A connection method for connecting metal linear objects facing each other includes disposing a pair of rotators with a space interposed therebetween. Each rotator including a pair of holding portions that are provided with a space interposed therebetween and that are able to hold the metal linear objects. The connection method also includes holding the vicinities of end portions of the metal linear objects at the holding portions of the rotators to hang the metal linear objects therebetween so that the vicinities of the end portions of the metal linear objects are overlapped with each other in an axis direction and rotating the rotators relatively in the opposite directions around between the pair of holding portions as a rotation center. As a result, the metal linear objects are twisted with each other between the rotators to perform connection.
FIG. 5

(a) [Diagram]

(b) [Diagram]
CONNECTION METHOD OF METAL LINEAR ELEMENT AND CONNECTION DEVICE OF METAL LINEAR ELEMENT

TECHNICAL FIELD

[0001] The present invention relates to a connection method for connecting metal linear objects and a connection device.

BACKGROUND ART

[0002] For example, as a connection method for connecting steel cords, a method has been disclosed in which after predetermined lengths of steel cords are detwisted from the respective ends thereof, two cores are connected to each other by a splice connection, and strands at the two sides are overlapped around the peripheries of the cores and are twisted together, followed by covering the connection portion with a heat-shrinkable tube (for example, see Patent Document 1).

[0003] In addition, as a method for bonding ends of strand bundles A and B each formed from a plurality of aligned strands, after the ends of the individual strand bundles A and B are respectively divided into a plurality of groups A1, A2, ..., and a plurality of groups B1, B2, ..., A1 and B1, A2 and
B2, ... are overlapped and aligned to form overlapped portions X1, X2, ..., Subsequently, after the individual overlapped portions X1, X2, ..., are introduced in respective tubular pathways, and two ends of each overlapped portion are restrained, compressed air is supplied to each tubular pathway to obtain a bonding state of the overlapped portion by forming a twisted part therein in which a central area thereof is in a non-twisted state, so that strand portions are boned to each other (for example, see Patent Document 2).

[0004] In this step, when the two ends of the overlapped portion (aligned portion) are held by fixturer or hands for restraint, the twisted part is formed in which the central area thereof is not twisted, and in which right-side and left-side areas other than the central area are twisted in different directions (for example, the left-side part is S twisted, and the right-side part is Z twisted). That is, the twisted part is formed in which the central area thereof is in a non-twisted state.

[0005] Furthermore, there has been a method in which after end surfaces of wires to be connected to each other are brought into contact, the contact portion therebetween is irradiated with laser light to be melted, and at least one wire is fed in the direction toward a melting portion, so that a molten block larger than the outer diameter of each wire is formed, and subsequently at least one wire is pulled back in the direction opposite to the molten portion to adjust the shape thereof, so that the connection is performed (for example, see Patent Document 3).


DISCLOSURE OF INVENTION

Problems to be Solved by the Invention

[0009] According to the method disclosed in the Patent Document 1, after predetermined lengths of the two cord ends to be connected together are detwisted, and a particular connection is formed between the cores, the strands at the two sides are overlapped around the peripheries of the connection portion and are twisted together by hand; hence, much labor and time are required. In addition, since the heat-shrinkable tube must be provided to cover the connection portion, it is difficult to perform automated production, the productivity cannot be improved, and as a result, the cost is inevitably increased.

[0010] In addition, according to the method disclosed in the Patent Document 2, compressed air is supplied to the central area of the overlapped portion, and twisting at the right side and that at the left side are performed in different directions; however, this method is only applied to glass fibers and is not suitably used for connecting linear objects made of metal.

[0011] Furthermore, according to the method disclosed in the Patent Document 3, since being melted by irradiation of laser light, the individual wires are connected to each other; however, the molten portion cannot withstand a twisting operation performed in a subsequent step, and fracture may occur in some cases. Even if a product is obtained without generating fracture, when the product is used for reinforcing a rubber product such as a tire, it cannot withstand repeated tensile and flexural stresses, and as a result, fracture occurs. As described above, since the wire which is reinforced beforehand is processed by a tempering treatment, the strength of the connection portion may be degraded in some cases.

[0012] Accordingly, the present invention has been conceived in consideration of the above situations, and an object of the present invention is to provide a connection method which can easily and tightly connect metal linear objects at a low cost and a connection device for connecting metal linear objects.

Means for Solving the Problems

[0013] A connection method for connecting metal linear objects, according to the present invention, which can solve the above problems, is a connection method for connecting metal linear objects facing each other, which comprises the steps of: disposing a pair of rotators with a space interposed therebetween, each rotator including a pair of holding portions which are provided with a space interposed therebetween and which are able to hold the metal linear objects; holding the vicinities of end portions of the metal linear objects at the holding portions of the rotators to hang the metal linear objects therebetween so that the vicinities of the end portions of the metal linear objects are overlapped with each other in an axis direction; and rotating the rotators relatively in the opposite directions around between the pair of holding portions as a rotation center, whereby the metal linear objects are twisted with each other between the rotators to perform connection.

[0014] According to the connection method for connecting metal linear objects, having the configuration described above, since the vicinities of the end portions of the metal linear objects are held by the holding portions of the rotators and are hung therebetween so that the vicinities of the end portions of the metal linear objects are overlapped with each other in the axis direction, and since the rotators are rotated relatively in the opposite directions around between the holding portions as the rotation center, the metal linear objects are twisted together as if screwed between the rotators, and hence the connection can be easily performed. In addition, the metal linear objects uniformly twisted together are tightly connected by a friction force generated therebetween. In addi-
tion, since the connection can be performed by simply rotating the rotators having the holding portions in the opposite directions, a connection operation can be easily performed at a low cost.

[0015] Preferably, in the state in which the metal linear objects which are hung between the pair of rotators are restricted to move outside in the diameter direction, the rotors are rotated. Accordingly, the metal linear objects can be stably set along a twisting axis, and the metal linear objects can be uniformly and tightly twisted together while being prevented from unstably moving and swinging.

[0016] A connection method for connecting metal linear objects, according to the present invention, which can solve the above problems, is a connection method for connecting metal linear objects facing each other, which comprises the steps of: disposing a pair of rotators with a space interposed therebetween, each rotator including a pair of holding portions which are provided with a space interposed therebetween and which are able to hold the metal linear objects; holding the vicinities of end portions of the metal linear objects, which are a main wire and a branch wire, at the holding portions of the rotators to hang the metal linear objects therebetween so that one metal linear object used as the main wire is disposed close to a rotation center side as compared to the other metal linear object used as the branch wire, and so that the vicinities of the end portions are overlapped with each other in an axis direction; and in the state in which the metal linear objects which are hung between the pair of rotators are restricted to move outside in the diameter direction, rotating the rotators relatively in the opposite directions around between the pair of holding portions as the rotation center, whereby the metal linear objects are twisted with each other between the rotators to perform connection.

[0017] According to the connection method for connecting metal linear objects, having the configuration described above, since the vicinities of the end portions of the main wire and the branch wire are held by the respective holding portions to be hung therebetween so that the vicinities of the end portions of the main wire and the branch wire are overlapped with each other in the axis direction, and since the rotors are rotated relatively in the opposite directions around between the holding portions as the rotation center, the branch wire is twisted as if screwed around the main wire, and hence the connection can be easily performed between the rotator. As a result, the twisted main wire and branch wire are tightly connected together by a friction force generated therebetween. Since the connection can be performed by simply rotating the rotators having the holding portions in the opposite directions, a connection operation can be easily performed at a low cost.

[0018] In addition, since the main wire and the branch wire are twisted together in the state in which the main wire and the branch wire which are hung between the pair of rotators are restricted to move outside in the diameter direction, the main wire and the branch wire can be stably set along the twisting rotation axis and can be tightly twisted together while being prevented from unstably moving and swinging. In this step, compared to the branch wire, since the main wire is disposed close to the rotation center side, the main wire and the branch wire are not uniformly nor equally overlapped, screwed, and twisted with each other; and the connection is performed such that the branch wire is wound around the screwed main wire. As a result, the strength of the connection portion can be suppressed from being degraded. That is, the main wire functioning as a central line can be responsible for anti-tensile load and the branch wire functioning as a lateral line (winding line) can be responsible for anti-sliding properties (anti-slip properties).

[0019] Preferably, a tensile load ratio of the main wire to the branch wire is set in the range from 10.3 to 10.6. Accordingly, the connection can be performed such that the branch wire is reliably and easily wound around the screwed main wire.

[0020] Preferably, after the metal linear objects are twisted together, the twisted portion is annealed at 250 to 500° C. for 10 seconds or more. Accordingly, a diameter shape forming rate of the connection portion can be made approximately 100%, and the contact resistance of the connection portion can be increased.

[0021] Preferably, as the holding portions of the rotators, slits are formed, each of which is opened at the outer circumference side of each rotator and is extended to the vicinity of the rotation center thereof, and by inserting the metal linear objects in the slits, the metal linear objects are held in the slits. Accordingly, by inserting the metal linear objects in the slits, the metal linear objects can be easily held by the holding portions made of the slits. In addition, after the metal linear objects are connected to each other, the metal linear objects can be easily removed from the slits.

