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PATENTED OCT. 25, 1904.

J. A. HORTON.
PROCESS OF MAKING STEEL WIRE.

APPLICATION FILED OCT. 26, 1903.

NO MODEL.

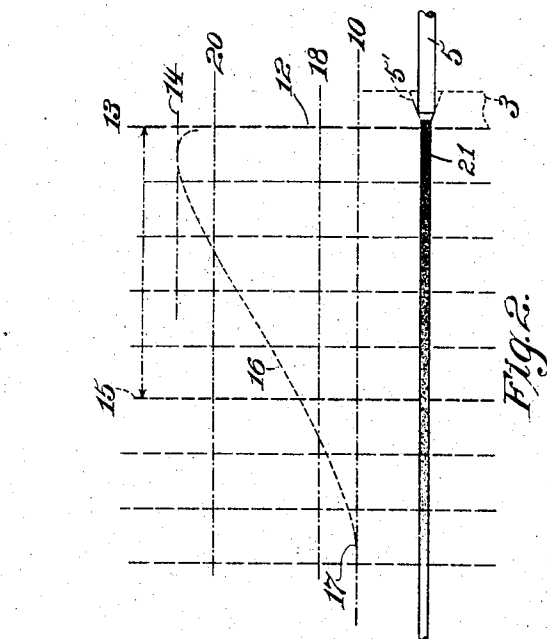


Fig. 2.

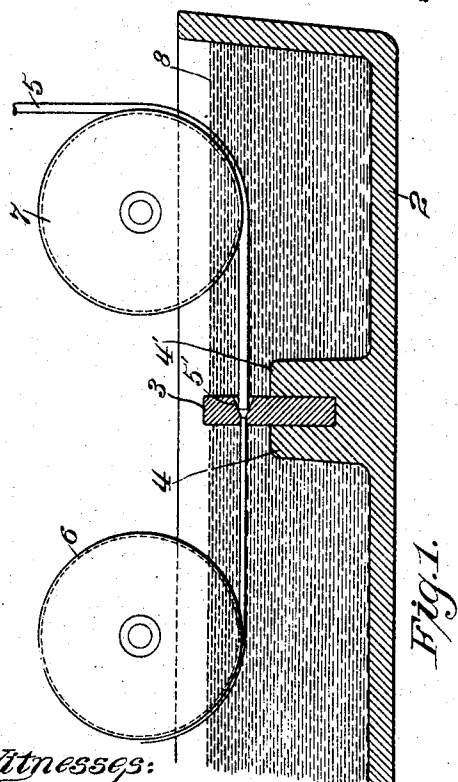


Fig. 1.

Witnesses:
Geo. E. Maynard
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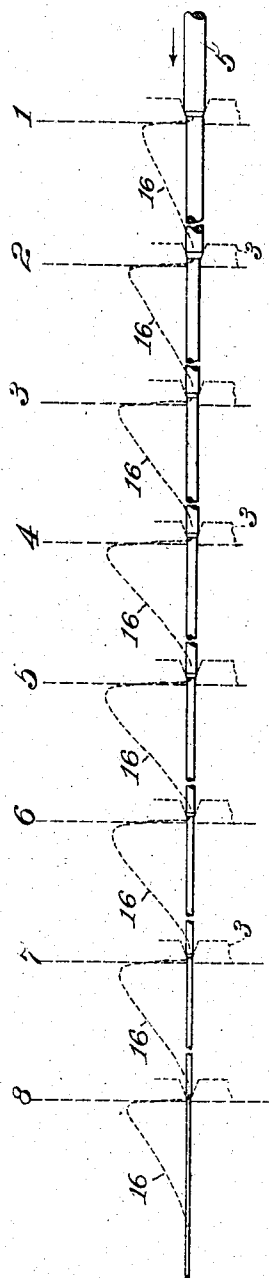


Fig. 3.

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UNITED STATES PATENT OFFICE.

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PROCESS OF MAKING STEEL WIRE.

SPECIFICATION forming part of Letters Patent No. 773,012, dated October 25, 1904.

Application filed October 26, 1903. Serial No. 178,488. (No model.)

To all whom it may concern:

Be it known that I, JAMES A. HORTON, a citizen of the United States, and a resident of Providence, in the county of Providence and State of Rhode Island, have invented certain new and useful Improvements in Processes of Making Steel Wire, of which the following is a specification.

This invention relates to the production of wire, and especially to the manufacture of steel wire, and more particularly steel wire made from medium and high qualities of steel, especially as regards the proportion of carbon and the resistant qualities of the metal.

