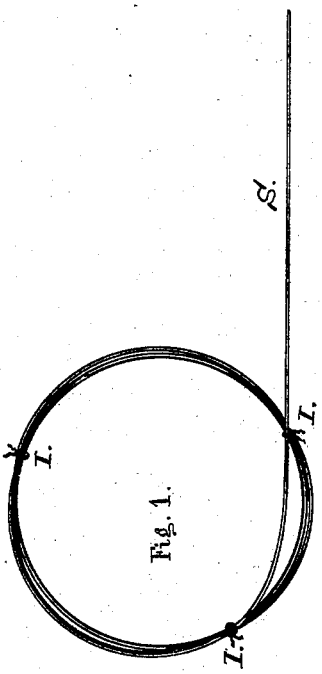
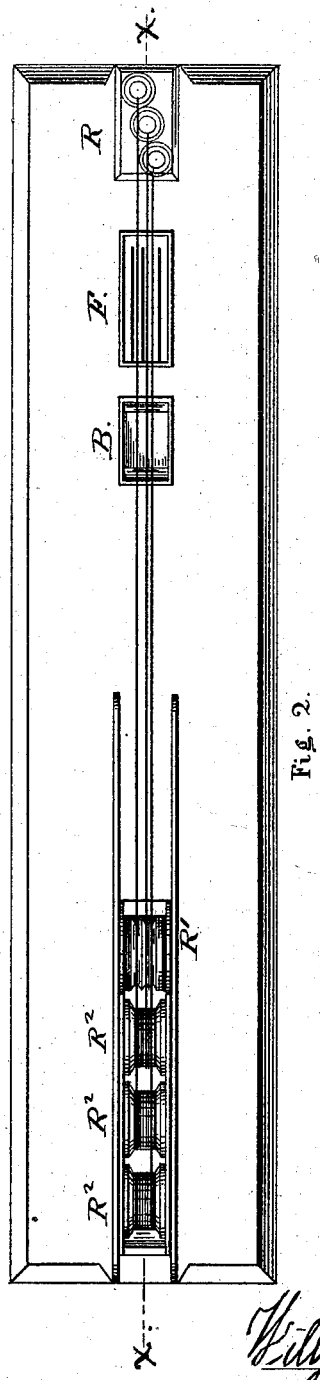
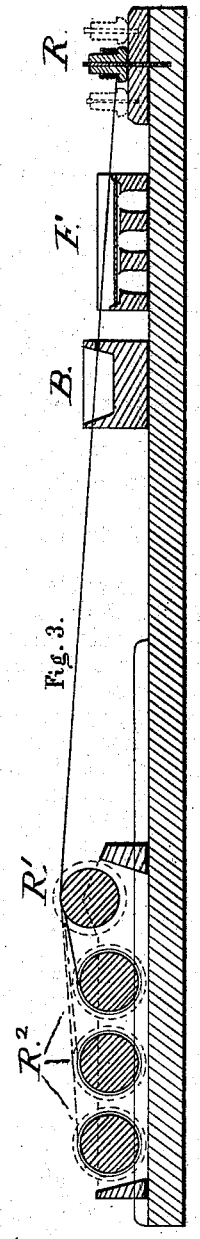
W. H. PAINE.

PROCESS OF MAKING STRAIGHT STEEL WIRE.

No. 182,510. Patented Sept. 19, 1876.







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WILLIAM H. PAINE, OF BROOKLYN, E. D., NEW YORK.

IMPROVEMENT IN PROCESSES OF MAKING STRAIGHT STEEL WIRE.

Specification forming part of Letters Patent No. **182,510**, dated September 19, 1876; application filed September 16, 1876.

To all whom it may concern:

Be it known that I, WILLIAM H. PAINE, of the city of Brooklyn, E. D., in the county of Kings and State of New York, have invented a new and useful Improvement in Process of Making Straight Steel Wire, of which the following is a specification:

My invention is, first, a new article of manufacture, consisting of round straight steel wire, the natural elastic limit of which is unimpaired.

Second, round straight tempered steel wire, with the natural elastic limit unimpaired, as a new article of manufacture, the same being one species of the new article first above described.

Third, in the guide-roller and winding-drum placed so far from the heating-furnace, and hardening or tempering bath, that the wire between the two former and the two latter shall become set while in a straight line between them, and in making the winding-drum sufficiently large to draw the wire from the swift, through the furnace, the hardening or tempering bath, and wind it upon the drum without resetting it thereby in spiral curves.

