United States Patent [19]

Richardson

[11] **3,783,736**

[45] **Jan. 8, 1974**

[54] **BRAIDING MACHINE**

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[52] U.S. Cl. **87/29,** 87/37, 87/38, 87/50, 87/51

[51] Int. Cl. **D04c 3/02,** D04c 3/40

[58] Field of Search 87/6, 28–30, 87/33, 37, 38, 50, 51, 55

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Primary Examiner—John Petrakes
Attorney—Synnestvedt & Lechner

[57] **ABSTRACT**

A maypole-type braider for the reinforcing of hose and other tubular products and for the production of ropes, cables and the like, having mechanism for directing strand supply carrier spindles in intersecting serpentine paths around a braiding point, the mechanism including a circle of carrier spindle drivers, cooperating means on the drivers and carrier spindles for retaining each carrier spindle in contact with a driver while it is being driven thereby and for transferring each carrier spindle from a driver to a next adjacent driver of the circle, said cooperating means eliminating the necessity of a track plate or other stationary part acting upon the carrier spindles, the braider also including means for maintaining a strand pay-off point of each carrier substantially on a line drawn through the center of the spindle and the braiding point during the travel of the carrier spindles in their serpentine paths around the braiding point, the last-mentioned means contributing to the operation of the carrier spindle retaining and transfer means.

14 Claims, 16 Drawing Figures

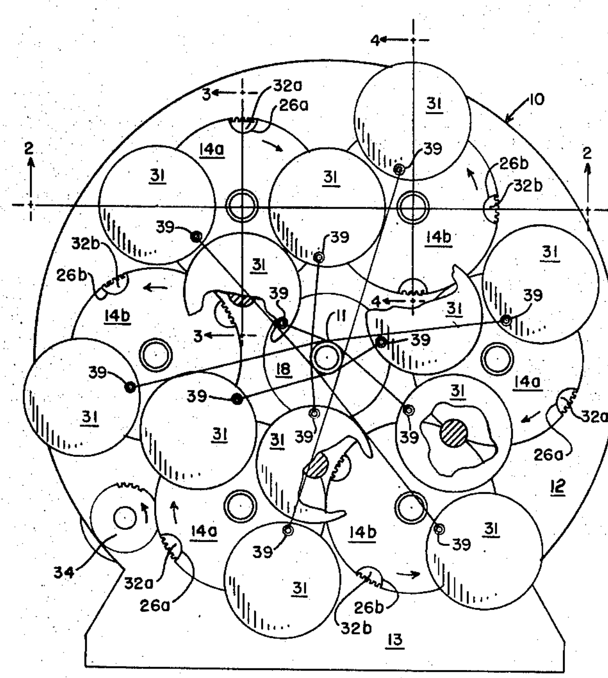
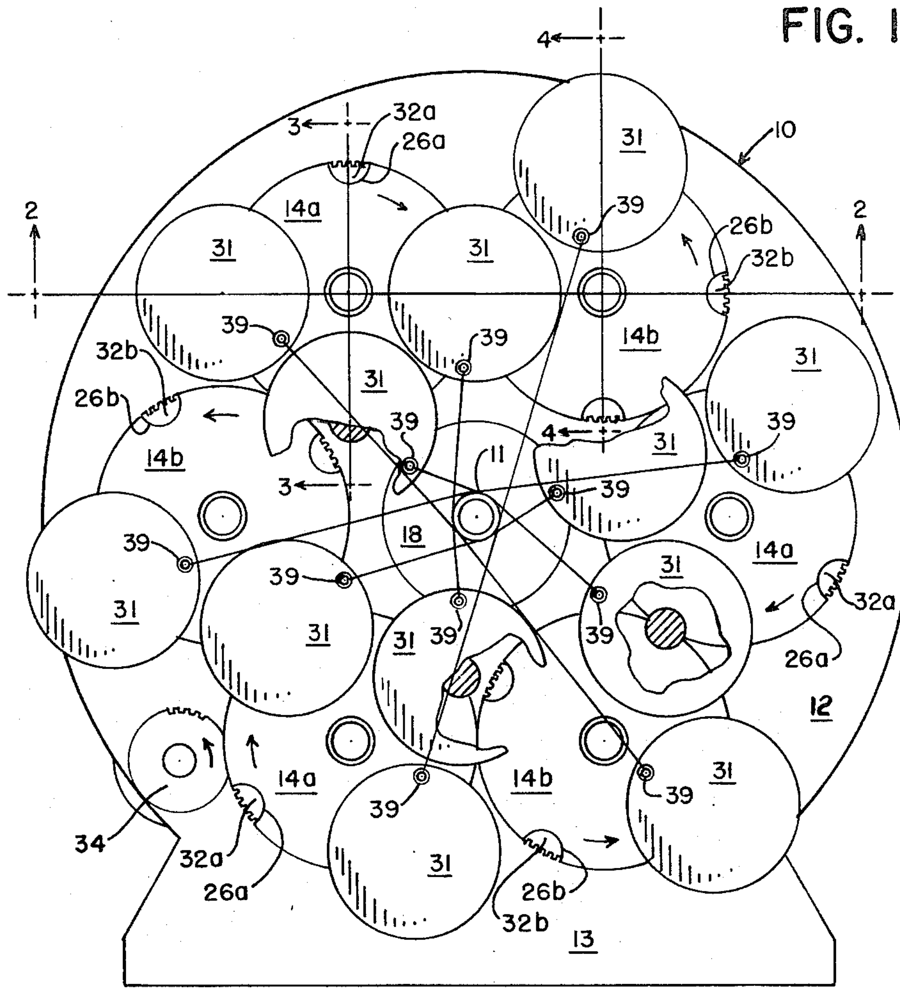


FIG. 1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31
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14a
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26b
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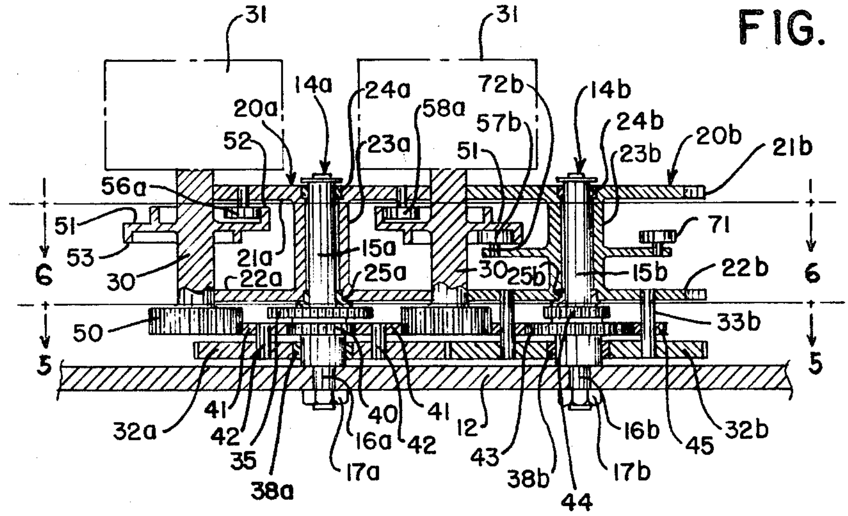
4
14b
3
11
39
18
14a
39
39
32a
31
26a
39
31
31
39
12
34
14a
14b
39
32a
26a
39
26b
32b
13

