Jan. 6, 1931. A. V. DE FOREST 1,787,936

PROCESS OF ELIMINATING INTERNAL STRESSES IN WIRE AT ANCHORAGES THEREOF

Filed Feb. 17, 1928

Fig. 1.

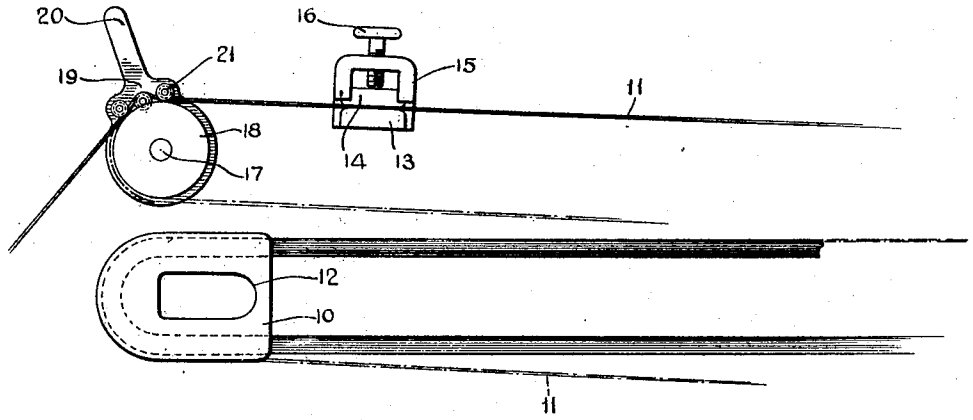
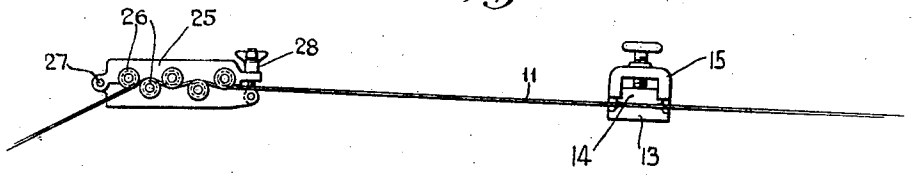


Fig. 2.



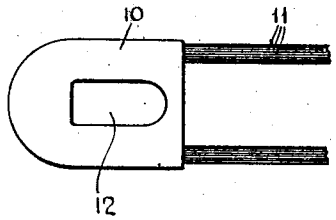


Fig. 3.

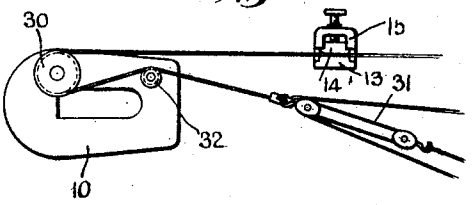
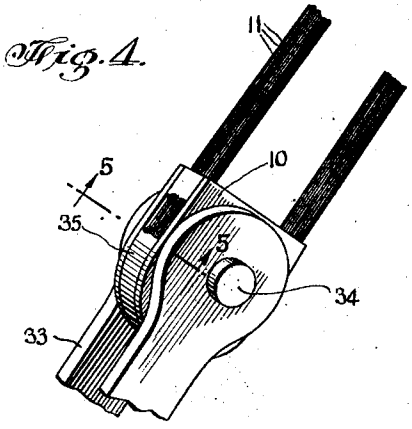


Fig. 4.



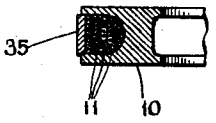


Fig. 5.

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UNITED STATES PATENT OFFICE

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PROCESS OF ELIMINATING INTERNAL STRESSES IN WIRE AT ANCHORAGES THEREOF

Application filed February 17, 1928. Serial No. 255,153.

The present invention relates to a process of eliminating internal stresses in wire tension members which are looped around an anchorage or an attachment member.

A specific application of the present invention is to be found in the cables of suspension bridges. It is customary to form such cables of a number of strands, each strand being formed of a continuous wire which is carried by a trolley back and forth from anchorage to anchorage until the desired number of wire lengths for a strand have been spun. Each wire length is subjected to tension as soon as it is spun and is then looped about an anchorage shoe. When the strand has been completed, the anchorage shoe is inserted between a pair of eye bars or other anchorage means and attached thereto, after which it is drawn back by any suitable means such as an hydraulic jack to adjust the strand as a whole to a predetermined tension or sag.