It will be remembered that in the manufacture of wire by the process of drawing the effect of the drawing-die upon the wire not only reduces the wire in size, thus extending a given length of relatively large wire to a considerably longer length of smaller wire, but this operation also tends immediately and directly, especially when the wire is made of steel having a medium or high proportion of carbon, (as contradistinguished from soft iron and steels low in carbon,) to increase the density and hardness of the body of the wire and, in general, to render the metal in the wire after reduction less ductile or mobile and less tractable under mechanical treatment than it was before being drawn through the die. As a result of these circumstances it is found to be difficult in practice to draw wires of the class referred to from a relatively large size down to much smaller size without resorting to intermediate annealing of the wire, this being done by taking the partially-reduced wire and subjecting it to an annealing operation in suitable ovens or furnaces specially arranged for annealing by heating the entire wire to a proper degree and then cooling the same with sufficient slowness to leave the metal of the wire in a properly-annealed condition.

The principal object of my present invention is to overcome these difficulties and objections and furnish a process or method of manufacture whereby the wire may be reduced by drawing the same rapidly through a series of dies in such manner and under such conditions as to

make the whole process substantially continuous and at the same time so treat the wire by drawing, heating, and cooling as to reduce the hardening and so-called "crystallization" of the metal to an amount below what would result in permanent injury to the metal, and thereby at the same time preparing the wire by drawing, heating, and cooling at one drawing-station into a suitable condition for a similar treatment immediately at a subsequent drawing-station, and so on through a relatively large number of drawings, whereby a relatively large wire of firm and highly-resistant material may be reduced rapidly and efficiently to a relatively small size by an operation that is in a sense continuous and which can, for the reasons here briefly set forth, be produced at a low cost, while preserving to a high degree the original quality of the metal in the wire and turning out the wire of a relatively high strength.

For illustrating my present improvements there is shown in the accompanying drawings, in Figure 1, an illustrative view, partially in section, somewhat diagrammatic, of a portion of a wire-drawing apparatus adapted for use in connection with my present invention. Fig. 2 is a diagrammatic view for further illustrating some of the phenomena which occur in connection with the reduction of the wire at a single drawing-station. Fig. 3 is a similar but more extended diagrammatic view illustrative of the operations which take place at the successive drawing-stations in an extended series.

Similar characters designate like parts in all the figures.

Referring to Fig. 1, the sectioned member 2 may be a portion of the framework of a suitable wire-drawing mechanism or apparatus. One such apparatus adapted for use in practicing my improved process is illustrated and described in Letters Patent of the United States No. 742,987, granted November 3, 1903, to which reference may be had. A suitable drawing-die 3 of the usual construction is represented supported on the framework, it being shown held in place between

abutments 4 5', so it may be readily removed and replaced as occasion requires. The unreduced wire 5 is drawn into the die-opening 5' and through said opening by some suitable draft device—such, for instance, as a drum or roller—which is diagrammatically represented by the circle 6. For convenience in properly directing the wire 5 toward the die-opening 5' when such guidance may be required I have shown a guide wheel or roller 7; but it will be understood that in practice any suitable guide device may be employed if the same shall be required for directing the wire to the drawing-die at the first drawing-station of the series and that afterward the wire may be passed directly from the draft device at one drawing-station forward to the drawing-die at the next succeeding drawing-station, and so on through the series, the wire finally being disposed of by winding the same on the usual wire drum or otherwise, as may be preferred.

In Fig. 2 the wire 5 and the die 3 have for convenience been illustrated on a larger scale. For the purposes of illustration I have shown in Fig. 2 a series of vertical lines, and crossing these parallel to the wire I have shown a base-line 10, upon which is drawn a diagram illustrative in a general way of the heating and cooling of the wire. When the wire 5 is drawn into the opening 5' of the die 3, and especially if such movement is relatively rapid, the force exerted between the wire and the die operates to beat the wire immediately forward of the die, (at the left hand of the die in Figs. 1, 2, and 3.) this heating being due, as I apprehend, to the conversion of power into heat by and during the forcible re-forming of the mass of metal which for the moment is being subjected to the drawing operation within the die, this being incident to the transformation of such mass of metal from a wire of one diameter or size to a relatively smaller diameter or size. This relatively sudden heating of the wire is diagrammatically and approximately represented by the upward line 12, and the total amount of heat so produced in some one instance is represented in the present diagram by the height of the line 14 above the line 10. Referring to Fig. 1, it will be noted that the frame 2 is represented as containing fluid to a level indicated by the line 8 to a height substantially above the wire 5. Therefore it will be seen that by means of such a fluid of a properly-regulated temperature the wire on passing through the die 3 will be drawn instantly into a cooling medium, such as cool water or other suitable fluid, which will therefore operate at once to abstract the heat from the wire, and so restore the wire to substantially its original state as to temperature. It is evident this operation will be performed much more quickly with relatively fine wire, and I have obtained exceptionally good results in reducing wire from