Fourth, in the process of straightening round steel wire of various sizes in continuous lengths, consisting in the following steps: first, passing the wire in continuous lengths through a furnace or any other heating device; second, continuing the wire in a straight line from the heating device, or from some guide near to the same, in the deflection or extension to which the wire shall not have its limit of elasticity disturbed by partial cooling and subsequent bending to the guide-roller, and winding-drum placed at a sufficient distance to allow the wire to become set while in a straight line between them, both of which latter shall be sufficiently large not to reset the wire wound thereon in spiral curves.

Fifth, in the combination of the process of tempering and the process of straightening round steel wire in continuous lengths, in one continuous process, consisting in passing the wire continuously through the heating device; thence to and through the tempering-bath; thence in a straight line to the guide-roller and drum, these latter placed so far from the hardening or tempering bath that the wire shall be cooled and set before reaching them, and then winding it upon the drum made of such a size (according to the size of the wire) that it shall not be permanently reset thereby.

The wire to be so treated may be that which is coiled in rings, and takes the form of spiral curves when set free; or it may be that which is already made straight by some process or treatment.

When hardened or when tempered in the manner now customary, both of these kinds of wire result in a finished product, which is coiled and set in the form of spiral curves by the guide-roller and winding-drum, as employed; but when hardened or when tempered according to my invention, the result in both cases is a product having the qualities previously ascribed to my improved article of manufacture.

In the process of manufacture, and also whenever submitted to any secondary heating process in continuous lengths, as in hardening, coating, &c., round steel wire, as hitherto made, has always received the form of rings, which shape themselves in spiral curves when set free.

To remove this objection, the operation of straightening by machinery while cold has been practiced in a great variety of ways, but with the invariable result of the disturbance of the elastic limit of the wire, and other injury thereto. In a machine contrived and used by myself this cold-straightening process is made to consist of only the necessary correcting-flexure required to make the wire straight; but in some machines the bendings received by the wire for this purpose are numerous, while in a large class of them a device is employed which, with the wire in charge, revolves rapidly, in some instances having as high as eight hundred revolutions per minute, and requiring five-horse power to drive them. In these machines the wire is bent and twisted incessantly, until, in some instances, its limit of elasticity is nearly, if not entirely, destroyed, and its strength diminished materially. The principle governing this operation may be approximately stated as follows: Given cast-steel wire No. 8, 14′ per pound, and .165″ diameter, capable of sustaining a strain

of 3,401 pounds, or 160,000 pounds per square inch, and of a modulus of elasticity of 28,000,000 pounds, and assumed limit of elasticity of 80,000 pounds per square inch, which usually takes a natural curve, when released, of twenty-four inches radius in the form of a spiral. Reverse this curve, by bending cold, until the radius of the reverse curve is nine and one-half inches. Then release the wire, and it will be straight.

It may be assumed that the extension and compression in each case are equal. Measurement and calculation show that the outer surface is compressed and the inner surface is extended during the operation, each to the amount of about one and two-tenths per cent., resulting in a permanent compression and extension of about one-third of one per cent., which causes the wire to naturally take the position of a straight line when set free. Assuming that the neutral axis passes through the center of the wire, I find that .3487 of the area of the cross-section has been strained over 80,000 pounds in extension, and the same in compression. This amounts in the aggregate to .6974 of the whole area.

I find, further, comparing the stretch with results obtained from the tests of long lengths, that about fifty per cent. has been subjected to strains of over 130,000 pounds, and above thirty-seven per cent. to strains of over 140,000 pounds per square inch. When the wire has been thus strained beyond the limit of elasticity it has received an injury, and also a permanent compression and extension in proportion to the area of its cross-section, which has, in any given case, been subjected to a strain beyond its limit of elasticity. In addition to the effects produced in .6974 of the area of the cross-section, the remainder of the whole area, while it has not been carried beyond the limit of elasticity, has been subjected to a strain which now becomes a constant and internal strain, operating, by compression and extension, each in opposition to the other.

When steel wire is treated in this manner to straighten it in quantities for practical use, it is really impossible to ascertain to what strains it has been subjected, or what injury it may have received. These defects of the steel wire now manufactured, which is required to be straight, and is cold-straightened, I avoid in my straight steel wire.

Figure 1 of the drawing shows my round straight steel wire, part of it in the "ring" and part extended. Fig. 2 is a plan view of the machinery employed in hardening or tempering and straightening steel wire. Fig. 3 is a longitudinal sectional view cut on the line *x x*.