However, internal stresses are introduced into the wire by bending it around an anchorage shoe, which stresses are by no means negligible even in cold drawn wire and which, in the case of heat-treated wire, are so serious as to preclude the use of heat-treated metal for the tension members of suspension bridges. The essential quality of heat-treated metal is its high modulus of elasticity and high yield point as compared with cold worked products. When such wire is bent around relatively small diameters such as the shoe at the anchorage of the suspension bridge, a very high stress is introduced by this bending in the outside fibres of the wire. If, as would usually be the case, this bend were beyond the elastic limit of the wire, the outside fibres would already be loaded with their fullest capacity before any straight pull was applied to them. The wire would thus be placed under peculiarly bad conditions in regard to resisting repeated loading or corrosion.

It is an object of the present invention to prevent any accumulation of stress at the bend in the wire and reduce the load on the wire at this point to the same figure as that in the straight portions of the wire.

A more specific object of the invention is to subject the wire to a forming operation which permanently stretches the outside fibres and permanently compresses the inside fibres so that the forces across any section will be zero, as they are in the straight portion of wire. In other words, although the wire is bent, it is not under stress due to the bending. The curved portion may then be loaded by any load which does not change its radius of curvature without introducing any other than the same tensile forces which operate on the straight portions leading to the curve.

Another object of the invention is to subject the wire to over-stressing whereby its elastic limit will be temporarily lowered so that it may be subjected to a considerable amount of deformation and after this deformation an aging effect will take place which will in time restore the full elastic properties of the wire. It is well known that heat-treated steel may have its elastic limits temporarily lowered by subjecting the material to over-stressing and that the full elastic properties will be restored in time by an aging effect.

Another object of the invention is to subject the looped wires of the strand to heat treatment after the strand, as a whole, has been subjected to final tension, so as to eliminate any internal stresses which may still be present in the members of the strand.

Still another object is to apply a protective metallic coating on the loop end of the strand, this coating being applied in molten condition at a temperature that will insure a certain amount of heat treatment to eliminate the internal stresses which may be present in the wire and to hasten the aging effect which will restore the wire to its full elastic properties.

With these and other objects in view which will appear hereinafter, the invention will now be described in connection with the accompanying drawings and thereafter the novelty and scope of the invention will be pointed out in the claims.

In the drawings,

Fig. 1 is a somewhat diagrammatical plan

view of a strand anchorage illustrating a process of preforming a loop in a wire before it is applied to an anchorage shoe;

Fig. 2 is a similar view of a different process;

Fig. 3 is a similar view of a still different process;

Fig. 4 is a fragmentary view in perspective of the anchorage end of a completed strand; and

Fig. 5 is a view in cross-section of a portion of the anchorage shoe taken in the plane 5—5 of Fig. 4 and viewed in the direction of the arrows.

The simplest method of preforming a loop in the wire before the wire is applied to the anchorage shoe, is to seize the wire length adjacent the anchorage shoe in a suitable clamp, after it has been subjected to the requisite preliminary tension, and then to form a loop in the wire by bending it around a stud or pulley of smaller diameter than that of the shoe. The wire is thus bent beyond its elastic limit, permanently stretching the outside fibres and compressing the inside fibres and the diameter of the stud is such that when the wire is released from the stud it will spring out to a diameter equal to that of the shoe, having taken a permanent set of such diameter. The internal stresses are thus overcome and, in time, the wire will resume its original elastic limit which was temporarily lowered by bending it beyond its yield point. The preformed loop is then transferred to the anchorage shoe.

Another process of preforming a loop of requisite diameter is illustrated in Fig. 1. In this figure, which is a plan view, an anchorage shoe 10 is shown which is formed with a peripheral channel or groove to receive wires 11 of the strand. The shoe is rounded at the rear end about which the wires are to be bent, that is, the left-hand end as viewed in Fig. 1. The shoe 10 is temporarily secured in fixed position by a lug or other means introduced through an opening 12 therein, said means not being shown in the drawing.

As a wire length is spun across the bridge to the anchorage, it is subjected to tension by any well known means and then is clamped adjacent to the shoe 10 by means of a clamp 15. This clamp may be of any desired form, but is here shown as consisting of a pair of jaws 13 and 14, the former being stationary and engaging one side of the wire while the jaw 14 slides in the frame of the clamp and may be adjusted against the opposite side of the wire by means of a bolt 16.