No. 16 down to Nos. 20 and 30, and finer. This cooling of the wire is represented in Fig. 2 by the diagrammatic curved line 16, which is shown descending from the line 14 downward to the line 10 at the point 17, this latter point representing the complete cooling of the wire to its original temperature before it entered the die at that particular drawing-station. A vertical line 13 is shown located at the forward side of the drawing-die, and it is believed that the maximum temperature in the wire is created at about that point in the travel of the wire forwardly through the die. Another vertical line, 15, at a considerable distance forward of the die indicates a point at which the line 16 crosses a horizontal line 18, that represents in a general way by its height above the line 10 the amount of heat which may remain in the wire after the heating and subsequent rapid cooling has progressed so far as to restore the wire approximately to its original physical condition, and thus bring it into a proper state for being subjected in a similar manner to the next succeeding wire-drawing operation. Another horizontal line 20 is intended to represent by its height above the line 10 an amount of heat which will bring the wire to that state of ductility or mobility which may be necessary for overcoming the hardening and crystallizing effect otherwise naturally produced by the intense and normally destructive mechanical action of the die upon the metal of the wire. By carrying out the drawing operation in such manner, having regard to the amount of reduction in the wire at one drawing, the physical character and resistant quality of the wire due to its proportion of carbon or otherwise, and speed with which the wire is forcibly drawn through the die, the heating of the wire may be carried to a point where the condition of the wire corresponds to a point in the diagram above the line 20, and thereby the injurious effects otherwise normally consequent to the wire-drawing operation may be so largely overcome as to permit the wire to be immediately conducted to a succeeding drawing-station, there to be further reduced by a succeeding drawing operation, and so on through an extended series of drawing operations following one immediately after the other, and thus constituting, in effect, a continuous operation. For illustrating this feature of my present improvement I have shown in Fig. 3 a series of drawing-stations, (designated by 1, 2, 3, 4, 5, 6, 7, and 8.) In practice it sometimes happens that a given quality of wire may be subjected to two successive drawings—as, for instance, at stations 1 and 2—without accumulating such an amount of change in the character or condition of the metal as to require the wire to be annealed. I may in such a case carry out the whole series of wire-drawing operations at such a speed as to develop the heating of the wire to a point above the diagrammatic line

20, Fig. 2, at the third station of the series, and this I deem sufficiently early in the continuous process when using certain kinds of steel—such, for instance, as has a medium
 5 amount of ductility and a medium amount of carbon, the latter being, for instance, between forty and sixty or seventy points. If the wire originally has a greater amount of ductility or mobility, the first complete heating
 10 of the wire to a point above said line 20 may occur at a somewhat later point in the series of drawing-stations—as, for instance, as station 4 or station 5 in Fig. 3. In this connection the evident fact should be noted that by
 15 reason of the continuity of the wire-drawing process involving a plurality of drawing-stations the speed of the wire at each succeeding station is higher than such speed at a preceding station by an amount corresponding to
 20 the extension of the wire due to the amount of reduction at such preceding station, so that at the later or forward station of the series the speed will be many times higher than at the stations where the reduction is begun.
 25 From the foregoing description, taken in connection with the illustrations referred to, it will now be evident how the wire by the heating and cooling of the same may be so
 30 “annealed,” to use this term in a general sense, that when it has been so far reduced that it would ordinarily require a special annealing operation such special operation may be omitted and the wire carried forward directly to
 35 a succeeding drawing-station, and thus the general process of wire reduction may go on through a relatively large number of successive stations, thereby greatly accelerating the
 40 process of manufacture and avoiding the delay and cost of the usual intervening annealing processes, by which means I also avoid the delay and labor due to the handling of the
 45 wire, as well as enabling the manufacturer to convert the original relatively large wire at once into wire of relatively small sizes of high or increased tensile strength, and thus enable
 50 him to so conduct the business of manufacturing small sizes of wire as to have in process of manufacture only a small quantity of wire at any one time. These are advantages
 55 of such practical importance that the economy and utility of the same will be obvious. The wire by being drawn through the die with a force and speed (the force required being
 60 measured largely by the amount of reduction effected by the die) sufficient to raise the heat above the condition indicated by the line 20, Fig. 2, and the wire being then drawn directly into the cooling medium, as indicated in
 65 Fig. 1, and such cooling medium being of proper temperature, having regard to the size and speed of the wire, the cooling of the wire is thereby readily effected so quickly (as I apprehend in view of my investigation up to the present time of the results of my present
 improvements) that the metal of the wire is

sufficiently annealed, this being done in a manner analogous to what is commonly known among metal workers as the “cold-water” anneal, by which means steel, especially when
 of medium grades, may be effectually annealed
 70 so far as to overcome the tendency to “crystallization,” so called, this operation involving the heating of the metal to a relatively low temperature as compared with the ordinary annealing process more usually employed. 75