FIG. 2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24b
20b
21b
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23a
57b
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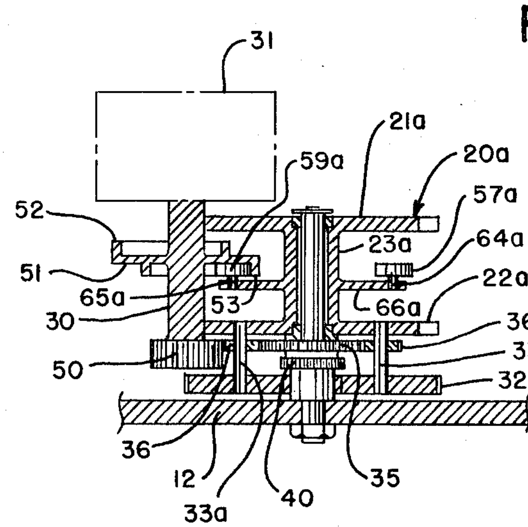
51
71
53
6
21a
15a
30
25b
15b
22b
6
30
22a
25a
30
50
33b
5
5
32a
41
40
41
12
16a
42
42
35
17a
43
38b
16b
45
32b
38a
44
17b

FIG. 3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57a
52
23a
64a
51
22a
65a
53
66a
30
36
33a
50
32a
36
12
40
35
33a

FIG. 4

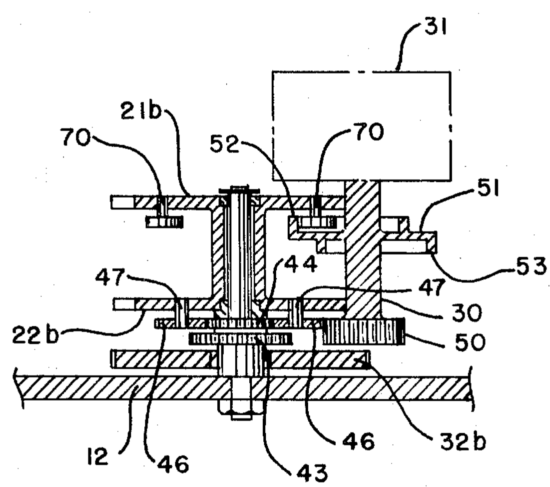

31
21b
70
70
52
51
44
53
47
47
30
22b
50
46
12
46
43
32b

FIG. 5

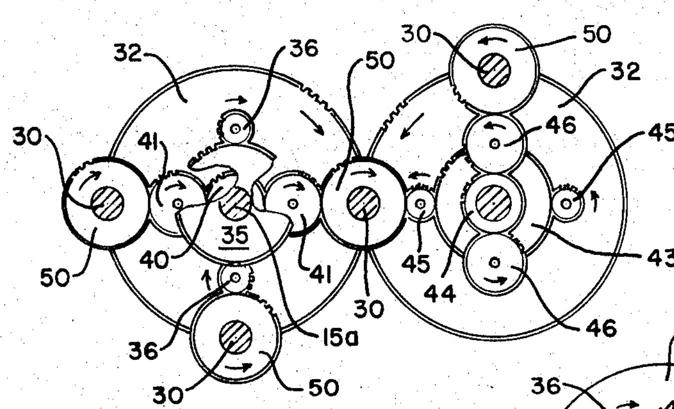


FIG. 5a

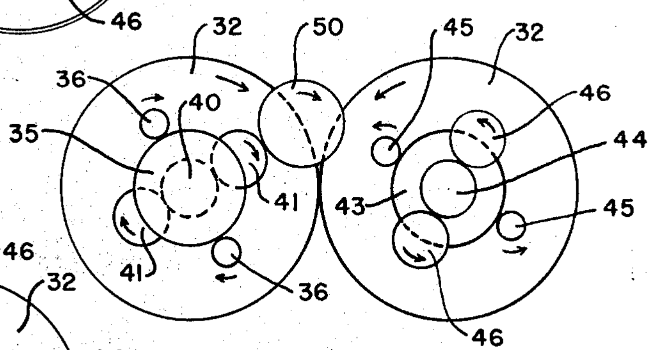


FIG. 5b

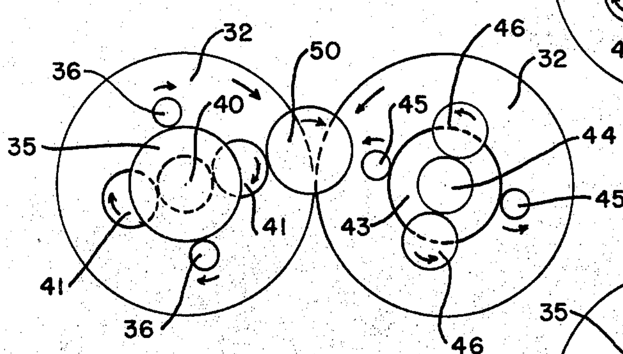


FIG. 5c

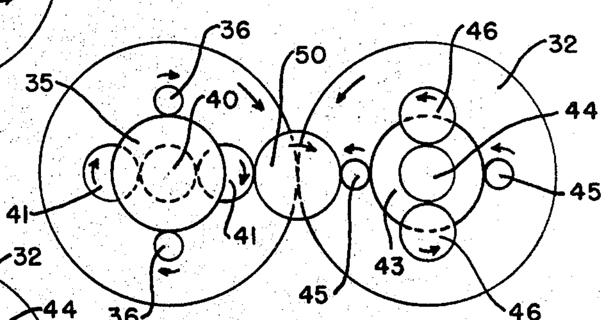


FIG. 5d

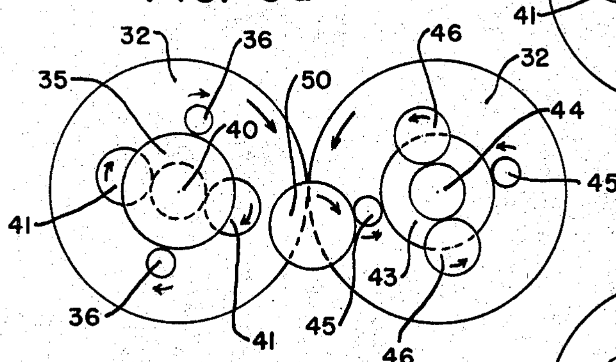
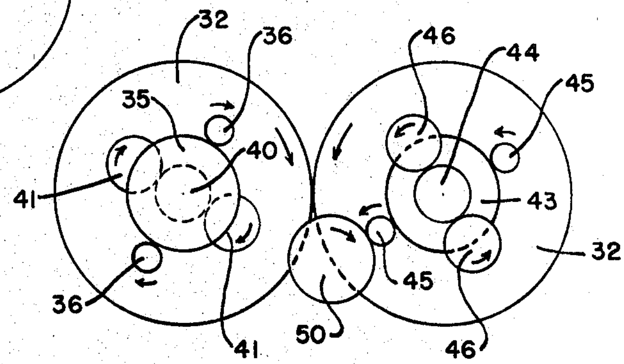