[0022] Preferably, the rotators have the slits as one type of holding portion and, as the other type of holding portion, through-holes through which the metal linear objects are allowed to pass. As described above, since the other holding portions are formed of the through-holes, in the case in which the metal linear objects are held by passing through the through-holes, when the metal linear objects are twisted together, the outer circumferences of the metal linear objects are reliably held by the inner circumferences of the through-holes, and hence the metal linear objects are further uniformly twisted together at the connection portion.

[0023] Preferably, the metal linear objects comprise a material which generates plastic deformation. Accordingly, the metal linear objects can be tightly twisted together by generating the plastic deformation at the connection portion, and hence a superior connection state can be obtained.

[0024] Preferably, at the connection portion formed by twisting the metal linear objects together, the metal linear objects are tightly fixed to each other by a low-temperature melting soft metal. Accordingly, detwisting of the metal linear objects at the connection portion is prevented, and further, the strength of the connection portion can be improved.

[0025] Preferably, the two end portions of the two linear objects are applied with tensile resistance during twisting so as to perform uniform screwing. Accordingly, the twisting can be uniformly performed, and by the twisting, the plastic deformation amount can be increased.

[0026] Preferably, when the metal linear objects are element wires, a plurality of which is subsequently twisted together into a strand wire, the twisting direction while the end portions are connected to each other is set to coincide with the twisting direction when a strand wire is formed. Accordingly, when element wires connected to each other are twisted together to form a strand, since the twisting of metal linear objects at each connection portion is further twisted, detwisting will not occur, and hence the connection state by the twisting can be reliably maintained.

[0027] Preferably, when the metal linear objects are wires formed by twisting a plurality of element wires, the twisting direction while the end portions are connected to each other is
set to coincide with the twisting direction of the element wires. Accordingly, when the metal linear objects are connected to each other by twisting, since the twisting between two strands is further twisted, detwisting between the strands will not occur, and hence the twisting state at the connection portion can be reliably maintained.

0028 Preferably, after the metal linear objects are connected to each other by twisting, at least one extra length portion of the end portions which are not twisted together is removed by cutting. Accordingly, the metal linear objects can be placed in a connected state without leaving an unnecessary extra length portion.

0029 Preferably, at least one of the end portions which are not twisted together is bent in the direction opposite to an introduction direction for a subsequent step, and an extra length portion is cut off so as to leave a part thereof as a bent formation part. Accordingly, when the metal linear objects having the connection portion is introduced in a subsequent step as an intermediate product, a trouble can be reliably prevented in which the cut end portion catches on something in a path line for a subsequent step and is then cut off.

0030 Preferably, after the twisting is performed, the connection portion is plastic-deformed by applying a compression force. Accordingly, the plastic deformation amount by the twisting can be maintained, and meandering in the diameter direction can be suppressed.

0031 In addition, a connection device for connecting metal linear objects, according to the present invention, which can solve the above problems, is a connection device for connecting metal linear objects facing each other, which comprises: a pair of second rotators which are rotatably provided around the same axis center, each having a pair of holding portions capable of holding the metal linear objects and provided around the axis center; a pair of first rotators engageable with teeth formed along the peripheries of the second rotators; driven bevel gears to be rotated with the respective first rotators; and a drive bevel gear engaged with the two driven bevel gears, wherein by rotation of the drive bevel gear, the driven bevel gears are rotated in the opposite directions, the rotations thereof are transmitted to the second rotators through the first rotators, and the second rotators are rotated in the opposite directions, whereby end portions of the metal linear objects held by the holding portions are twisted between the second rotators.

0032 According to the connection device for connecting metal linear objects, having the above structure, since the vicinities of the end portions of the individual metal linear objects are held by the holding portions of the second rotators to be hung therebetween so that the vicinities of the end portions of the metal linear objects are overlapped in the axis direction, and in the state described above, the drive bevel gear is rotated, the second rotators are rotated relatively in the opposite directions through the driven bevel gears and the first rotators, and between the second rotators, the connection can be performed by twisting the metal linear objects with each other. Furthermore, since a simple structure is employed without using a particular mechanism or the like, the installation cost can be significantly reduced.

0033 Preferably, since a linear object restriction member is further provided which restricts the metal linear objects, which are hung between the pair of second rotators, to move outside in the diameter direction, the metal linear objects are restricted to move outside in the diameter direction when being twisted together and can be stably set along the twisting axis, and as a result, while being prevented from meandering and being decentered, the metal linear objects can be uniformly and tightly twisted together.

0034 In addition, a connection device for connecting metal linear objects, according to the present invention, which can solve the above problems, is a connection device for connecting metal linear objects facing each other, which comprises: a drive bevel gear to which a rotation force is applied; a pair of driven bevel gears which are intersected with the drive bevel gear and are applied with the rotation force; a pair of discs integrally bonded to the respective driven bevel gears; and a pair of first rotators to be concentrically and integrally rotated with the respective discs. Furthermore, the connection device described above further comprises: a pair of second rotators which are engaged with the respective first rotators, which are rotatably provided around the same axis center, and each of which have a pair of holding portions provided around the axis center and being capable of holding the metal linear object such that among the metal linear objects, a metal linear object used as a main wire is disposed close to a rotation center side as compared to a metal linear object used as a branch wire and such that the metal linear objects are hung so that the vicinities of end portions thereof are overlapped with each other in the axis direction; and a linear object restriction member for restricting the metal linear objects which are hung between the pair of second rotators to move outside in the diameter direction. In addition, by rotation of the drive bevel gear, the driven bevel gears are rotated in the opposite directions, the rotations thereof are transmitted to the second rotators through the first rotators, and the second rotators are rotated in the opposite directions, whereby the end portions of the metal linear objects are twisted together while being restricted by the linear object restriction member to move outside in the diameter direction between the second rotators.

0035 According to the connection device for connecting metal linear objects, having the structure described above, the vicinities of the end portions of the main wire and the branch wire are respectively held by the holding portions and are hung therebetween so as to be overlapped with each other in the axis direction, and in the state described above, the drive bevel gear is rotated. Accordingly, the second rotators are rotated relatively in the opposite directions through the driven bevel gears, the discs, and the first rotators, and between these second rotators, the connection can be performed by twisting the branch wire around the main wire. Furthermore, since a simple structure is employed without using a particular mechanism or the like, the installation cost can be significantly reduced.

0036 In addition, since the linear object restriction member for restricting the main wire and the branch wire, which are hung between the pair of second rotators, to move outside in the diameter direction is provided, when the main wire and the branch wire are twisted together, the main wire and the branch wire are restricted to move outside in the diameter direction and can be stably set along the twisting rotation axis, and hence while being prevented from meandering and being decentered, the main wire and the branch wire can be uniformly and tightly twisted together. In this step, since the main wire is disposed close to the rotation center side as compared to the branch wire, the main wire and the branch wire are not uniformly nor equally overlapped, screwed, and twisted with each other, and as a result, connection is performed such that the branch wire is wound around the main
wire. Accordingly, the strength of the connection portion can be suppressed from being degraded. That is, the main wire can be responsible for anti-tensile load as a central line, and the branch wire can be responsible for anti-sliding properties as a lateral line.

[0037] Preferably, an electric heating means is further provided which heats only the connection portion after the end portions of the metal linear objects are twisted together. Accordingly, after the connection is performed, while the metal linear objects are set in the connection device, steps including the annealing can be performed.

[0038] Preferably, as the holding portions, slits are formed, each of which is opened at the outer circumference side of each second rotator and is extended to the vicinity of the axial center described above, and by inserting the metal linear objects in the slits from the outer circumference sides of the above rotators, the metal linear objects are held in the slits. Accordingly, by easily inserting the metal linear objects in the slits, the metal linear object can be held by the holding portions formed of the slits.

[0039] Preferably, the slits are each opened between teeth provided at the outer circumference side of each second rotator which are to be engaged with those of the corresponding first rotator. As described above, since the slits, which are the holding portions for holding the metal linear objects, are opened between teeth provided at the outer circumference sides of the second rotators which are to be engaged with those of the respective first rotators, compared to the case in which the slit is formed at a position at which a tooth is present, the teeth of the second rotator can be reliably engaged with those of the corresponding first rotator. In addition, a decrease in tooth life and power transmission defect from the first rotator can be suppressed.

[0040] Preferably, the first rotators are united with the respective driven bevel gears. Accordingly, reduction in number of components and simplification of the structure can be performed, and the cost can be further reduced.

[0041] Preferably, the first rotators are concentrically united with the respective driven bevel gears with a space interposed therebetween. Accordingly, since the first rotators and the respective driven bevel gears are concentrically united together with a space interposed therebetween, the length of the holding portion for twisting the branch wire around the main wire can be increased.

[0042] Preferably, the second rotators are engaged with pairs of idle rotators located at the side opposite to the first rotators, and by the idle rotators, the second rotators are supported at the side opposite to the first rotators. Accordingly, together with the first rotators, the second rotators can be rotatably and detachably supported by the idle rotators without using bearings or the like.

[0043] Preferably, between the second rotators, a spacer having a predetermined length dimension is provided. Accordingly, the metal linear objects can be twisted together by a predetermined length, and in addition, the twisting can be more uniformly performed.