I designates the ring part of the wire, which must be tied or otherwise secured to retain the ring form. S designates the straight part of the wire, and shows the position which the wire tends to take when released from the ring by its own natural and inherent force.

My steel wire is fixed, and its particles are fixed or set in continuous lengths, while the wire is still kept straight, and when unrolled from the ring it naturally extends in a straight line and free from curves. It retains its elastic limit, and also its original tensile strength unimpaired. No bending or straightening process while cold, and while its particles are subject to strains and incipient rupture, is required.

The limit of the strain to which it is to be subjected in any structure having been ascertained, the quantity necessary for absolute safety and certainty, or to keep the strain within the limit of elasticity, may be ascertained and employed. Since no cold compression and extension having occurred from bending and straightening, my straight steel wire, unlike wire as now made, retains its natural limit of elasticity and its strength unimpaired to be employed in the structure.

I have made practical comparative tests of the coiled steel wire set in curves, as previously described, direct from the coil or ring without straightening, and of my round straight steel wire of the size, weight, and quality previously named, with results as follows: Taking a given length of each I subjected it to a strain of 800 pounds to take out all slight curves or kinks, and to obtain an assumed zero-point, at which the wire might be treated as straight, and beyond which any gain in length might be treated as extension, I took off 400 pounds, leaving still on 400 pounds. Adding thereto 500 pounds weight on each, I found a resulting stretch or extension in the coiled wire of .00088, and in the straight of .00085. Taking off the 500 pounds, and leaving on only the 400 pounds, again I found in the former a permanent increase of length of .00002, and in the latter no perceptible increase whatever; but, instead, a return to zero. Adding next 600 pounds to each, the first result was extension .00109 and .00103½, respectively; and taking it off a permanent extension remained of .00003 in the coiled, while the straight returned to zero again. Continuing the increase by 100 pounds each time, I found an increasing stretch in each at each stage, less in the straight than in the coiled, and without any apparent permanent extension in the straight until the strain was 1,400 pounds total, when a visible extension first appeared. At 1,500 pounds a permanent extension first appeared. At 1,500 pounds a permanent extension of .00001 appeared in the straight, against .00019 in the coiled. From this point the extension in the coiled increased much faster than in the straight, until at 2,400 pounds total it was .00600 and .00370, respectively, with corresponding permanent extension in each.

The result of these tests was approximately as follows: in the coiled wire, ultimate strength per square inch equal to 125,290 pounds—modulus of elasticity undiscoverable; and in the straight wire, ultimate strength per square inch equal to 127,446 pounds—modulus of elas-

ticity equal to 28,944,011 pounds; limit of elasticity equal to fifty per cent.

Referring now to the drawing, and Figs. 2 and 3, the description of the machinery employed is as follows: R is the usual swift to receive the coil to be treated. F is the furnace in which the wire is operated upon by heat in direct contact, its function being to render the particles of the wire mobile, so as to facilitate the straightening of the wire without violence to them, in case the wire is previously curved or kinked, and so as to relieve or resolve any constant internal strains received in drawing or otherwise, in case the wire is already straight. This furnace should be made of such a length as to properly heat the wire when passing at any required rate of speed, and of such a width and construction as to receive, side by side, any desired number of wires for treatment.

The furnace may be supplied with fuel of any usual kind, or, instead thereof, a gas-combustion chamber, or any other heating device, may be employed. In these devices the heat is applied directly to the wire. I also contemplate the use of heating devices, wherein the heat acts indirectly or through some intermediate body in contact with the wire, and capable of transmitting sufficient heat thereto for the purposes named.

B is the hardening or the tempering bath, intended to contain water in the one case, and oil or any other usual liquid for hardening or for tempering, and is so elevated as to receive the wire in a straight line from the furnace through an aperture in the end of the bath into the liquid therein, and pass it out in the same manner in a straight line toward the guide-roller R^1 and winding-drum R^2. These apertures may have any suitable packing, to prevent leakage.

The bath B may be placed on a level with the furnace, and the wire be depressed as it passes from the furnace under a guide in the bath, so as to carry it beneath the surface of the liquid therein, and extend thence in a straight line to the guide-roller, but in that case the bath should be so near the furnace, and also the guide therein under which it is depressed, that the particles of the wire shall not set nor materially begin to set while it is being thus bent out of a straight line. On the contrary, in order to secure the best results, it is necessary that the gradual and the completed setting of the particle should take place while the wire is held in a straight line, in order that the finished wire may be as free as possible from curves, from tendency to curve, and from all internal strains, whether of extension, compression, or otherwise.