Adjacent the shoe there is a fixed stud 17, which carries a pulley 18. Mounted on the stud 17 is an arm 19 formed with a handle 20 and on the arm 19 are three rollers 21. These rollers are relatively staggered so as to engage opposite sides of wire 11 and produce reverse bends therein after the manner of a wire straightener. Thus, after the wire has been clamped between the jaws 13 and 14, it is threaded between the rollers 21, and the handle 20 is then operated to swing the arm 19 with the rollers about the stud 17. The rollers bend the wire beyond its elastic limit and as the handle 20 is swung around the stud 17, the wire 11 is formed into a loop which passes about the pulley 18. In this manner the wire 11 is bent into a loop which takes a permanent set, because of the overstressing produced by the rollers 21. The preformed loop is then taken out of the rollers 21 and off the pulley 18 and transferred to the adjacent shoe 10. The wire length beyond the loop may then be conveyed, by the trolley, to the opposite anchorage of the bridge where by the same process a loop is preformed in the wire before it is applied to the anchorage shoe at that end. Thus the strand is built up of a number of lengths of wire each having a preformed loop therein in which the internal stresses have been eliminated.

Another system is shown in Fig. 2 in which corresponding numerals are used to indicate corresponding parts. In this instance, however, the wire is subjected to treatment which temporarily reduces its elastic limit, after which it is bent around the anchorage loop. Adjacent the shoe 10 is a support 25 on which is mounted a number of rollers 26. These rollers are arranged in an upper and a lower series, somewhat like the rollers of a wire straightener, so as to produce bends in the wire. However, the rollers at the rear end of the support 25, that is the left hand end, as viewed in Fig. 2, are closer together, producing sharper bends in the wire than those near the right hand end. There is thus a tapering off of the bending operation so that the wire, after passing through the series of rollers, is left free of internal stresses. Preferably, the support 25 is made in two parts which are hinged together at one end as indicated at 27 and are clamped together at the opposite end by means of the clamp 28. The upper series of rollers 26 is supported on the upper section of the support 25 and lower series on the lower section. The wire is then laid on the lower rollers and the two sections are swung together and clamped, causing the upper rollers to bite into the wire and press it over and between the lower rollers. The support 25 is then drawn toward the left as viewed in Fig. 2 so as to subject the wire to repeated bendings of such magnitude as to exceed the elastic limit of the wire and by such working temporarily to reduce brittleness or hardness of the wire. This done, the wire is seized in the clamp 15 after which the support 25 is opened. Then the wire may be readily bent around the shoe 10 without introducing any serious internal stresses therein. An advantage of thus working the wire before forming the loop is that the exact radius

over which the wire is bent is of no particular importance and there is no danger of weakness due to inexactness of the location of the tangent between the strain portion of the wire and the beginning of the curvature. After the loop has been formed, an aging process takes place which restores the full elastic properties to the wire.

Fig. 3 shows still another method of temporarily reducing the elastic limit of that portion of the wire which is to be looped about the anchorage shoe. On the anchorage shoe 10 is mounted a form 30, such as a pulley, about which an incoming wire is bent. The wire, after passing about the form 30, is attached to a tension means 31, such as a block and tackle, by which the wire may be drawn up to the desired preliminary tension so that it will lie parallel to other wires in the strand. The diameter of the form 30 is such that the wire on being drawn thereabout is bent beyond its elastic limit to such an extent as to take a fixed curvature corresponding to the curvature of the shoe 10. After the wire has been given this curvature, it is held in advance of the form 30 by the clamp 15 to maintain said preliminary tension in the main body of the wire while tensioning means 31 is released. The curved portion of the wire is then transferred to the shoe 10.

The length of wire subjected to the bending process by drawing it about the form 30 is considerably greater than the length of the curved portion of the shoe about which the wire loop is to be fitted. It is necessary, therefore, to eliminate the curvature in that part of the wire which extends beyond the curved part of the shoe. This is done by passing the wire, after it leaves the form 30, in a reverse bend about a second form 32, also mounted on the anchor shoe. The form 32 is so located with respect to form 30 that the length of wire from the point at which it begins to bend about the pulley 30 to the point at which it begins to bend about the form 32 equals the length of the curved part of the shoe. The curve thus formed in the wire corresponds not only to the curvature of the shoe but also to the length of said curvature. Furthermore the pulley 30 is so positioned that the wire will be curved in the proper location to coincide with the curved part of the shoe.