[0044] Preferably, the spacer is the linear object restriction member. As described above, when the linear object restriction member and the spacer are formed as one member, the number of components can be reduced, and the structure of the device can be simplified.

[0045] Preferably, the number of teeth of each first rotator is smaller than the number of teeth of each driven bevel gear. Accordingly, since a rotation force is transmitted from the first rotator having a smaller number of teeth than that of the driven bevel gear to the corresponding second rotator, by increasing the transmission torque, the twisting torque can be increased.

Advantages

[0046] According to the present invention, since the vicinities of the end portions of the metal linear objects are held by the holding portions of the rotators to be hung therebetween so that the vicinities of the end portions of the metal linear objects are overlapped with each other in the axis direction, and since the rotators are rotated relatively in the opposite directions around between the holding portions of the rotators as a rotation center, the metal linear objects are uniformly twisted together as if being screwed, thereby easily performing the connection. In addition, the metal linear objects which are uniformly twisted together are tightly connected to each other by a friction force generated therebetween. In addition, since the connection can be performed by simply rotating the rotators having the holding portions in the opposite directions, a connection operation can be easily performed at a low cost. Furthermore, since the diameter shape forming rate of the twisted portion can be made approximately 100% by annealing, the connection can be more tightly performed by a friction force generated therebetween.

BRIEF DESCRIPTION OF DRAWINGS

[0047] FIG. 1 includes side views each showing metal linear objects according to a first embodiment of the present invention.

[0048] FIG. 2 includes side views each showing the state in which a connection portion in FIG. 1 is tightly fixed with a low-temperature melting soft metal.

[0049] FIG. 3 is a front view of a connection device connecting the metal linear objects shown in FIG. 1.

[0050] FIG. 4 is a cross-sectional view of the connection device shown in FIG. 3.

[0051] FIG. 5 includes side views each showing metal linear objects according to a second embodiment of the present invention.

[0052] FIG. 6 is a front view of a connection device connecting the metal linear objects shown in FIG. 5.

[0053] FIG. 7 is a cross-sectional view of the connection device shown in FIG. 6.

[0054] FIG. 8 is a cross-sectional view showing the structure of a core according to an example.

[0055] FIG. 9 is a cross-sectional view showing the structure of a sheath according to the example.

[0056] FIG. 10 is a cross-sectional view showing the structure of a metal cord according to the example.

REFERENCE NUMERALS

[0057] 1 metal linear object
[0058] 3 main wire (metal linear object)
[0059] 4 branch wire (metal linear object)
[0060] 7 connection portion
[0061] 8 low-temperature melting soft metal
[0062] 10 metal linear object
[0063] 11 connection device
[0064] 12 low-temperature melting soft metal
[0065] 31a, 31b idle gear (idle rotator)
[0066] 41a, 41b second spur gear (rotator, second rotator)
[0067] 43 through-hole (holding portion)
Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings. In addition, in this description, the same element or an element having the same function is designated by the same reference numeral, and description thereof will not be repeated.

With reference to FIGS. 1 to 4, a preferable embodiment of the present invention will be described.

As shown in FIG. 1(a), end portions 1α of metal linear objects 1 are connected to each other at a connection portion 2. At this connection portion 2, the metal linear objects 1 are twisted equivalently with each other, and at this twisted portion, the metal linear objects 1 are plastic-deformed and united together. The metal linear objects 1 which are twisted equivalently with each other are strongly connected by a friction force generated therebetween by twisting.

In addition, as shown in FIG. 1(b), in the case in which after a bent portion 1b is formed by bending the end portion 1α of the metal linear object 1, located at an introduction direction side of the connection portion 2, in the direction opposite to the introduction direction, an extra length portion is removed by cutting to leave a part of the end portion 1α having a length of 3 to 10 mm used as a bent formation part, and this metal linear object 1 is introduced as an intermediate product to a path line for a subsequent step (in the direction shown by the arrow in the figure), a trouble can be reliably prevented in which the connection portion 2 is cut off when the end portion 1α catches on something and generates an excessive load to be applied thereto.

In addition, when the two metal linear objects 1 are twisted together, by applying tensile resistance to each terminal portion, more uniform twisting can be performed.

This metal linear object 1 is formed, for example, of a plastic deformable material, such as steel, copper, or aluminum. Hence, the twisted shape is maintained, and even when a tensile force or the like is applied to the metal linear object 1, the connection state can be firmly maintained.

In addition, when the connection portion 2 formed by connecting the metal linear objects 1 to each other by the above method is compressed by a vise or the like using a fixture formed of two half parts having a diameter equal to or slightly smaller than that of the connection portion, tighter connection can be performed.

In addition, as the metal linear object 1, various types of linear objects, such as a single element wire, a twisted wire (strand), a multiple twisted strand (cord) which is formed by twisting twisted wires, may be used.

In addition, as shown in FIG. 2, the metal linear objects 1 are preferably tightly fixed to each other at the connection portion 2a with a low-temperature melting soft metal 12. As the low-temperature melting soft metal, for example, a copper-tin alloy (solder) may be preferably used. In the structure shown in FIG. 2(a), the low-temperature melting soft metal 12 is brazed using its wettability along each boundary portion between the twisted metal linear objects 1, and the metal linear objects 1 are tightly fixed to each other; however, the entire connection portion 2 may be overlaid with the low-temperature melting soft metal 12 for tight fixing.

In addition, as shown in FIG. 2(b), when the bent portion 1b is formed by bending the end portion 1α of the metal linear object 1, located at an introduction direction side of the connection portion 2, in the direction opposite to the introduction direction, the trouble in which, for example, the connection portion 2 is cut off can be reliably prevented as described above.

As described above, since the metal linear objects 1 are tightly fixed to each other with the low-temperature melting soft metal 12, detwisting of the metal linear objects 1 at the connection portion 2a can be prevented, and in addition, the strength of the connection portion 2 can be improved. In addition, as a fixing agent to be provided between the metal linear objects 1, instead of the low-temperature melting soft metal 12, an adhesive may also be used.

Next, a connection device used for connecting the metal linear objects 1 will be described. FIG. 3 is a front view of a connection device connecting metal linear objects, and FIG. 4 is a cross-sectional view of the connection device connecting metal linear objects.

As shown in FIGS. 3 and 4, this connection device 11 includes a casing 21 in the form of a box. This casing 21 is formed of a lower casing 22 and an upper casing 23 provided above this lower casing 22, and the upper casing 23 is turnably connected to the lower casing 22 with a hinge 24.

In the lower casing 22, a pair of idle gears 31α is provided at one side plate 22α with a space interspersed therebetween, and shafts 32α of these idle gears 31α are rotatably supported at the side plate 22α by bearings 33α.

In addition, also at the other side plate 22β of the lower casing 22, a pair of idle gears 31β is provided with a space interspersed therebetween, and shafts 32β of these idle gears 31β are rotatably supported at the side plate 22β by bearings 33β.

In addition, the idle gears 31α at the side plate 22α are disposed so as to face the respective idle gears 31β at the side plate 22β.

Second spur gears 41α and 41β, which are second rotators each formed of a spur gear having gear teeth (not shown) formed along the periphery thereof, are disposed to be engaged with the idle gears 31α and 31β. In addition, when these second spur gears 41α and 41β are engaged with the idle gears 31α and 31β, the spur gears 41α and 41β are rotatably supported in the lower casing 22.

In each of these second spur gears 41α and 41β, at an eccentric position in the vicinity of the center thereof, a through-hole 43 having a diameter slightly larger than that of the metal linear object 1 is formed, and this through-hole 43 is designed to allow the metal linear object 1 to pass therethrough. In addition, in these second spur gears 41α and 41β,
slits 44 which are opened between teeth provided at the outer circumferences thereof are formed to extend to the centers of the second spur gears 41a and 41b, and the bottoms of these slits 44 are disposed at the central positions of the second spur gears 41a and 41b. These slits 44 each have a width dimension slightly larger than the diameter of the metal linear object 1 and are designed so that the metal linear objects 1 can be inserted therein from the respective open portions provided at the outer circumference sides of the second spur gears 41a and 41b. In addition, the formation direction of each slit 44 is angled in the vicinity of the bottom portion of the slit 44, so that the metal linear object 1 disposed in the vicinity of the bottom portion is not likely to move to the outside in the diameter direction of each of the second spur gears 41a and 41b. That is, the metal linear object 1 can be easily held at the bottom portion.

[0102] Between the second spur gears 41a and 41b, a hollow cylindrical spacer 45 is disposed at the central positions thereof. The spacer 45 has a notch portion 46 at a part of the periphery thereof along the axis direction. The second spur gears 41a and 41b have protrusions 47a and 47b facing each other at the central positions thereof, and these protrusions 47a and 47b are designed to be fitted in the spacer 45. In addition, by this spacer 45, the second spur gears 41a and 41b provided in the lower casing 22 are disposed with a predetermined space interposed therebetween.