FIG. 5e



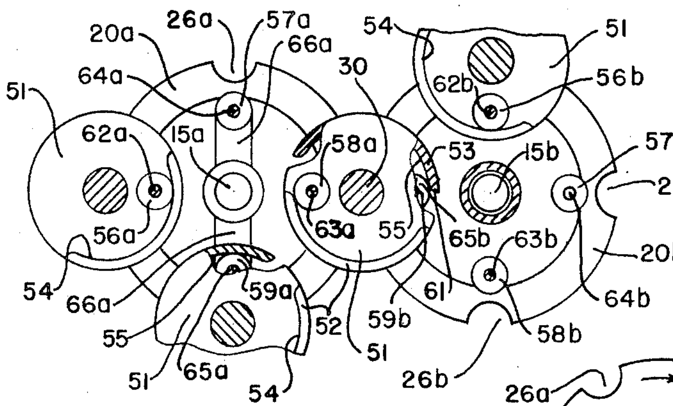


FIG. 6

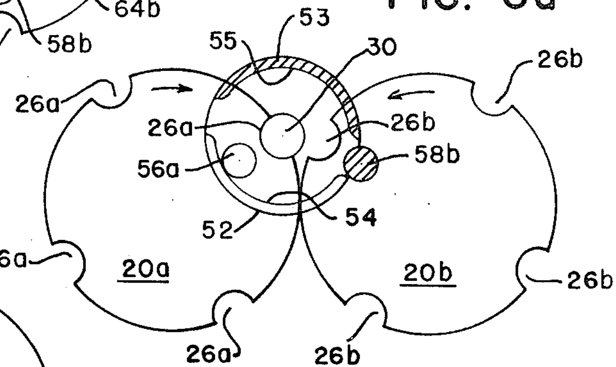


FIG. 6a

FIG. 6b

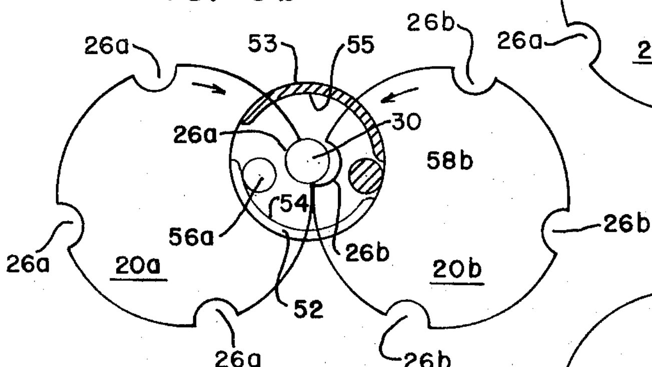


FIG. 6c

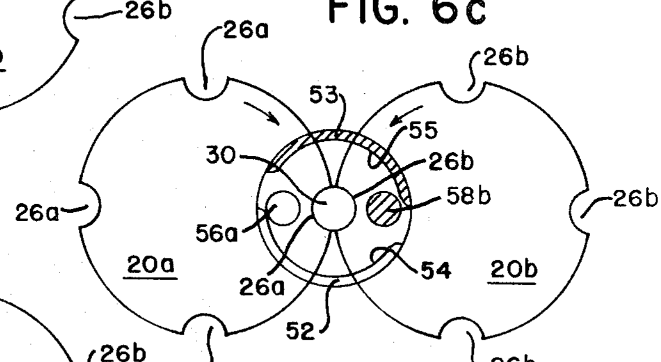


FIG. 6d

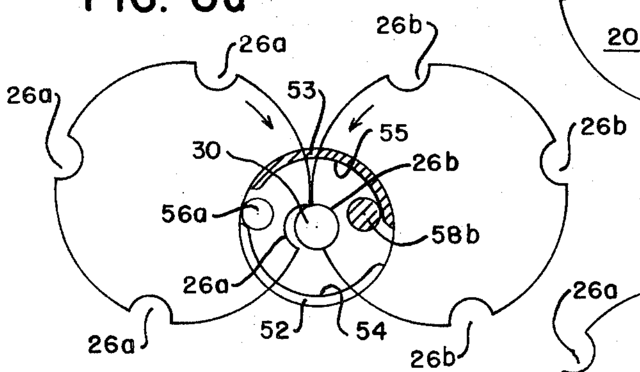
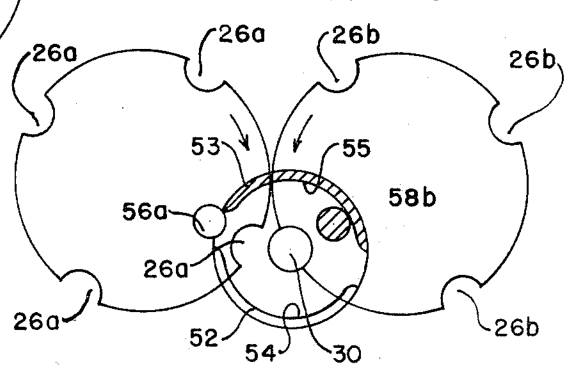


FIG. 6e



BRAIDING MACHINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is directed to improvements in maypole braiders as employed in the reinforcement of hose or the like and in the manufacture of ropes and other products, the braiders being of the type employing a plurality of strand supply carrier spindles moving in serpentine paths around the braiding point, with driver means for the carrier spindles, the drivers involving rotors with successive rotors rotating in opposite directions. More particularly, the invention is directed to a braider construction eliminating the need of a track or race plate or other stationary element for the transfer of the carrier spindles from the rotor of one driver to the rotor of a next adjacent driver, conventionally employed in commercial braiders, and also eliminating the inertial forces normally created by the instantaneous change of direction of rotation of a carrier spindle as it is transferred from one rotor to the next rotor rotating in an opposite direction.

