wound upon the reel in uniformly tensioned condition, and thereafter removed from the reel, by disassembling, partially collapsing, or otherwise reducing the size of the reel, for placement of the wire upon an arrangement of opposing pulleys.

Thereafter, each of the pulleys 36 is rotated about a radial axis generally parallel with the stretches of wire extending therefrom (FIGURE 7). The pulleys 36, with the possible exception of terminal pulleys 36*a*, are rotated an identical number of turns in the same or different direction. The terminal pulleys 36*a* may be rotated one or more fewer turns in the same or different direction because of the fact that the terminal intermediate sections 27 comprises three strands of wire rather than only two strands as in intermediate sections 23. When the wire is fully twisted, the looped end sections 24, 25 and 28 are removed from the pulleys. The results is a mat formed of wire having generally parallel elements of equal length, each element consisting of a double strand intermediate section (except for the terminal elements) and single strand end sections.

Since the end sections are only of single strand construction, they may be looped about the horizontal movable tensor rod 19, or the stationary vertical tensor rods 17, of the apparatus illustrated in FIGURE 1, and the wire elements of the mat may then be stressed or stretched without danger that one strand might sever another strand in contact with the tensor rods. Furthermore, since the elements of the mat are of identical length, with all of the two-strand intermediate portions having an identical number of turns or twists, there is no appreciable longitudinal sliding movement of the wire over the tensor rods during a tensioning operation. These important results are achieved while at the same time providing a mat having wire elements with twisted intermediate sections. Such sections constitute the principal length of each wire element and are essentially the only sections imbedded in the concrete member formed thereabout. Therefore, because of the twisted character of the imbedded wire, the chances of wire slippage in the finished concrete product are substantially eliminated.

FIGURES 8 through 11 illustrate different ways in which the same wire, previously stretched and preformed by the means illustrated in FIGURES 5 and 6, may be twisted to form mats of different configuration. Starting with the wire with parallel stretches 29 as illustrated in FIGURE 8, the looped ends designated by the letters A, B and C may be rotated by pulleys 36 in the manner already described to form the completed mat 10 (FIGURE 9) in which A, B and C become closed loops 24. Loops D–G, supported by pulleys 37 all carried upon the same shaft 38, form open loops 25 and closed loop 28 in the final mat 10.

The same wire of FIGURE 8 may be twisted differently to form the modified mat 10′ illustrated in FIGURE 10. Mat 10′ is formed by superimposing loops D and E, and twisting them simultaneously while holding loops A, B and C stationary. Loops F and G are separately twisted in the same manner as composite loops D, E. As in mat 10, the intermediate portions 23′ of mat 10′ are twisted the same number of turns, whereas the terminal intermediate portion 27′ has a lesser number of turns to form twisted elements of equal length. One advantage of mat 10′ over mat 10 lies in a more secure connection between the terminal stretch 26′ and the remaining wire portions which form the terminal element.

The mat 10″ of FIGURE 11 is similar to the mat 10′ of FIGURE 10 except that the pulleys supporting loops A, B and C have been rotated as well as the pulleys supporting loops D–E, F and G. In other words, mat 10′ is formed by twisting the wire of FIGURE 8 from all of the looped ends, the apparatus for performing such an operation consisting, as already indicated, of opposing sets of independently mounted pulleys 36.

From the foregoing, it is believed apparent that mats having single strand looped end portions and twisted intermediate elements may assume a variety of configurations. All of the elements of such mats are of substantialy identical length and, therefore, there is no appreciable longitudinal sliding movement of the wire over the tensor rods during a tensioning operation. Since the portion of the mat embedded in the concrete consists primarily of twisted wire, the mat is firmly anchored in place and is well able to perform its essential function in prestressing the surrounding concrete body.

While several embodiments have been disclosed in considerable detail for purposes of illustration, it will be understood by those skilled in the art that many of these details may be varied without departing from the spirit and scope of the invention.

I claim:

1. A pre-formed wire mat for use in prestressing concrete members comprising a strand of wire extending between spaced points along a pair of spaced parallel lines to define a plurality of stretches of wire of substantially identical length, adjacent stretches of said wire having intermediate portions thereof twisted together to provide a plurality of parallel double-strand intermediate sections, all of the double-strand intermediate sections of said mat having an identical number of twists, each of said intermediate sections having the twists thereof extending in the same rotative direction and comprising an identical number of twists of each of the wires forming such section, said mat including end sections at opposite ends of said intermediate sections, said end sections consisting of single-strand loops adapted to receive tensor rods for the stressing of said wire mat, the loops along one side of said mat interconnecting adjacent double-strand intermediate sections of the mat.

2. The structure of claim 1 in which each of the loops at the opposite side of said mat is closed and extends to only a single double-strand intermediate section.

3. A pre-formed wire mat for use in prestressing concrete members, said mat comprising a plurality of generally parallel wire elements extending from one side to the other side thereof, each of said elements having a multiple-strand intermediate section and single-strand loops at opposite ends thereof, the strands of each of said elements being of substantially identical length, the loop at one end of each element being closed and a loop at the opposite end thereof being open and connecting the intermediate sections of adjacent elements, said single-strand loops being adapted to receive tensor rods for the stressing of the elements of said wire mat, each multiple-strand intermediate section being twisted and having the twists thereof all extending in the same rotative direction and composed of an identical number of twists of each of the strands of such section.

4. The structure of claim 3 in which all of said elements excluding the terminal elements of said mat have double-strand intermediate sections.

5. The structure of claim 4 in which said multiple-strand intermediate sections all have identical numbers of twists.

6. The structure of claim 4 in which the terminal elements of said mat are provided with intermediate sections each having a greater number of strands of wire twisted together than the intermediate sections of the other remaining elements, the number of twists of intermediate sections of each of said terminal elements being no greater than the number of twists of each of said other elements.

7. A pre-formed wire mat for use in prestressing concrete members, said mat being formed from a single piece of single-strand wire and comprising a plurality of generally parallel wire elements extending from one side to the other side thereof, each of said elements having multiple-strand intermediate sections and single-strand loops at opposite ends thereof, the strands of each of said elements being of substantially identical length, the intermediate sections of all of said elements other than the terminal elements of said mat consisting of twisted double strands of wire having identical number of twists, the loop at one end of each element of said mat being closed

and a loop at the opposite end thereof being open and connecting the intermediate sections of adjacent elements, said single-strand loops being adapted to receive tensor rods for the stressing of the elements of said wire mat, each multiple-strand intermediate section having the twists thereof all extending in the same rotative direction and composed of an identical number of twists of each of the strands of such section.

8. The structure of claim 7 in which the terminal elements of said mat are each provided with intermediate sections having at least three strands of wire twisted together.

9. The structure of claim 7 in which all of the elements of said mat are of substantially identical length.

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