[0103] In addition, the inside diameter of the spacer 45 is formed to be slightly larger than the state in which two metal linear objects 1 are overlapped in the axis direction, and the spacer 45 is designed to function as a linear object restriction member for restricting the metal linear objects 1 which are hung between the pair of the second spur gears 41a and 41b to move outside in the diameter direction. As one example, the inside diameter of the spacer 45 is 2.2 times the outside diameter of the metal linear object 1.

[0104] In addition, in the lower casing 22, concave portions 48a and 48b are formed along the upper edges of the side plates 22a and 22b, and the central portions of the second spur gears 41a and 41b and their vicinities in the lower casing 22 are exposed.

[0105] In the upper casing 23, at one side plate 23a and the other side plate 23b, transmission gears 51a and 51b are respectively provided at positions facing each other, and these transmission gears 51a and 51b are formed so that shafts 52a and 52b thereof are rotatably supported at the side plates 23a and 23b by bearings 53a and 53b, respectively.

[0106] These transmission gears 51a and 51b each have a first spur gear 54 and a driven bevel gear 55, and the first spur gears 54 are designed to be engaged with the second spur gears 41a and 41b.

[0107] In addition, at a roof plate 23c of the upper casing 23, a drive bevel gear 56 is provided, and this drive bevel gear 56 is engaged with the driven bevel gear 55 of the transmission gears 51a and 51b. In this drive bevel gear 56, a shaft 57 thereof is rotatably supported by a bearing 59 provided at the roof plate 23c, and at an end portion of the shaft 57 projecting to the upper surface side of the roof plate 23c, which is opposite to the drive bevel gear 56, a handle 58 is provided. In addition, by holding and rotating this handle 58, the drive bevel gear 56 is rotated. In this embodiment, the driven bevel gears 55 and the drive bevel gear 56 are spiral bevel gears.

[0108] As one example, the number of teeth of the drive bevel gear 56 is 20, the numbers of teeth of the bevel gear 55 and the first spur gear 54 of each of the transmission gears 51a and 51b are each 40, the numbers of teeth of the second spur gears 41a and 41b are each 24, and the numbers of teeth of the idle gears 31a and 31b are each 12. In this case, when the drive bevel gear 56 rotates twice, the transmission gears 51a and 51b rotate once. In addition, when the transmission gears 51a and 51b rotate 3 times, the second spur gears 41a and 41b rotate 5 times.

[0109] Next, a method for connecting the metal linear objects 1 using the above connection device 11 will be described.

[0110] First, from the two sides of the connection device 11, the end portions 1a of the metal linear objects 1 are inserted in the respective slits 44 of the second spur gears 41a and 41b in the casing 21 and are extended outside by a predetermined length through the through-holes 43 of the second spur gears 41a and 41b located at the opposite sides.

[0111] Alternatively, after the second spur gears 41a and 41b are removed from the casing 21 of the connection device 11, the metal linear objects 1 are inserted in the gears, and the gears are again disposed at the predetermined positions in the casing 21.

[0112] In the state described above, the handle 58 of the connection device 11 is held and rotated. Accordingly, the drive bevel gear 56 is rotated, and by this rotation, the transmission gears 51a and 51b are rotated in the opposite directions. Furthermore, the rotations of the transmission gears 51a and 51b are transmitted to the second spur gears 41a and 41b, and these second spur gears 41a and 41b are rotated in the opposite directions.

[0113] Accordingly, the metal linear objects 1 which are restricted by passing through the through-holes 43 and the slits 44 of the second spur gears 41a and 41b are twisted therebetween. In this step, the metal linear objects 1 are pulled toward the connection portion 2 by twisting, and a force reducing the distance between the second spur gears 41a and 41b is generated; however, since the spacer 45 is disposed therebetween, the second spur gears 41a and 41b are maintained at the predetermined positions, and hence uniform twisting can be performed.

[0114] In addition, since the spacer 45 is disposed at the position in the vicinity of the outside of the metal linear objects 1, which are hung between the second spur gears 41a and 41b, in the diameter direction, when twisting is performed, the metal linear objects 1 are restricted to move outside in the diameter direction. That is, even when the metal linear objects 1 tend to meander (or be decentered) during twisting, the metal linear objects 1 are brought into contact with the inner circumference surface of the spacer 45, and by this contact resistance, the metal linear objects 1 are stably set along the twisting axis (along the rotation shafts of the second spur gears 41a and 41b). Accordingly, the metal linear objects 1 can be uniformly and tightly twisted with each other. In addition, after the twisting is performed predetermined times, the handle 58 is stopped so as to stop the twisting.

[0115] Next, as shown in FIG. 4, in the state in which the connection portion 2 is formed by twisting the metal linear objects 1 together, terminals h1 and h2 of a heating device H used as an electric heating means provided in the connection device 11 are connected to the end portions 1a of the metal linear objects 1. Subsequently, by tuning on the switch of the heating device H, electricity is supplied between the terminals h1 and h2, and by the electrical resistance of the connection portion 2 itself, the twisted portion is heated to 250 to 500° C. and preferably approximately 400° C. and is main-
tained for at least 10 seconds or more and preferably approximately 20 seconds for annealing. As a result, a diameter performing percentage of the connection portion 2 can be made approximately 100%.

[0116] Next, by turning the upper casing 23 using the hinge 24, the upper portion of the lower casing 22 is opened, and the second spur gears 41a and 41b in the lower casing 22 are brought out.

[0117] The second spur gears 41a and 41b are moved in the directions so as to be apart from each other, and the end portions 1a of the metal linear objects 1 are pulled out from the through-holes 43 of the second spur gears 41a and 41b. In addition, the metal linear objects 1 are further pulled out from the slits 44 of the second spur gears 41a and 41b and the spacer 45 is removed by pulling out the metal linear objects 1 from the notch portion 46 thereof.

[0118] Subsequently, non-twisted portions of the end portions 1a extended from the connection portion 2 are cut off by a nipper, a clipper, or the like.

[0119] As a result, the metal linear objects 1 are uniformly twisted together at the end portions 1a thereof and are united together by plastic deformation of the twisted connection portion 2, so that a tightly connected state can be obtained.

[0120] In addition, without performing annealing after twisting, the connection portion 2a can be tightly fixed with the low-temperature melting soft metal 12, as shown in FIG. 2. Accordingly, dewristing of the connection portion 2a can be prevented, and in addition, a tightly connected state can be obtained.

[0121] As described above, according to this embodiment, the vicinities of the end portions 1a of the metal linear objects 1 are held by holding portions formed of the through-holes 43 and the slits 44 of the second spur gears 41a and 41b and are hung therebetween so as to be overlapped with each other in the axis direction, and the second spur gears 41a and 41b are rotated relatively in the opposite directions. As a result, between the second spur gears 41a and 41b, the metal linear objects 1 can be easily and uniformly twisted together and plastic-deformed at a low cost, so that tight connection can be performed.

[0122] In addition, since the through-holes 43 and the slits 44 of the second spur gears 41a and 41b are used as the holding portions for the metal linear objects 1, by inserting the metal linear objects 1 in the slits 44, the metal linear objects 1 can be easily held by the holding portions formed of the slits 44. In addition, when the metal linear objects 1 are held by being inserted in the through-holes 43, the outer circumferences of the metal linear objects 1 can be reliably held by the inner circumferences of the through-holes 43 while the metal linear objects 1 are twisted together, and uniform twisting can be further performed.

[0123] In addition, the spacer 45 functions as the linear object restriction member, and in the state in which the metal linear objects 1, which are hung between a pair of rotators, are restricted to move outside in the diameter direction, the metal linear objects 1 are twisted together. Hence, the metal linear objects 1 can be stably set along the twisting axis, and while being prevented from unstably moving and swinging, the metal linear objects 1 can be uniformly and tightly twisted together.

[0124] In addition, by supplying electricity using the heating device 11 between the end portions 1a at the connection portion 2 formed by twisting the metal linear objects 1 together, the connection portion 2 placed in the connection device is heated to a temperature of 250 to 500° C. and is maintained for 10 seconds or more for annealing. As a result, the diameter shape forming rate of the connection portion 2 is made approximately 100% by the simple heating device, so that the contact resistance of the connection portion can be improved.

[0125] In addition, since the connection device 11 connecting the metal linear objects 1 together has a simple structure which uses no particular mechanism or the like, the installation cost can be significantly reduced. Furthermore, since the linear object restriction member and the spacer 45 are formed as one member, the number of components can be reduced, and the device structure can be simplified. In addition, the spacer 45 and the linear object restriction member may be separately provided.

[0126] In particular, since the slits 44 used as the holding portions for holding the metal linear objects 1 are opened between teeth provided at the outer circumference sides of the second spur gears 41a and 41b which are to be engaged with those of the first spur gears 54 of the transmission gears 51a and 51b, compared to the case in which the slits are formed at the tooth positions, the teeth of the second spur gears 41a and 41b can be reliably engaged with those of the first spur gears 54. In addition, a decrease in tooth life and a transmission defect of power from the transmission gears 51a and 51b can be suppressed.

[0127] Since the transmission gears 51a and 51b each having the first spur gear 54 and the driven bevel gear 55, which are united together, are used, the reduction in number of components and simplification of the structure can be performed, and furthermore, cost reduction can also be achieved.