1. Description of the Prior Art

Heretofore braiders have been developed which do not have track or race plates. In this connection, reference is made to U. S. Pats. Nos. to Dickhouse 578,916 issued Mar. 16, 1897; Diebold 1,028,446 issued June 4, 1912; Elliott 1,103,181 issued July 14, 1914; and Diebold 1,296,271 issued Mar. 4, 1919; and also to German Patent 1,947,976 issued Mar. 4, 1971. However, these prior proposed constructions still require an interaction between the strand supply carrier spindles and stationary portions of the machine in the transfer of each carrier spindle from one driver to an adjacent driver with the attendant disadvantages that excessive noise and wear problems are created and high equipment costs are involved.

A braiding machine for the production of rope products has also been proposed as disclosed in U. S. Pat. No. to Koreki et al. 3,371,573 issued Mar. 5, 1968 which includes mechanism for rotating the strand supply carriers on their own axes at an angular velocity equal to that of the driving rotors which move them through their serpentine paths around the braiding point, and in directions opposite to the directions of rotation of the rotors, the purpose being to prevent reverse twisting and excess twisting of the braiding strands. While this construction also contributes to the elimination of inertial forces during the transfer of the carriers, at least two adverse effects remain. Firstly, the strand pay-off point of each strand supply carrier must constantly and widely vary from a line drawn through the center of the carrier spindle and the braiding point as the carrier spindle makes one complete rotation therearound. Secondly, the construction still necessitates the involvement of stationary parts in the transfer of the carriers from rotor to rotor with the attendant disadvantages noted above.

SUMMARY OF THE INVENTION

The principal object of the instant invention is the provision of a braider of the maypole type and which is particularly adapted for the reinforcement of hose and other tubular elements or for the production of ropes, cables and the like in which a series of strand supply carrier spindles are driven in serpentine paths around a braiding point by a circular series of drivers having rotors with the rotors of adjacent drivers rotating in opposite directions, and in which each strand supply carrier spindle is rotated on its own axis, the rotation being so controlled that a reversal of the direction of rotation of the spindle as it is transferred from one driver rotor to the next driver rotor is avoided, whereby the inertial forces which otherwise would be created are eliminated and also the transfer of each carrier spindle from one driver to another can be accomplished without subjecting the carrier spindle to interaction with fixed portions of the machine such as cam tracks and cams.

Another object of the invention in its preferred embodiment is the provision of a braider attaining the foregoing object in which the means for rotating each strand supply carrier spindle on its own axis maintains a strand supply pay-off point of the carrier substantially on a line drawn through the center of the carrier and the braiding point as the spindle travels in its serpentine path there-around.

Another object of the invention is the provision of a braider attaining the foregoing objects in which the transfer of each strand supply carrier spindle from one driver rotor to an adjacent driver rotor is performed solely by cooperating elements on the rotors and carrier spindles, whereby a smooth transfer is effected with substantial reduction in noise, friction loads and other undesirable factors, as compared to known carrier spindle transfer means involving fixed machine elements.

A further object of the invention is the provision of a braider attaining the foregoing objects which can be operated at substantially higher speeds, permits the use of simplified strand supply carriers, and is of a less expensive construction than known braiders.

The aforementioned objects of the invention are attained by a maypole-type braider incorporating the invention, the braider requiring no deck or race plate and comprising a circular series of drivers surrounding the braiding point and strand supply carrier spindles driven thereby. The drivers include rotors and mechanism for rotating adjacent rotors in opposite directions, the rotors having pockets in their peripheries to receive the carrier spindles and, in conjunction with cooperative means on the carrier spindles and rotors which retain the carrier spindles within the pockets, to propel each carrier spindle from a point of transfer from a preceding driver rotor to a point of transfer to a succeeding driver rotor without contact of the carrier spindle with a deck plate or other stationary part or with a part moving at a different velocity than the carrier spindle.

Each driver includes a gear system for driving relationship to a gear affixed to each carrier spindle when it is driven thereby, the relationship of the gears being such that each carrier spindle is rotated relatively to each of the successive drivers by which it is driven and independently thereof to maintain a constant direction and rate of rotation as it travels its serpentine path around the braiding point. The gearing system in the preferred embodiment of the invention is of the planetary type and the relationship between the several gears of the system is such that a strand pay-off point on each strand supply carrier spindle is maintained substantially on a line connecting the center of the spindle and the braiding point during the entire travel of the spindle through its serpentine path around the braiding point.

The planetary gear system, in addition to eliminating the inertial forces normally encountered during the transfer of the carriers, contributes to the operation of the cooperative means on the carrier spindles and rotors for retaining the carrier spindles in the rotor pockets and to the transfer of each carrier spindle from the pocket of a rotor to the pocket of an adjacent rotor at the transfer point.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevation view, with parts broken away for clearness of illustration, of a braiding machine of the horizontal type, the braiding machine incorporating the machanisms of the instant invention;

FIG. 2 is a sectional view taken on the line 2—2 of FIG. 1 and looking in the direction of the arrows;

FIG. 3 is a sectional view taken on the line 3—3 of FIG. 1 and looking in the direction of the arrows;

FIG. 4 is a sectional view taken on the line 4—4 of FIG. 1 and looking in the direction of the arrows;

FIG. 5 is a sectional view, with parts broken away for clearness of illustration, taken on the line 5—5 of FIG. 2 and looking in the direction of the arrows, the view illustrating gear systems carried by the drivers, the gear systems being in the positions they assume at the time of transfer of a carrier spindle from one rotor to a next adjacent rotor;

FIGS. 5*a* to 5*e* inclusive are diagrammatic views taken on the same line as FIG. 5, with parts deleted, illustrating successive steps in the operation of the gear systems as a carrier spindle moves from a position prior to that shown in FIG. 5 to a position subsequent thereto;

FIG. 6 is a sectional view, with parts broken away for clearness of illustration, taken on the line 6—6 of FIG. 2 looking in the direction of the arrows with a strand supply carrier spindle shown at the point of transfer from one rotor to an adjacent rotor; and

FIGS. 6*a* to 6*e* inclusive are diagramatic views taken on the same line as FIG. 6, with parts deleted, illustrating successive steps in the carrier spindle transferring operation from a position prior to that shown in FIG. 6 to a position subsequent thereto.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, there is shown the braiding head **10** of a braiding machine of the horizontal type, but, as will be understood, the invention is equally applicable to vertical-type braiding machines. The machine is shown in FIG. 1 as employed for the application of a reinforcing braided covering of wire or textile strands to a tubular hose **11** or the like, However, as previously mentioned, a machine of the invention is in no way limited to this use and may be employed in the manufacture of ropes, cables and other products. The frame of the machine includes a base plate **12** supported in a vertical position from the floor or other foundation by a foot portion **13**, plate **12** having a central opening **18** through which the hose **11** passes. As will be noted, a race or track plate or equivalent structure, as employed in conventional commercial braiders, is not required.