Fig. 4 shows the shoe turned at right angles to the position shown in the plan views Figs. 1, 2 and 3 and secured between a pair of eye bolts 33 by which the shoe is seized and drawn backward to subject the strand as a whole to the requisite tension. A stud 34 passes through the eye bolts and also through the opening 12 in the shoe. After the shoe has been secured to the eye bolts, a metallic shield 35 is fitted around the shoe over the strand loop. The shoe and strand loop are then heated and molten lead is poured into the peripheral recess of the shoe around the wires 11. The lead is maintained at such temperature and introduced in such quantity as to raise the temperature of the strand loop to approximately 800 degrees Fahrenheit, which temperature is sufficient to draw the temper of the wires so that if there be any internal stresses therein they will be dissipated. The lead filling thus serves not only to coat the wires at this point and protect them from rust, but also to bind them all together and to heat-treat them, so as to eliminate objectional internal stresses. After this, the strand may be subjected to the necessary tension by drawing on the eye bolts 33 so as to raise the strand to the predetermined sag of the finished cable.

While particular reference has been made herein to the application of the present invention to bridge strands and cables, and to high tensile heat-treated wire, obviously the invention is not limited to such wire nor to such application, but can be used in the looping of any tension member in rod or wire form and in which it is desirable to eliminate internal stresses.

Having thus described my invention, what I claim and desire to protect by Letters Patent is:

1. In the process of forming a stress-free anchorage loop in high tensile wire, the steps which comprise progressively subjecting a portion of the wire to reverse flexing beyond its elastic limit, and simultaneously bending such portion of the wire to form a loop having a permanent set of predetermined curvature.

2. In the process of forming a stress-free anchorage loop in high tensile wire, the steps which comprise drawing a portion of the wire under tension about a form to progressively bend the wire beyond its elastic limit and give it a predetermined fixed curvature, and drawing a part of the curved portion of the wire in a reverse bend about a second form.

3. In the process of spinning bridge cables of high tensile wire, the steps which comprise progressively subjecting a portion of the wire to reverse flexing beyond its yield point, simultaneously bending such portion of the wire into a loop having a permanent set of predetermined curvature, and transferring the loop thus formed to an anchorage.

4. In the process of spinning bridge cables of high tensile wire, the steps which comprise drawing the wire under tension in one direction about a form to progressively bend the wire beyond its elastic limit, drawing the wire in the opposite direction about another form to eliminate, from a portion of the wire, the curvature produced by bending the wire around the first form, and fitting the remaining curved portion of the wire about an anchorage.

5. In the process of spinning bridge cables of high tensile wire, the steps which comprise bending a portion of each length of wire into

a loop, applying molten metal about the loops thus formed, maintaining the metal at a predetermined temperature sufficient to relieve internal stress and artificially age the wires and allowing the metal to solidify about the wire loops.

6. In the process of spinning bridge cables of high tensile wire, the steps which comprise bending a portion of each length of wire beyond its elastic limit into a loop of such dimensions that when released the loop will assume a fixed form of predetermined curvature, transferring each loop thus formed to an anchorage, applying molten metal about the loops, maintaining the metal at a predetermined temperature sufficient to relieve internal stress and artificially age the wires, and allowing the metal to solidify about the wire loops.

7. In the process of spinning bridge cables of high tensile wire, the steps which comprise bending a portion of each length of wire beyond its elastic limit into a loop of such dimensions that when released the loop will assume a fixed form of predetermined curvature, transferring each loop thus formed to an anchorage, preheating the wire loops, applying molten metal about the loops and anchorage, maintaining the metal at a predetermined temperature sufficient to relieve internal stress and artificially age the wires, and allowing the metal to solidify about the loops and anchorage.

8. In the process of anchoring high tensile wire, the steps which comprise subjecting the wire to a predetermined tension and simultaneously drawing a portion of the wire about a form of such diameter as to bend the wire beyond its elastic limit and give the wire a predetermined fixed curvature, drawing the wire in a reverse bend about a second form to straighten a portion of the wire curved by drawing it about the first form, and fitting the remaining curved portion of the wire about an anchorage.

In testimony whereof, I have signed this specification.

ALFRED V. DE FOREST.