[0128] In addition, since the pairs of idle gears 31a and 31b are provided at the sides opposite to the transmission gears 51a and 51b and are engaged with the second spur gears 41a and 41b so as to rotatably support the second spur gears 41a and 41b, by the idle gears 31a and 31b together with the transmission gears 51a and 51b, the second spur gears 41a and 41b can be rotatably and detachably supported without using bearings or the like.

[0129] In addition, since the spacer 45 having a predetermined length is provided between the second spur gears 41a and 41b, the metal linear objects 1 can be twisted by a predetermined length for connection, and in addition, the twisting can be further uniformly performed.

[0130] In addition, since the metal linear objects 1 are tightly fixed together by the low-temperature melting soft metal 12 at the connection portion 2, dewristing of the metal linear objects 1 can be suppressed, and further the contact resistance of the connection portion 2 can be improved.

[0131] In this embodiment, although the case in which the metal linear objects 1 each formed of a single wire are connected to each other has been described by way of example, as the metal linear objects 1 to be connected to each other, twisted wires each formed by twisting a plurality of element wires may also be used. In the case described above, the twisting direction when the end portions 1a are connected to each other is preferably set to coincide with the twisting direction of the element wires. Accordingly, when the metal linear objects 1 are twisted with each other for connection, twisting of two twisted wires is further performed, and hence the connection condition by the twisting can be reliably maintained.

[0132] In addition, in the case in which a plurality of metal linear objects 1 which are twisted beforehand for connection
are twisted to form a twisted wire, the twisting direction when the end portions 1a are connected to each other is preferably set to coincide with the twisting direction when the twisted wire is formed. Accordingly, when a plurality of the metal linear objects 1 are twisted together, the state of the connection portion 2 of the metal linear objects 1 can be reliably maintained.

[0133] In addition, as the above connection method, although the case in which the end portions 1a of a pair of the metal linear objects 1 are connected to each other has been described by way of example, even when the metal linear object 1 has a circular shape, of course, the above method can also be applied to connect two end portions 1a of the metal linear object 1.

[0134] In addition, in a circular metal cord formed by twisting the metal linear objects 1 while they are being circularly warped, when end portions of one metal linear object 1 are connected to each other, metal linear objects 1 not to be connected, which are other than the metal linear object 1 to be connected, are hooked by a plurality of pins, and these pins are moved to the direction so as to be apart from the metal linear object 1 to be connected. Accordingly, the connection is preferably performed in the state in which the metal linear object 1 to be connected is placed apart from the metal linear objects 1 not to be connected.

[0135] Next, with reference to FIGS. 5 to 7, a preferable second embodiment of the present invention will be described.

[0136] As shown in FIG. 5(a), in a metal linear object 10, a main wire 3, which is a base wire screwed by a small twist having a long wavelength cycle, and a branch wire 4, which is a winding wire twisted with the main wire 3 by a large twist having a shorter wavelength cycle than that of the main wire 3, are connected to each other at end portions 5 and 6 thereof at a connection portion 7. At this connection portion 7, while the main wire 3 and the branch wire 4 are twisted together, the twisting is performed such that the branch wire 4 is wound around the main wire 3. At the twisted portion, the main wire 3 and the branch wire 4 are mutually plastic-deformed and are tightly connected together by a friction force generated therewith.

[0137] In addition, as shown in FIG. 5(b), in the case in which after a bent portion 5a is formed by bending the end portion 5 of the metal linear object 10, located at an introduction direction side of the connection portion 7, in the direction opposite to the introduction direction side, an extra length portion is removed by cutting to leave a part of the end portion 5 having a length of 3 to 10 mm used as a bent formation part, and this metal linear object 10 is introduced as an intermediate product to a path line for a subsequent step (in the direction shown by the arrow in the figure), a trouble can be reliably prevented in which the connection portion 7 is cut off when the cut end portion 5 catches on something and generates an excessive load to be applied thereto.

[0138] The main wire 3 is formed, for example, of a plastic deformable material, such as steel, copper, or aluminum. In addition, as the case of the main wire 3, the branch wire 4 is also formed by using a plastic deformable material, such as steel, copper, or aluminum. Hence, a twisted shape of the main wire 3 and the branch wire 4 is maintained, and even when a tensile force or the like is applied to the metal linear object 10, the connection state can be firmly maintained. In addition, the metal linear object 10, various types of linear objects, such as a single element wire, a twisted wire (strand), and a multiple twisted strand (cord) formed by twisting twisted wires together, may be used.

[0139] In addition, in the metal linear object 10, the main wire 3 and the branch wire 4 are tightly fixed together at the connection portion 7 by a low-temperature melting soft metal 8. As the low-temperature melting soft metal 8, for example, a copper-tin alloy (solder) may be preferably used. In FIG. 5, the individual boundary portions between the twisted main wire 3 and branch wire 4 are brazed with the low-temperature melting soft metal 8 using the wettability thereof, so that the main wire 3 and the branch wire 4 are tightly fixed together; however, the entire connection portion 7 may be overlaid with the low-temperature melting soft metal 8 for tight fixing.

[0140] As described above, since the main wire 3 and the branch wire 4 are tightly fixed to each other with the low-temperature melting soft metal 8, detwisting of the main wire 3 and the branch wire 4 at the connection portion 7 can be suppressed, and in addition, the contact resistance of the connection portion 7 can be improved. In addition, as a fixing agent for the main wire 3 and the branch wire 4, instead of the low-temperature melting soft metal 8, an adhesive may also be used.

[0141] Next, with reference to FIGS. 6 and 7, a connection device used for connecting the metal linear object 10 will be described.

[0142] As shown in FIGS. 6 and 7, this connection device 60 primarily includes a casing 61, a drive bevel gear 62, a pair of driven bevel gears 63 and 64, a pair of discs 65 and 66, first spur gears 67 and 68 which are a pair of first rotors, second spur gears 69 and 70 which are a pair of second rotors having a small diameter, and two pairs of idle gears 71 and 72 which are idle rotors. In addition, in this embodiment, the drive bevel gear 62 and the driven bevel gears 63 and 64 are straight bevel gears.

[0143] The casing 61 is formed of a lower casing 73 and an upper casing 74 provided above the lower casing 73, and the lower casing 73 and the upper casing 74 are turnably connected to each other with a hinge 75. In the lower casing 73, the second spur gears 69 and 70 and the idle gears 71 and 72 are received, and in the upper casing 74, the drive bevel gear 62, the driven bevel gears 63 and 64, and the discs 65 and 66, and the first spur gears 67 and 68 are received.

[0144] In the drive bevel gear 62, a shaft 76 is rotatably supported at a roof plate 78 of the upper casing 74 through a bearing 77. The drive bevel gear 62 is rotated by rotating a handle 79 provided at an end portion of the shaft 76. The number of teeth of the drive bevel gear 62 is, for example, 20 (20T). The drive bevel gear 62 is engaged with the driven bevel gears 63 and 64.

[0145] The driven bevel gears 63 and 64 have shafts 80 and 81, respectively, perpendicular to the shaft 76 of the drive bevel gear 62, the shaft 80 of these shafts is rotatably supported at a side plate 83 of the upper casing 74 through a bearing 82, and the other shaft 81 is rotatably supported at the other side plate 85 of the upper casing 74 through a bearing 84. The number of teeth of each of the driven bevel gears 63 and 64 is, for example, 40 (40T).

[0146] The discs 65 and 66 are integrally and concentrically bonded to the driven bevel gears 63 and 64, respectively, and each have a predetermined thickness dimension 71 and approximately the same diameter as that of each of the driven bevel gears 63 and 64. In addition, after being separately formed, the discs 65 and 66 may be tightly fixed to the driven bevel gears 63 and 64, respectively.
The first spur gears 67 and 68 are integrally and concentrically connected to the discs 65 and 66, respectively. Since the first spur gears 67 and 68 are disposed outside the driven bevel gears 63 and 64 with the discs 65 and 66 having a thickness dimension 11 interposed therebetween, a relatively large space dimension 1.1 is formed between the first spur gears 67 and 68. The numbers of the first spur gears 67 and 68 are each, for example, 32 (32T).

The second spur gears 69 and 70 are disposed with the space dimension 1.1 which is formed between the first spur gears 67 and 68 and are engaged with the first spur gears 67 and 68, respectively.

At an eccentric position in the vicinity of the center of each of the second spur gears 69 and 70, a through-hole 86 having a diameter slightly larger than that of the branch wire 4 is formed as one type of holding portion, and this through-hole 86 is designed to allow the branch wire 4 to pass therethrough.

In addition, in each of the second spur gears 69 and 70, a slit 87 used as the other type of holding portion, which is opened between teeth provided at the outer circumference of each of the above gears, is formed by cutting from a position located slightly outside the rotation center, the position being used as a bottom portion of the slit. The slit 87 has a width dimension slightly larger than the diameter of the main wire 3 and is designed so that the main wire 3 can be inserted therein from the open portion provided at the outer circumference side. In addition, although this slit 87 is formed so that a part thereof in the vicinity of the bottom portion is slightly angled, this angled direction is changed in accordance with the twisting direction when connection is performed and is formed so that the main wire 3 is inserted in the vicinity of the bottom portion is not likely to be displaced outside in the diameter direction. That is, it is designed so that the main wire 3 is easily held at the bottom portion of the slit 87. In this case, the eccentric amount of the center of the bottom portion of the slit 87 from the rotation center of the second spur gears 69 and 70 is smaller than the eccentric amount of the center of the through-hole 86 from the rotation center of the second spur gears 69 and 70.