The base plate **12** supports a circular series of drivers, alternate drivers being indicated by the reference characters **14*a*** and intervening drivers by the reference characters **14*b***. Drivers **14*a*** and **14*b*** include posts **15*a*** and **15*b*** respectively, the posts having lower end portions **16*a*** and **16*b*** respectively which penetrate openings in the base plate **12** and which are threaded to receive nuts **17*a*** and **17*b*** respectively whereby the posts are secured in fixed positions on the base plate **12** and against rotation relatively thereto. Drivers **14*a*** and **14*b*** additionally include rotors **20*a*** and **20*b*** respectively, the rotors consisting of upper and lower circular plates **21*a*** and **22*a*** and **21*b*** and **22*b*** respectively, the plates being connected by preferably integral tubular portions **23*a*** and **23*b*** mounted for rotation on posts **15*a*** and **15*b*** respectively. Suitably, bearing members **24*a*** and **24*b*** and **25*a*** and **25*b*** of any desired type are interposed between the posts and the tubular portions of the rotors. Rotors **20*a*** and **20*b*** are of equal diameters which are such that the periphery of each rotor **20*a*** is in substantially tangential relationship to the periphery of the adjacent rotors **20*b*** at their points of closest adjacency. The plates **21*a*** and **22*a*** of each rotor **20*a***, and the plates **21*b*** and **22*b*** of each rotor **20*b*** are provided with four pockets **26*a*** and **26*b*** respectively spaced 90° apart, each pocket of plates **21*a*** and **21*b*** being in alignment with a pocket of plates **22*a*** and **22*b*** respectively. The pockets are so located that at the points of closest adjacency between the plates of successive rotors, hereinafter referred to as the "carrier spindle transfer points," the pockets will lie in opposed relationship to each other. The pockets are adapted to receive the spindles **30** of a succession of strand supply carriers indicated diagrammatically at **31** and to convey the spindles and the strand supply carriers supported thereby in intersecting serpentine paths around the braiding point at the hose **11**, each carrier spindle being retained in a rotor pocket as it is conveyed thereby and being transferred from such pocket to the pocket of a rotor rotating in the opposite direction at each transfer point by mechanisms later to be described in detail.

Posts **15*a*** and **15*b*** support gears **32*a*** and **32*b*** respectively for free rotation thereon, suitable bearing members **38*a*** and **38*b*** being interposed between the posts and the gears. The gears **32*a*** of drivers **14*a*** and the gears **32*b*** of drivers **14*b*** are of the same pitch diameter, the diameter being such that the teeth of adjacent gears are in intermeshing engagement. The gear **32*a*** of each driver **14*a*** (see FIG. 3) is connected to the rotor of the driver to cause rotation of the rotor with the gear by means of a pair of pins **33*a*** spaced 180° apart on opposite sides of the axis of the rotor, one end of each pin being affixed to the gear **32*a*** and the other end affixed to the lower plate **22*a*** of the rotor **20*a***. Similarly, gear **32*b*** of each driver **14*b*** (see FIG. 2) is connected to the rotor of the driver by a pair of pins **33*b*** spaced 180° apart and affixed to gear **32*b*** and plate **22*b***. Pins **33*a*** and **33*b*** also perform additional functions as will be later explained. The succession of gears **32*a*** and **32*b*** and their associated rotors **20*a*** and **20*b*** respectively are driven by a gear **34** having its teeth in intermeshing engagement with the teeth of one of the gears **32*a*** (see FIG. 1), gear **34** being in turn driven by any suitable driving means such as a motor (not shown). It will be understood that as a result, each rotor will be driven in a direction opposite that of its adjacent rotors. In the construction shown, rotors **20*a*** will rotate in a clockwise direction and rotors **20*b*** in a counterclockwise direction.

As previously pointed out, the braider of the instant invention includes means for controlling the rotation of each carrier spindle **30** independently of the rotation which will be imparted to it by the rotors **20***a* and **20***b* as it is moved around portions of the circumferences thereof, whereby the disadvantageous inertial forces normally created by the angular acceleration of the carrier spindles and the strand supply packages supported thereby during an abrupt change of direction of rotation of each carrier spindle as it is transferred from a rotor rotating in one direction to a rotor rotating in the opposite direction, is eliminated.

The independent rotation of the spindles also so orients them that a strand pay-off point or eye **39** of each strand supply carrier, and hence a corresponding point on each carrier spindle, is maintained substantially on a line drawn through the center of the carrier spindle and the braiding point at the hose **11** as the strand supply carriers move in their serpentine paths therearound. This particular orientation of the strand supply carriers has a number of additional advantages, as for example, better control of the braiding strands is obtained. Also, it contributes to the operation of the machanisms for retaining the carrier spindles in the notches of the rotors during their travel with the rotors and for transferring each carrier spindle from one rotor to an adjacent rotor at the transfer points.

The above referred-to orientation of the carrier spindles is obtained by gear trains which are conceptually the same for all sizes of braiders regardless of the number of carriers and drivers employed. However, it will be understood that the specific ratios of the gears of the trains will differ for each number of drivers employed. In the embodiment of the invention shown and described, six drivers and **12** strand supply carrier spindles are used, this necessitating, in order to achieve the orientation of the strand supply carriers with their strand pay-off points substantially on a line drawn through the center of the carrier spindle and the braiding point, as noted above, that the carrier spindles have a rotation continuously in one direction of one-third of a degree for each full degree of rotation of each driver rotor by which it is being driven irrespective of the direction of rotation of the rotor. Inasmuch as, in the absence of the independent rotation of the strand supply carriers, any point on the periphery of a carrier would be rotated in the same direction and to the same extent as the rotor by which it is carried, this requires that a carrier being driven by a rotor rotating in the same direction as the carrier is to be rotated have an arc of rotation relatively to the rotor of two-thirds of a degree in a direction opposite to that of the rotor for a full degree of rotation of the latter. On the other hand, when the carrier is being driven by a rotor rotating in a direction opposite to that in which the carrier is to be rotated, the carrier must have an arc of rotation relatively to the rotor and in the same direction as the rotor of one and one-third degrees for each full degree of rotation of the rotor.