The temperature of the liquid contents of the bath may be high, low, or intermediate, as may be required to produce wire of any particular desired kind or quality.

Where neither hardening nor tempering is desired, the bath B may be omitted or put one side, and the wire be extended directly from the furnace to the guide-roller through the air of an average, or of an artificially lowered or elevated, temperature within the limits suitable for setting the wire. A modification of an average temperature, either in the bath contents or in the air, requires a corresponding modification of the distance required between the furnace and the guide-roller to produce the desired result. As the temperature is lowered, the length of the straight-line extension between them may be diminished; and as it is elevated it must be increased, in operating upon any given size of wire. In other words, the distance of the guide-roller R^1 and the drum R^2 from the furnace is variable, and regulated both by the size of the wire and the temperature of the intervening medium, the principle being that the particles must have time to set or become fixed while the wire is yet held in a straight line, and before it is bent by the guide-roller and drum out of a straight line. The wire may be supported at intervals.

The sizes of R^1 and R^2 must be such for any given size and quality of wire that they shall not give the wire sufficient flexure to reset the wire in the form of spiral curves when bent over or around the same. For No. 8 wire, and in an average temperature, acting upon the straight-line extension of the wire, I make the drum about four and one-half feet in diameter, and locate the guide-roller and winding-drum about eighty feet from the heating apparatus. For No. 14 wire, I make the drum about two and one-half feet in diameter, and the distances from the heating apparatus about fifty feet. For other sizes of wire, I make these sizes and distances in proportion. In the case of wire that is hard and of a spring temper, a smaller guide-roller, a smaller drum, and a greater flexure in leading from the one to the other may be used, and when the wire is softer and of a lower temper, the roller and drum must be sufficiently large and the amount of flexure from one to the other should be less than it may be in the other case. As round steel wire comes from the draw-plate, it has a variety of unascertainable and fixed or constant internal strains, due to its severe mechanical treatment in the process of drawing. These strains may be supposed to be disposed irregularly throughout the body of the wire. There is, however, one fixed and characteristic element present, which, to a greater or lesser extent, controls or modifies these inherent strains. This is the form of the wire which is round, and its right angle cross-section has the contour of a circle which is divided by a line coincident with the neutral axis into two half-circles.

In using the term "natural limit of elasticity" I do not refer to any limit of elasticity existing in the wire at any time previous to the treatment herein described. In passing through the furnace, any such previous limit will be disturbed. I refer instead to the resulting limit of elasticity produced in each case

by the processes or combinations of processes described herein, when the wire is allowed to cool, or harden, or temper, and set while straight. This natural limit of elasticity is retained, when the wire is not permanently bent or reset, by passing over the guide-roller and around the drum.

I claim—

1. As a new article of manufacture, round straight steel wire, in continuous lengths, with the natural limit of elasticity imparted by the heating device, and subsequent cooling unimpaired.

2. As a new article of manufacture, round straight tempered steel wire, in continuous lengths, with the limit of elasticity imparted by the heating device and subsequent tempering-bath and cooling unimpaired.

3. The process of straightening round steel wire, of various sizes, in continuous lengths, consisting of passing the wire through the heating device, and thence in a straight line to the roller-guide and drum, placed so far from the heating apparatus that the wire shall be permanently set between them, and then wound on a drum of such diameter as shall not reset it in the form of spiral curves.

4. The combination of the process of tempering, and the process of straightening, round steel wire, in continuous lengths, in one continuous process, consisting in passing the wire continuously through the heating device, thence to and through the tempering-bath, thence in a straight line to the guide-roller and drum, the latter placed so far from the tempering-bath that the wire shall be cooled and set before reaching them, and then winding it upon the drum, made of such a size, according to the size of the wire, that it shall not be permanently bent thereby.

5. The combination of the heating device F, the hardening and tempering bath B, and the winding-drum R^2, and guide-roller R^1, the two latter being placed at the relative distances from the tempering-bath described, so that the wire shall be cooled and set while extended in a straight line between them, and the winding-drum R^2 and guide-roller R^1 being constructed of diameters proportioned to the size of the wire, as set forth, whereby the resetting of the wire in spiral curves, upon its being wound or bent thereon, is prevented, substantially as described.

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