The through-holes 86, the slits 87, and the vicinities thereof of the second spur gears 69 and 70 are exposed through concave portions 90 and 91 formed along the upper edges of two side plates 88 and 89 of the lower casing 73.

In addition, between the second spur gears 69 and 70, a hollow cylindrical spacer 92 used as one holding portion is formed within the space dimension 1.1 so that the rotation center thereof is coaxial with the second spur gears 69 and 70. This spacer 92 has a notch portion 93 formed in part of the periphery thereof along the axis direction.

The second spur gears 69 and 70 have protrusions 94 and 95 facing each other at the rotation central positions thereof, and these protrusions 94 and 95 are fitted in the spacer 92. In addition, by this spacer 92, the second spur gears 69 and 70 are disposed at predetermined positions with the space dimension 1.1 interposed therebetween.

In addition, since the inside diameter of the spacer 92 is formed to be slightly larger than the dimension obtained when the main wire 3 and the branch wire 4 are bundled together, the spacer 92 functions as a linear object restriction member for restricting the main wire 3 and the branch wire 4 which are hung between the pair of the second spur gears 69 and 70 to move outside in the diameter direction. The inside diameter of the spacer 92 is, for example, 2.2 times the outside diameter of the main wire 3 or the branch wire 4.

In the idle gears 71 and 72, a pair of shafts 96 and a pair of shafts 97 are rotatably supported at the two side plates 88 and 89 of the lower casing 73 through bearings 98 and 99, respectively, and a pair of the idle gears 71 and a pair of the idle gears 72, each pair being provided with a space interposed therebetween, are engaged with the second spur gears 69 ([71]) and 70 ([72]), respectively. Since the idle gears 71 and 72 each have a number of teeth, for example, of 12 (12T) and are disposed in the lower casing 73, the idle gears 71 and 72 rotatably support the second spur gears 69 and 70.

The connection device 60 forms a gear decelerating mechanism by the drive bevel gear 62, the driven bevel gears 63 and 64 engaged with the drive bevel gear 62, the first spur gears 67 and 68 coupled with the driven bevel gears 63 and 64, and the second spur gears 69 and 70 engaged with the first spur gears 67 and 68. In this case, since the number of teeth of the drive bevel gear 62 is 20, the number of teeth of the driven bevel gears 63 and 64 is 40, the number of the first spur gears 67 and 68 is 32, and the number of the second spur gears 69 and 70 is 32, a rotation force applied to the drive bevel gear 62 is transmitted to the driven bevel gears 63 and 64 such that the rate is decelerated and the torque is increased. Accordingly, a relatively higher torque is transmitted to the first spur gears 67 and 68 engaged with the driven bevel gears 63 and 64 and to the second spur gears 69 and 70 engaged with the first spur gears 67 and 68.

Next, a connection method for manufacturing the metal linear object 10 using the connection device 60 will be described.

First, the main wire 3 is inserted in the through-hole 86 of the other second spur gear 70 ([69]) by opening the upper casing 74 of the connection device 60 or through the concave portion 90 of the lower casing 73 without opening the upper casing 74, and the end portion 5 of the main wire 3 is pulled out through the slit 87 of the other second spur gear 70 via the spacer 92 by a predetermined length.

Next, from the side opposite to the insertion direction of the main wire 3, the branch wire 4 is inserted in the through-hole 86 of the other second spur gear 69 ([70]), and the end portion 6 of the branch wire 4 is pulled out through the slit 87 of the second spur gear 69 via the spacer 92 by a predetermined length.

Subsequently, the handle 79 of the connection device 60 is rotated by applying a rotation force thereto. The rotation force is applied by hand or a power source not shown in the figure. When the handle 79 starts to rotate, since the drive bevel gear 62 is rotated, by this rotation force, the driven bevel gears 63 and 64 are rotated in the opposite directions. In this step, the discs 65 and 66 and the first spur gears 67 and 68 are rotated in the same directions as those of the driven bevel gears 63 and 64, respectively, and the second spur gears 69 and 70 are rotated in the opposite directions.

Since the second spur gears 69 and 70 are rotated in the opposite directions, the main wire 3 which passes through from the second spur gear 69 to the other second spur gear 70 and which is disposed at the bottom portions of the slits 87 is screwed by a small twist having a long wavelength cycle, and at the same time, the branch wire 4 which passes through from the other second spur gear 70 to the second spur gear 69 and is disposed in the through-holes 86 is screwed around the main wire 3 by a large twist having a short wavelength cycle. In this step, since a tensile force to the main wire 3 is adjusted
by a tensile-force application roller not shown in the figure, and the branch wire 4 obtains a tensile force by the resistance to the spacer 92, the tensile load ratio of the main wire 3 to the branch wire 4 is set in the range of 10.3 to 10.6. Accordingly, the main wire 3 and the branch wire 4 are pulled to each other toward the connection portion 7 by twisting.

[0162] In this step, although the force works to shrink the distance between the second spur gears 69 and 70, since the spacer 92 is provided therebetween, while the second spur gears 69 and 70 are maintained at predetermined positions, the twisting is performed.

[0163] In addition, since the spacer 92 is disposed at the position in the vicinity of the outside of the main wire 3 and the branch wire 4, which are hung between the second spur gears 69 and 70, in the diameter direction, when the twisting is performed, the main wire 3 and the branch wire 4 are restricted to move outside in the diameter direction. That is, even when the main wire 3 and the branch wire 4 tend to meander (or be decentered) during twisting, they are brought into contact with the inner circumference surface of the spacer 92, and by this contact resistance, the main wire 3 and the branch wire 4 are stably set along the twisting axis (along the rotation shafts of the second spur gears 69 and 70). Accordingly, the main wire 3 and the branch wire 4 can be tightly twisted with each other. In addition, after the twisting is performed predetermined times, the handle 79 is stopped so as to stop the twisting.

[0164] Next, as shown in FIG. 7, in the state in which the connection portion 7 is formed by twisting the main wire 3 and the branch wire 4, which form the metal linear object 10, the terminals h1 and h2 of the heating device 11 used as an electric heating means provided in the connection device 60 are connected to the end portions 5 and 6 of the metal linear object 10. Subsequently, by tuning on the switch of the heating device 11, electricity is supplied to the terminals h1 and h2, and by the electrical resistance of the connection portion 7 itself, the twisted portion is heated to 250 to 500°C and preferably approximately 400°C and is maintained for at least 10 seconds or more and preferably approximately 20 seconds for annealing. As a result, the diameter shape forming rate of the connection portion 7 can be made approximately 100%, and the contact resistance of the connection portion 7 can be improved.

[0165] Next, by disengaging the upper casing 74 from the lower casing 73 through the hinge 75, the upper portion of the lower casing 73 is opened, and an assembly of the spacer 92 and the second spur gears 69 and 70 in the lower casing 73 is brought out.

[0166] The twisted metal linear object 10 is then brought out through the notch portion 93 of the spacer 92. Subsequently, non-twisted portions of the end portions 5 and 6 extended from the connection portion 7 are cut off by a nipper, a clipper, or the like. As a result, the end portions 5 and 6 of the metal linear object 10 are twisted with each other and are plastic-deformed and united together at the connection portion 7, so that a tight connection state can be obtained.

[0167] In addition, without performing annealing after twisting, the connection portion 7 can be tightly fixed using the low-temperature melting soft metal 8. Accordingly, detwisting of the connection portion 7 can be suppressed, and in addition, the contact resistance thereof can be improved, thereby obtaining a tight connection state.

[0168] As described above, according to this embodiment, the vicinity of the end portion of the branch wire 4 is held in the through-holes 86, the vicinity of the end portion of the main wire 3 is held by the slits 87, the main wire 3 and the branch wire 4 are hung so that the vicinities of the end portions thereof are overlapped with each other in the axis direction, and the second spur gears 69 and 70 are rotated relatively in the opposite directions around between the through-hole 86 and the slits 87 as the rotation center. As a result, between the second rotators 69 and 70, when the branch wire 4 is twisted as if screwed around the main wire 3, the connection can be easily performed, and the main wire 3 and the branch wire 4 thus twisted together are tightly connected to each other due to a friction force generated therebetween. In addition, since the connection can be performed by simply rotating the second rotators 69 and 70 having the through-holes 86 and the slits 87 in the opposite directions, the connection operation can be easily performed at a low cost.

[0169] In addition, since the branch wire 4 is twisted around the main wire 3 in the state in which the main wire 3 and the branch wire 4 which are hung between the pair of the second rotators 69 and 70 are restricted to move outside in the diameter direction, the main wire 3 and the branch wire 4 can be stably set along the twisting rotation axis, and while being prevented from unstably moving and swinging, the main wire 3 and the branch wire 4 can be tightly twisted together. In this step, since the main wire 3 is disposed close to the rotation center side as compared to the branch wire 4, the main wire 3 and the branch wire 4 are not uniformly nor equally overlapped, screwed, and twisted with each other, and the connection is performed such that the branch wire 4 is wound around the screwed main wire 3. Accordingly, a decrease in strength of the connection portion 7 can be suppressed. That is, the main wire 3 functioning as a central line can be responsible for anti-tensile load and the branch wire 4 functioning as a lateral line can be responsible for anti-sliding properties.