Due to the fact that the rotors are arranged in a circle around the braiding point, each carrier spindle and associated strand supply carrier will, as it is being driven around an outer arc of rotation of a rotor, travel a greater distance than when it is being driven around an inner arc of such rotation. For example, in a six-rotor machine, the spindle will be driven through an outer arc of 240° and through an inner arc of 120°. As a result, the strand pay-off point of a carrier as the carrier travels in a serpentine path will actually vary between positions in which it lies directly on a line drawn through the center of the carrier and the braiding point and positions on opposite sides of such line spaced 10° therefrom. As the number of driver rotors increases, the angle of variation will be less. Thus, for braiders having twelve, eighteen and twenty-four driver rotors, the angle of variation in each direction will be 2.500°, 1.111° and 0.625° respectively. For the above reasons, in the description of the invention and in the appended claims the relationship of the strand pay-off point to the braiding point has been indicated to be "substantially" on a line drawn through the center of the carrier spindle and the braiding point, the term "substantially" being employed to include any and all of the variations resulting from the circular arrangement of the drivers irrespective of the number of drivers employed.

The required rotation of each carrier spindle may be obtained by various gear systems, but in the preferred embodiment of the invention disclosed, planetary gear systems are used as they are simpler and more reliable than other systems. The planetary gear systems employed (see FIGS. **2**, **3** and **5**) are fundamentally the same for each driver but vary in certain particulars with respect to the rotors which are rotated in a clockwise direction as compared to the rotors which are rotated in a counterclockwise direction. Referring first to the rotors **20***a* which are rotating in a clockwise direction, the planetary gear system for each rotor includes a nonrotatable gear **35** affixed to post **15***a* and in intermeshing engagement with each of a pair of gears **36** (see FIG. **3**), each gear of the pair being mounted for free rotation on one or the other of the pins **33***a* previously mentioned and supported thereon in alignment with gear **35** by any suitable means (not shown). The planetary gear system for the rotors **20***a* additionally includes a nonrotatable gear **40** affixed to post **15***a* similarly as gear **35** but inwardly thereof and of a substantially reduced pitch diameter as compared to gear **35**. Gear **40** is in intermeshing relationship with a pair of gears **41**, each of the gears **41** being mounted for free rotation on one of a pair of pins **42** affixed to and projecting outwardly from gear **32***a* and lying in a diametrical plane at right angles to the diametrical plane of pins **33***a*. The gears **41** are maintained in alignment with gear **40** by any suitable means (not shown). It is to be noted that each gear **41** is of sufficiently greater pitch diameter than the pitch diameters of gears **36** that the pitch diameter of a gear **41** added to the pitch radius of gear **40** is equal to the pitch diameter of a gear **36** added to the pitch radius of gear **35**.

The gear trains of the rotors **20***b* which rotate counterclockwise and which are best shown in FIGS. **2**, **4** and **5** have respectively the same gear ratios as the gear trains just described and employed in conjunction with the rotors **20***a* which rotate in a clockwise direction. However, a stationary gear **43** which corresponds to gear **35** is affixed to post **16***b* in the plane of gears **41** and a stationary gear **44** which corresponds to gear **40** is affixed to post **16***b* in the plane of gear **35**. Gears **45** mounted for free rotation on pins **33***b* and which correspond to gears **36** are supported on their pins **33***b* in the plane of gear **43** by any suitable means (not shown).

Gears **46** (see FIG. **4**) which correspond to gears **41** are mounted for free rotation on pins **47** affixed to and projecting outwardly from plate **22***b* and are positioned on the pins in the plane of gear **44** by any suitable means (not shown). Each carrier spindle **30** carries a gear **50** which may be affixed to the lower end of or formed as an integral part of the carrier spindle, the gear **50** being of a pitch diameter, having a face width and being so positioned as to intermesh with each of the gears **36, 40, 45** and **46** at certain times, as will be later described.

In the operation of the braider of the invention as so far described, upon rotation of gear **34** through the energization of its driving motor, each gear **32***a* will be driven in a clockwise direction, and adjacent gears **32***b* in a counterclockwise direction, as previously mentioned. Rotation of the gears **32***a* and **32***b* will in turn cause rotation of the gears of the planetary gear system associated with each driver as well as gear **50** of each carrier spindle.

Reference will now be made particularly to FIGS. 5a to 5*e* inclusive which diagrammatically illustrate the operation of the gears of a gear train as a strand supply carrier spindle **30** traveling an outer arc of the circumference of a clockwise rotating rotor and in a clockwise direction around the braiding point approaches a transfer point, completes its transfer to a counterclockwise-rotating rotor, and then leaves the transfer point. It will be recognized that upon the transfer of the carrier spindle **30** to the counterclockwise-rotating rotor, it will be carried thereby around an inner arc of the circumference thereof to a succeeding rotor rotating in a clockwise direction and a similar but reverse transfer operation will take place. Also, that the cooperation of the several gears of each rotor gear system with the gear **50** of each carrier spindle **30** traveling in the counterclockwise direction around the braiding point will be equivalent to but the reverse of that described for the clockwise traveling spindles.

Referring first to FIG. **5***a*, as carrier spindle **30** is carried in its outer arc of travel in a clockwise direction, the teeth of gear **50** are in intermeshing relationship with the teeth of gear **41** which in turn are in intermeshing relationship with fixed gear **40.** As a result, gear **50** will be rotated on its own axis in a counterclockwise direction through an arc which will in effect be subtracted from the arc of rotation of gear **50** in a clockwise direction resulting from its travel with the rotor. Hence the actual rotation of the spindle is in the same direction as that of the rotor but at a substantially slower rate. To produce this result in the six-rotor braider disclosed, the gear ratios are such that two-thirds of a rotation of gear **50** on its own axis will be subtracted from that imparted to it by the rotation of the rotor for each arc of rotation of the rotor of one degree, as previously explained. The control of rotation of gear **50** through gears **40** and **41** continues as the carrier spindle further approaches the transfer point, as shown in FIG. 5b, and gear **45** of the adjacent counterclockwise-rotating rotor approaches gear **50** of the carrier spindle. When the carrier spindle has been brought to the position of FIG. **5***c*, which corresponds to that of FIG. **5**, both gear **41** and gear **45** are in mesh with gear **50** of the carrier spindle, the ratio of the gears being such that gear **50** continues its rotation in a clockwise direction at its predetermined velocity.