[0170] In addition, since the tensile load ratio of the main wire 3 to the branch wire 4 can be set in the range of 10.3 to 10.6, the branch wire 4 can be more reliably twisted around the screwed main wire 3.

[0171] In addition, by supplying electricity from the heating device 11 between the end portions 5 and 6 of the twisted connection portion 7 of the metal linear object 10, the connection portion 7 placed in the connection device is heated to a temperature of 250 to 500°C and is maintained for at least 10 seconds or more for annealing. As a result, the diameter shape forming rate of the connection portion 7 is made approximately 100% by the simple heating device, so that the contact resistance of the connection portion can be improved.

[0172] In addition, by inserting the main wire 3 in the slits 87, the main wire 3 can be easily held by the holding portions made of the slits 87. In addition, after the main wire 3 and the branch wire 4 are connected to each other, the metal linear object 10 can be easily removed from the slits 87.

[0173] In addition, since the other holding portions are made of the through-holes 86, when the branch wire 4 is held by passing through the through-holes 86, the outer circumference of the branch wire 4 is held by the inner circumferences of the through-holes 86 while the main wire 3 and the branch wire 4 are twisted together, and the twisting can be further reliably performed at the connection portion 7.

[0174] In addition, at the connection portion 7, the main wire 3 and the branch wire 4 can be tightly twisted with each other by plastic deformation, so that superior connection state can be obtained. Furthermore, detwisting of the main wire 3 and the branch wire 4 at the connection portion 7 can be
suppressed, and further the strength of the connection portion 7 can be improved. In addition, without leaving an extra length portion, the main wire 3 and the branch wire 4 can be placed in a connected state.

In addition, in the case in which the metal linear object 10 is introduced to a path line for a subsequent step as an intermediate product, a trouble can be reliably prevented in which the connection portion 7 is cut off when the cut end portion 5 catches on something and generates an excessive load to be applied thereto.

In addition, the main wire 3 is held in the slits 87. Accordingly, the main wire 3 can be easily inserted in the slits 87, and the metal linear object 10 can be held by the holding portions made of the slits 87.

In addition, since the heating device H for heating only the connection portion 7 is provided, while being placed in the connection device 60, steps including the annealing can be performed.

In addition, the slits 87 which are the holding portions holding the main wire 3 are opened between teeth provided at the outer circumference sides of the second spur gears 69 and 70 which are to be engaged with those of the first spur gears 67 and 68. Accordingly, compared to the case in which the slit is formed at the tooth position, the teeth of the second spur gears 69 and 70 can be reliably engaged with those of the first spur gears 67 and 68, and hence a decrease in tooth life and a transmission defect of power from the first spur gears 67 and 68 can be suppressed.

In addition, since the first spur gears 67 and 68 and the driven bevel gears 63 and 64 are concentrically united together, respectively, with a space interposed therebetween, the length of the spacer 92 for twisting the branch wire 4 around the main wire 3 can be set large, and in addition, when the number of the teeth of the first spur gears 67 and 68 to be engaged with the second spur gears 69 and 70 is set smaller that that of the driven bevel gears 63 and 64, the twisting torque can be relatively increased. In addition, reduction in number of components and simplification of the structure can be performed, and hence the cost can be further reduced.

In addition, the connection can be performed by twisting predetermined lengths of the main wire 3 and the branch wire 4, and in addition, the twisting can be more uniformly performed.

In addition, since the rotation force is transmitted from the first spur gears 67 and 68 having a smaller outer diameter than that of the discs 65 and 66 to the second spur gears 69 and 70, the number of teeth of the first spur gears 67 and 68 and that of the second spur gears 69 and 70 can be set smaller than that of the driven bevel gears 63 and 64, and by increasing the transmission torque, the twisting torque can be increased.

The above connection method has been described by way of example using the case in which the main wire 3 and the branch wire 4 are connected to each other; however, of course, the connection method can also be applied to the case in which after one metal linear object 10 is warped to form a circular shape, the end portions 5 and 6 thereof are connected to each other.

In addition, as the first rotators and the second rotators, instead of the first spur gears 67 and 68 and the second spur gears 69 and 70, power transmission means such as spiral gears or pulleys may also be used.

**EXAMPLE 1**

Next, with reference to FIGS. 8 to 10, Example 1 will be described which was performed in order to confirm the operation and effect of the first embodiment of the connection method and connection device for connecting metal linear objects, according to the present invention.

As shown in FIG. 8, around a core (strand) 15 formed by twisting 3 single element wires 14 of a diameter of 0.17 mm at pitches of 5.0 mm in a S-twisting direction, a sheath layer 17 was formed by twisting 7 single element wires 16 of a diameter of 0.20 mm at pitches of 12.0 mm in the same S-twisting direction, as shown in FIG. 9, so that a sheath 18 was formed. In addition, a metal cord 20 was investigated which was formed by winding a wrapping wire 19 of a diameter of 0.15 mm around the outer circumference of the sheath 18 at pitches of 3.50 mm in a Z-twisting direction, which was the opposite direction, as shown in FIG. 10.

After the three types of metal linear objects, the core 15, the sheath 18, and the wrapping wire 19, forming the metal cord 20 were each connected at intervals of approximately 50 m using the above connection device 11, the metal cord 20 was formed. Subsequently, the joint efficiencies (ratio of breaking load of the connection portion to that of the other portion) of the connection portions of the core 15, the sheath 18, and the wrapping wire 19 were measured and were compared to the case in which connection was performed by butt welding. Furthermore, the joint efficiencies obtained in the case in which the connection portions of the core 15, the sheath 18, and the wrapping wire 19 were each covered with a low-temperature melting soft metal for tight fixing were also measured and compared in a manner similar to that described above. In addition, the joint efficiencies obtained in the case in which the connection portions of the core 15, the sheath 18, and the wrapping wire 19 were annealed at an annealing temperature of 400±20°C. (measured by a contact surface thermometer) for a holding time of 20 seconds were also measured and compared in a manner similar to that described above.

In addition, the connection conditions for the core (strand), the sheath, and the wrapping wire were respectively set as follows.

(1) Core (strand)

- **Dimension between teeth of second spur gear:** 21 mm
- **Twisting number:** 7 rotations
- **Twisting direction:** S direction
- **Length of connection portion:** 19 mm

(2) Sheath

- **Dimension between teeth of second spur gear:** 24 mm
- **Twisting number:** 7 rotations
- **Twisting direction:** S direction
- **Length of connection portion:** 21 mm

(3) Wrapping Wire

- **Dimension between teeth of second spur gear:** 18 mm
- **Twisting number:** 7 rotations
- **Twisting direction:** Z direction
- **Length of connection portion:** 17 mm
The measurement results are shown below.

### TABLE I

<table>
<thead>
<tr>
<th>Type of metal linear object</th>
<th>Connection by butt welding (N = 1)</th>
<th>Connection by twisting (average of N = 5)</th>
<th>Connection by twisting and subsequent tight fixing with low-temperature melting point soft metal (average of N = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Core (strand)</td>
<td>43</td>
<td>49</td>
<td>68</td>
</tr>
<tr>
<td>(2) Sheath</td>
<td>41</td>
<td>44</td>
<td>65</td>
</tr>
<tr>
<td>(3) Wrapping wire</td>
<td>45</td>
<td>73</td>
<td>74</td>
</tr>
</tbody>
</table>

### TABLE II

<table>
<thead>
<tr>
<th>Type of metal linear object</th>
<th>Connection by butt welding (N = 1)</th>
<th>Connection by twisting (average of N = 5)</th>
<th>Connection by twisting and subsequent annealing (annealing temperature: 400°C, holding time: 20 seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Core (strand)</td>
<td>43</td>
<td>54</td>
<td>70</td>
</tr>
<tr>
<td>(2) Sheath</td>
<td>41</td>
<td>49</td>
<td>69</td>
</tr>
<tr>
<td>(3) Wrapping wire</td>
<td>45</td>
<td>74</td>
<td>73</td>
</tr>
</tbody>
</table>

Furthermore, with respect to the joint efficiency at an annealing temperature of 400°C, the joint efficiencies at an annealing temperature of 200°C and 600°C were measured and compared in a manner similar to that described above. The measurement results are shown below.

### TABLE III

<table>
<thead>
<tr>
<th>Type of metal linear object</th>
<th>Joint efficiency by annealing temperature after connection of metal linear objects (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 ± 10°C</td>
</tr>
<tr>
<td>(1) Core (strand)</td>
<td>55</td>
</tr>
<tr>
<td>(2) Sheath</td>
<td>51</td>
</tr>
<tr>
<td>(3) Wrapping wire</td>
<td>71</td>
</tr>
</tbody>
</table>

As described above, it was confirmed that by the connection method and connection device for metal linear objects, according to the present invention, the joint efficiencies could be improved, and tight connection could be performed. In particular, it was found that when tight fixing was performed with the low-temperature melting soft metal after the twisting was performed, a superior joint efficiency could be obtained. In addition, it was also found that annealing at a temperature of approximately 400°C was more effective.