Following the transfer operation, the carrier spindle is first moved into the position of FIG. **5***d* and then to the position of FIG. **5***e*, the rotation of gear **50** being continued due to its intermeshing engagement with gear **45** which in turn is in intermeshing engagement with gear **43** of the counterclockwise-rotating driver. Inasmuch as the rotation of the carrier spindle to maintain its desired orientation is now in a direction opposite to that of the direction of rotation of the rotor, the gear ratio must be such that the spindle remains in rotation on its own axis at the same rate and direction as imparted to it by the last previous rotor by which it was driven. This results in an angular velocity sufficient to give the spindle an arc of rotation of one and one-third degrees for each 1° of rotation of the rotor, as also previously mentioned. The pitch diameters of the several gears to provide the required ratios for machines having any number of drivers may be mathematically determined. However, for braiders of popular sizes, namely braiders having six, **12, 18** or **24** drivers with driving gears **32***a* and **32***b* of 9-inch pitch diameter, the pitch diameters in inches of the several gears are set forth in the following table:

TYPICAL GEAR PITCH DIAMETERS IN INCHES

No. drivers braiding head	Gear **44**	Gear **41**	Gear **50**	Gear **45**	Gear **43**
6	4	1	3	2	2
12	3 ½	1 ¼	3	1 ¾	2 ½
18	3 ⅓	1 ⅓	3	1 ⅔	2 ⅔
24	3 ¼	1 ⅜	3	1 ⅝	2 ¾

Referring now to FIGS, **2, 3, 4** and **6,** the mechanism for retaining each carrier spindle within a pocket **26***a* of driver rotor **20***a* rotating in a clockwise direction and within a pocket **26***b* driver rotor rotating in a counterclockwise direction and for transferring each carrier spindle from the pocket of the rotor by which it has been driven to a pocket of the next adjacent rotor rotating in the opposite direction will be described. It is to be understood that the mechanism operates in conjunction with the planetary gear systems previously explained and which controls the rate of travel of the spindles and positions them for the transfer operation.

Each strand supply carrier spindle **30** has a track support plate **51** affixed thereto or suitably made integral therewith whereby it will be rotated with the spindle. Each plate **51** is provided with semicircular peripheral flanges **52** and **53** projecting in opposite directions from the plate, the inner faces of the flanges defining tracks **54** and **55** respectively for cooperation with rollers **56***a*, **57***a*, **58***a* and **59***a* carried by each rotor **20***a*, and rollers **56***b*, **57***b*, **58***b* and **59***b* carried by each rotor **20***b*, as will later be described in detail. As will be noted, the rollers of each rotor lie opposite to the pockets **26***a* or **26***b* thereof. Tracks **54** and **55** are in opposed relationship on opposite sides of and equidistant from the axis of spindle **30,** such axis defining the center line of curvature of the tracks. Each of the flanges extends along the circumference of its associated plate **51** for a distance somewhat less than one-half of the circumference of the plate and is preferably provided with inwardly-rounded edges, indicated at **61,** at its opposite ends for promoting graceful, smooth entry of a roller onto the associated tracks **54** and **55.**

Rollers **56***a* and **58***a* are mounted for free rotation on pins **62***a* and **63***a* respectively, the centers of the pins lying on a diametric line of rotor **20***a* and the pins being affixed in any suitable way to the upper plate **21***a* of the rotor. The spacing of the pins from the center of each rotor **20***a* and the locations of the rollers thereon are such as to position one or the other of the rollers for rolling contact with the track **54** of a carrier spindle when the spindle is being driven by the rotor in a clockwise direction around the braiding point. Rollers **57***a* and 59*a* are mounted for free rotation on pins 64*a* and 65*a* respectively, the centers of the pins also lying on a diametric line of rotor 20*a* but one which is at a 90° angle to that of pins 62 and 63. The pins (see FIG. 3) are supported by arms 66*a* which are affixed to, for rotation with, tubular portion 23*a* connecting the upper and lower rotor plates 21*a* and 22*a*. The spacing of the pins 64*a* and 65*a* from the center of each rotor 20*a* and the location of the rollers thereon is such as to position one or the other of the rollers for rolling contact with the track 55 of a carrier spindle when the spindle is being driven by the rotor in a counterclockwise direction around the braiding point.

The rollers 56*b* and 58*b*, which correspond to rollers 56*a* and 58*a*, as they are also adapted for cooperation with track 54, are mounted for free rotation on pins 62*b* and 63*b* respectively, the centers of which lie on a diametric line of the rotor, the rollers being affixed to rotor plate 21*b*. The pins are positioned similarly as pins 62*a* and 63*a* to place one or the other of the rollers carried thereby for rolling contact with the track 54 of a carrier spindle when the spindle is being driven by the rotor but in a counterclockwise direction around the braiding point. Rollers 57*b* and 59*b*, which correspond to rollers 57*a* and 59*a*, are mounted for free rotation on pins 64*b* and 65*b* respectively, lying on a diametric line of the rotor but at a 90° angle to that of pins 62*b* and 63*b*, the pins being supported by arms 66*b* affixed to or suitably made integral with tubular portion 23*b*. The rollers are positioned similarly as rollers 57*a* and 57*b* so that one or the other of the rollers will be in rolling contact with the track 55 of a carrier spindle when the spindle is being driven by a rotor 20*b* but in a clockwise direction around the braiding point.

Reference is now made particularly to FIGS. 6*a* to 6*e* inclusive in which, for convenience of illustration, the flanges 53 of the carrier spindle and the rollers which ride on the tracks defined thereby have been cross-hatched toreadily distinguish them from flanges 52 and the rollers cooperating therewith. Also, parts for cooperation with other than the one carrier spindle shown have been omitted. The figures diagrammatically illustrate the movement of a carrier spindle traveling in a clockwise path around the braiding point as it is carried by a driver rotor 20*a* to a transfer point, is transferred at the transfer point to driver rotor 20*b*, and then continues its travel in a counterclockwise direction. It will be understood that while the explanation will be limited to a spindle traveling such path and transferring from a clockwise-rotating to a counterclockwise-rotating rotor, the same principles will apply and equivalent operations will be performed in the transfer of the spindle from a counterclockwise-rotating to a clockwise-rotating rotor. Also, the same principles will apply to and equivalent operations be performed with respect to a carrier spindle traveling in a counterclockwise direction around the braiding point and which is transferred from a counterclockwise-rotating to a clockwise-rotating rotor and vice versa.

In FIG. 6*a* the carrier spindle is shown as it approaches the point of transfer from the clockwise-rotating rotor 20*a* to counterclockwise-rotating rotor 20*b*. During its travel with rotor 20*a*, the carrier spindle 30 has been retained in a pocket 26*a* of the rotor 20*a* by the contact of roller 56*a* with the track 54, the roller proceeding along the track in a clockwise direction and approaching the end of the track. Also, at this stage, roller 58*b* carried by the counterclockwise-rotating rotor 20*b* is approaching the end of track 55 defined by flange 53. As the rotation of the rotors continues to bring the several parts into the positions shown in FIG. 6*b*, roller 56*a* is close to the end of the track 54 and roller 58*b* has moved into position adjacent an end of track 55 defined by flange 53. Also, a pocket 26*b* of rotor 20*b* has moved into a position adjacent the spindle. At the point of transfer, as illustrated in FIG. 6*c*, the pocket 26*a* in which the carrier spindle has been retained has moved into a position directly opposite the above-mentioned pocket 26*b* and roller 56*a* is leaving track 54 and roller 58*b* is moving onto track 55. As the operation continues through the stages illustrated by FIGS. 6*d* and 6*e*, roller 56*a* moves out of contact with track 54 and roller 58*b* moves into contact with track 55 and then travels along the track and retains the spindle within pocket 26*b* until the spindle, which is now being driven by rotor 20*b* rotating in a counterclockwise direction, reaches the next transfer point at which, as mentioned above, the same operations are performed, but in reverse.