**EXAMPLE 2**

Next, with reference to FIGS. 8 to 10, Example 2 (change in connection portion length) will be described which was performed in order to confirm the operation and effect of the second embodiment of the connection method and connection device for connecting metal linear objects, according to the present invention.
Twisting number: 10 rotations
Twisting direction: Z direction
Length of connection portion: 28 mm
The measurement results are shown below.

<table>
<thead>
<tr>
<th>Type of metal linear object</th>
<th>Connection by butt welding (N = 1)</th>
<th>Connection by twisting (average of N = 5)</th>
<th>Connection by twisting and subsequent tight fixing with low-temperature melting point soft metal (average of N = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Core (strand)</td>
<td>43</td>
<td>54</td>
<td>70</td>
</tr>
<tr>
<td>(2) Sheath</td>
<td>41</td>
<td>49</td>
<td>68</td>
</tr>
<tr>
<td>(3) Wrapping wire</td>
<td>45</td>
<td>74</td>
<td>75</td>
</tr>
</tbody>
</table>

As shown above, it was confirmed that by the connection method and connection device for metal linear objects, according to the present invention, by using the main wire 3 and the branch wire 4, the joint efficiency could be improved, and tight connection could be performed. In particular, it was found that when tight fixing was performed with the low-temperature melting soft metal after the twisting was performed, a superior joint efficiency could be obtained. In addition, it was also found that annealing at a temperature of approximately 400°C was more effective. In addition, since the measurement results of the annealing in this Example 2 were the same as the joint efficiencies shown in Tables II and III, the results were not shown.

Although the present invention has been described in detail with reference to the particular embodiments, it is naturally understood by a person skilled in the art that various modifications and changes may be made without departing from the spirit and scope of the present invention.


INDUSTRIAL APPLICABILITY

As described above, the connection method and connection device for connecting metal linear objects, according to the present invention, can be applied, for example, to a connection method and connection device for connecting steel cords.

1. A connection method for connecting metal linear objects facing each other, comprising the steps of: disposing a pair of rotators with a space interposed theretwixt, each rotator including a pair of holding portions which are provided with a space interposed theretwixt and which are able to hold the metal linear objects; holding the vicinities of end portions of the metal linear objects at the holding portions of the rotators to hang the metal linear objects theretwixt so that the vicinities of the end portions of the metal linear objects are overlapped with each other in an axis direction; and

2. The connection method for connecting metal linear objects, according to claim 1, wherein in the state in which the metal linear objects which are hung between the pair of rotators are restricted to move outside in the diameter direction, the rotators are rotated.

3. A connection method for connecting metal linear objects facing each other, comprising the steps of: disposing a pair of rotators with a space interposed theretwixt, each rotator including a pair of holding portions which are provided with a space interposed theretwixt and which are able to hold the metal linear objects; holding the vicinities of end portions of the metal linear objects, which are a main wire and a branch wire, at the holding portions of the rotators to hang the metal linear objects theretwixt so that one metal linear object used as the main wire is disposed close to a rotation center side as compared to the other metal linear object used as the branch wire, and so that the vicinities of the end portions are overlapped with each other in an axis direction; and

4. The connection method for connecting metal linear objects according to claim 3, wherein a tensile load ratio of the main wire to the branch wire is set in the range from 10:3 to 10:6.

5. The connection method for connecting metal linear objects, according to claim 1, wherein as the holding portions of the rotators, slits are formed, each of which is opened at the outer circumference side of each rotator and is extended to the vicinity of the rotation center thereof, and by inserting the metal linear objects in the slits, the metal linear objects are held in the slits.

6. The connection method for connecting metal linear objects, according to claim 5, wherein the rotators have the slits as one type of holding portion and, as the other type of holding portion, through-holes through which the metal linear objects are allowed to pass.
7. The connection method for connecting metal linear objects, according to claim 1,
wherein the metal linear objects comprise a material which generates plastic deformation.

8. The connection method for connecting metal linear objects, according to claim 1,
wherein the two end portions of the two linear objects are applied with tensile resistance during twisting so as to perform uniform screwing.

9. The connection method for connecting metal linear objects, according to claim 1,
wherein when the metal linear objects are element wires, a plurality of which is subsequently twisted together into a strand wire, the twisting direction while the end portions are connected to each other is set to coincide with the twisting direction when a strand wire is formed.

10. The connection method for connecting metal linear objects, according to claim 1,
wherein when the metal linear objects are wires formed by twisting a plurality of element wires, the twisting direction while the end portions are connected to each other is set to coincide with the twisting direction of the element wires.

11. The connection method for connecting metal linear objects, according to claim 1,
wherein after the metal linear objects are connected to each other by twisting, at least one extra length portion of the end portions which are not twisted together is removed by cutting.

12. The connection method for connecting metal linear objects, according to claim 11,
wherein at least one of the end portions which are not twisted together is bent in the direction opposite to an introduction direction, and an extra length portion is cut off so as to leave a part thereof as a bent formation part.

13. The connection method for connecting metal linear objects, according to claim 1,
wherein after the metal linear objects are twisted together, the twisted portion is annealed at 250 to 500 °C. for 10 seconds or more.

14. The connection method for connecting metal linear objects, according to claim 1,
wherein at a connection portion formed by twisting the metal linear objects together, the metal linear objects are tightly fixed to each other by a low-temperature melting soft metal.

15. The connection method for connecting metal linear objects, according to claim 1,
wherein after the twisting is performed, a connection portion is plastic deformed by applying a compression force thereto.

16. A connection device for connecting metal linear objects facing each other, comprising:
a pair of second rotators which are rotatably provided around the same axis center, each having a pair of holding portions being capable of holding the metal linear objects and provided around the axis center;
a pair of first rotators engageable with teeth formed along the peripheries of the second rotators;
driven bevel gears to be rotated with the respective first rotators; and
a drive bevel gear engaged with the two driven bevel gears, wherein by rotation of the drive bevel gear, the driven bevel gears are rotated in the opposite directions, the rotations thereof are transmitted to the second rotators through the first rotators, and the second rotators are rotated in the opposite directions, whereby end portions of the metal linear objects held by the holding portions are twisted between the second rotators.

17. The connection device for connecting metal linear objects, according to claim 16,
further comprising a linear object restriction member for restricting the metal linear objects which are hung between the pair of second rotators to move outside in the diameter direction,
wherein the end portions of the metal linear objects are twisted together while being restricted to move outside in the diameter direction between the second rotators by the linear object restriction member.

18. A connection device for connecting metal linear objects facing each other, comprising:
a drive bevel gear to which a rotation force is applied;
a pair of driven bevel gears which are intersected with the drive bevel gear and are applied with the rotation force;
a pair of discs integrally bonded to the respective driven bevel gears;
a pair of first rotators to be concentrically and integrally rotated with the respective discs;
a pair of second rotators which are engaged with the respective first rotators, which are rotatably provided around the same axis center, and each of which have a pair of holding portions provided around the axis center and being capable of holding the metal linear objects; and
a linear object restriction member for restricting the metal linear objects which are hung between the pair of second rotators to move outside in the diameter direction,
wherein by rotation of the drive bevel gear, the driven bevel gears are rotated in the opposite directions, the rotations thereof are transmitted to the second rotators through the first rotators, and the second rotators are rotated in the opposite directions, whereby end portions of the metal linear objects are twisted together while being restricted by the linear object restriction member to move outside in the diameter direction between the second rotators.

19. The connection device for connecting metal linear objects, according to claim 16,
further comprising an electric heating means which heats only a connection portion after the end portions of the metal linear objects are twisted together.

20. The connection device for connecting metal linear objects, according to claim 16,
wherein as the holding portions, slits are formed, each of which is opened at the outer circumference side of each second rotor and is extended to the vicinity of the axis center, and by inserting the metal linear objects in the slits, the metal linear objects are held in the slits.

21. The connection device for connecting metal linear objects, according to claim 20,
wherein the slits are each opened between teeth provided at the outer circumference side of each second rotor which are to be engaged with those of the corresponding first rotor.

22. The connection device for connecting metal linear objects, according to claim 16,
wherein the first rotators are united with the respective driven bevel gears.
23. The connection device for connecting metal linear objects, according to claim 22,
wherein the first rotators are concentrically united with the respective driven bevel gears with a space interposed therebetweeen.

24. The connection device for connecting metal linear objects, according to claim 16,
wherein the second rotators are engaged with pairs of idle rotators located at the side opposite to the first rotators, and by the idle rotators, the second rotators are supported at the side opposite to the first rotators.

25. The connection device for connecting metal linear objects, according to claim 16,
further comprising a spacer having a predetermined length dimension provided between the second rotators.

26. The connection device for connecting metal linear objects, according to claim 25,
wherein the spacer is the linear object restriction member.

27. The connection device for connecting metal linear objects, according to claim 16,
wherein the number of teeth of each first rotator is smaller than the number of teeth of each driven bevel gear.