It will be seen that the above-described carrier spindle transfer operation results in a smooth, quiet and reliable transfer of the carrier spindles as all components involved are in motion and at substantially the same velocities. Also, as only rolling contact between the spindle tracks and the rollers is involved, little energy must be expended. It will further be noted that the transfer occurs during that portion of the cycle in which the rotor pockets, in cooperation with the gar system, maintain the spindles under positive control.

Although certain embodiments of the invention have been shown in the drawings and described in the specification, it is to be understood that the invention is not limited thereto, is capable of modification, and can be rearranged without departing from the spirit and scope of the invention. For example, while gear trains comprising gears with conventional intermeshing teeth are shown and described for rotating the carrier spindles on their own axes, the trains may be composed of driving and driven elements having no teeth of the conventional type shown, but rather having cooperating friction surfaces but of a character to ensure against slippage therebetween as is essential, the terms "gears" and "intermeshing gears" encompassing such elements. Also, while rollers and roller tracks have been shown and described as the cooperative elements on the rotors and carrier spindles for maintaining the latter in the pockets of the rotors, other track followers may be employed, such as shoes or the like.

I claim:

1. In a braiding machine, a support member, a series of drivers carried by said support member arranged in a circle around a braiding point, means to rotate adjacent of said drivers in opposite directions, a series of strand supply carrier spindles and means to cause said spindles to be driven by said drivers for travel in serpentine intersecting paths in opposite directions around said braiding point, the improvement comprising means for maintaining a point on each of said carrier spindles substantially on a line drawn through the center of the carrier spindle and said braiding point during the travel of said carrier spindles around said braiding point.

2. A braiding machine according to claim 1 wherein said means for maintaining a point on each of said car-

rier spindles substantially on a line drawn through the center of the carrier spindle and said braiding point comprises means to rotate each carrier spindle on its axis as it is driven by said drivers.

3. A braiding machine according to claim **2** wherein said means to rotate each carrier spindle on its axis as it is driven by said drivers comprises a planetary gear system associated with each driver and including a gear in intermeshing engagement with a gear associated with a carrier spindle as said carrier spindle is being driven by said driver.

4. A braiding machine according to claim **3** wherein said drivers comprise rotors, there is means for rotating each rotor of each driver on its axis with the rotors of adjacent drivers rotating in opposite directions, and wherein said planetary gear system includes a gear associated with each driver, said gear having a common center with the rotor of the driver with which it is associated and being fixed against rotation relatively to said rotor, and intermediate gears associated with each driver with each intermediate gear in intermeshing engagement with one of said first-mentioned gears, and wherein said gear associated with each carrier spindle is affixed thereto for rotation therewith.

5. A braiding machine according to claim **1** wherein said drivers comprise rotors with adjacent rotors of said circle of drivers defining carrier spindle transfer points and being in substantially tangential relationship at said carrier spindle transfer points, carrier spindle-receiving pockets in the rotors, and means for maintaining a carrier spindle in a pocket of each rotor for travel with said rotor between said carrier spindle transfer points and for transferring each carrier spindle from the said pocket of one rotor to a pocket of an adjacent rotor at said carrier spindle transfer points.

6. A braiding machine according to claim **5** wherein said means for maintaining the carrier spindles within the pockets of the rotors comprises mechanical cooperative means on said carrier spindles and rotors.

7. A braiding machine according to claim **6** wherein said cooperative means on said carrier spindles and rotors comprise means carried by each carrier spindle and defining tracks, and track followers carried by each rotor with one of said track followers in cooperative engagement with a track of a carrier traveling with said rotor.

8. A braiding machine according to claim **7** wherein said tracks comprise roller tracks and said track followers comprise rollers, and said roller tracks are of a length and are so positioned in relation to the rotation of the carrier spindle on its axis that the roller in cooperative engagement with a roller track rides off of said roller track when the rotor has carried the carrier spindle to a carrier spindle transfer point.

9. A braiding machine according to claim **6** wherein said cooperative means on said carrier spindles and rotors comprises means carried by each carrier spindle defining two roller tracks of semicircular configuration with the tracks at different levels and in opposed relationship and there are rollers carried by adjacent rotors with a roller of one of the adjacent rotors being positioned for engagement with the roller track at one level and a roller of the other rotor being positioned for engagement with the roller track at the other level.

10. A braiding machine according to claim **9** wherein said tracks are of a length and are so positioned in relation to the rotation of the carrier spindles on their axes that a roller of a rotor rides of the roller track of a carrier spindle at its level and the roller of an adjacent rotor rides onto the roller track of said carrier spindle at its level when said carrier spindle passes through a carrier spindle transfer point.

11. In a braiding machine, a support member, a series of drivers comprising rotors arranged in a circle around a braiding point, means for rotating adjacent rotors of said series in opposite directions, a series of strand supply carrier spindles, carrier spindle-receiving pockets in said rotors, and means for retaining a strand supply carrier spindle of said series in a pocket of a rotor for travel therewith, the improvement wherein said last-names means solely comprises mechanical cooperative means on said carrier spindles and rotors and means timing the cooperation of said cooperative means.

12. A braiding machine according to claim **11** wherein said cooperative means on said carrier spindles and rotors comprise means carried by each carrier spindle and defining tracks and track followers carried by each rotor with one of said track followers in cooperating engagement with a track of a carrier traveling with said rotor.

13. A braiding machine according to claim **11** wherein said cooperative means on said carrier spindles and rotors comprise means carried by each carrier spindle defining two roller tracks of semicircular configuration with the tracks at different levels and in opposed relationship and rollers carried by adjacent rotors with a roller on one of the adjacent rotors being positioned for engagement with a roller track at one level and a roller of the other rotor being positioned for engagement with a roller track at the other level.

14. A braiding machine according to claim **13** wherein adjacent rotors of said circle define carrier spindle transfer points and whereby said means for timing the cooperation of said cooperative means comprises means for rotating each carrier spindle on its own axis, and wherein said tracks are of a length and are so positioned in relation to the rotation of the carrier spindles on their axes that a roller of a rotor rides off the roller track of a carrier spindle at its level and the roller of an adjacent rotor rides onto the roller track of said carrier spindle at its level when said carrier spindle passes through a carrier spindle transfer point.

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