By means of my present improvements it is made practicable to carry the continuous process of wire reduction through a relatively large number of consecutive drawing operations by preventing such accumulative crystallizing action as would injuriously affect the metal by rendering the same during the later
 80 drawing operations weak or brittle to the extent of causing frequent breakage or otherwise interrupting the continuity of the manufacture. It will be understood that in some cases the ratio of reduction by the die at the several drawing-stations, respectively, may be modified so that a greater proportionate reduction will be effected at some stations than
 85 will take place at other stations, so that in practice some crystallizing action may be permitted at some of the drawing-stations and the annealing of the wire by heating and cooling in accordance with the principles herein
 90 set forth may be effected in a relatively high degree at few only of the succeeding stations—as, for instance, at the third and fifth stations of a more extended series of stations. In this connection it should be noted
 95 that due regard should be had in any given instance to the amount of the crystallization due to a given amount of reduction by die action upon such size and quality of wire as may be employed, and the successive steps
 100 of the continuous process should be so adjusted in the manner hereinbefore indicated as to effect the restoration or annealing of the wire at one of the drawing-stations through which the wire will pass prior to the
 105 time such crystallizing action would become destructive to the continuity of the process. The proportions and ratios herein referred to may be ascertained and duly determined by observing and testing the several
 110 features herein set forth as being involved in the complete operation or process by adjusting and regulating the several steps of the operations comprised in the continuous process in accordance with the data so ascertained
 115 or determined. In practice I deem it preferable, in view of my experience in connection with these improvements up to the present time, to make several reductions each of a moderate or average amount only as compared
 120 with the maximum reductions which are sometimes effected by single and non-consecutive wire-drawing operations; but in some cases it may be desirable to effect a relatively larger reduction, as I have indicated, at one or more
 125 130

points during the series of consecutive wire-drawings, thereby to increase the heat action to a sufficiently high point, and thus better prepare the metal for further reduction by successive die actions of relatively less amount.

By the term "crystallization" or "crystalline" action as I have used the same in this application I refer to that well-known tendency usually resulting from the drawing of steel wire to effect the hardening or stiffening of the metal, which is naturally cumulative and which if carried beyond a moderate amount tends to injure the character of the wire, so that one or more intermediate annealing operations are usually required in the manufacture of the smaller sizes of steel wire in accordance with the methods of manufacture heretofore employed. By carrying the die action up to a speed which, in connection with the amount of reduction made by the die, will raise the heat in the wire up to the point of substantially reducing such injurious effect or crystallizing action the metal of the wire is naturally restored to a considerable extent and is thereby better prepared for being subjected to subsequent die action without thereby carrying the accumulation of the crystallizing effect to a higher point than before existed. By this means it will now be evident the series of consecutive die actions employed during the continuous process may be considerably extended, and at the same time the speed with which the entire process is carried out may be increased, with the beneficial result of reducing the time and labor involved, effecting a corresponding reduction in cost, and delivering the wire reduced to a relatively small size from the original wire taken at a relatively large size, the wire so reduced and delivered retaining the high quality and a maximum of strength.

When the wire is reduced in accordance with the method herein described and is carried through a considerable number of drawing-stations, the cumulative effect of the die action would naturally, except for the special treatment to which it is subjected, soon attain such proportions as to render the further drawing of the wire impractical, particularly when the wire was originally of high quality or high in carbon; but by subjecting the wire to the treatment set forth whereby it is heated to a relatively high temperature, but less than would be required to eliminate the die temper produced in the wire by the wire-drawing action of the die, there results a limited annealing of the wire immediately after its reduction, such annealing being less in amount than would be required to eliminate those characteristics of the wire which are directly produced by the process of reduction, and as a further result of the present process the beneficial results produced by the reduction followed by a partial annealing or limited annealing at one drawing-station are carried

forward and become cumulative during the progress of the continuous process, with the final result that the wire is delivered at the end of the process free of any deterioration which would be due to a full or complete annealing by the old process of heating to a high temperature, and retaining in its finished form the beneficial results gradually accruing during the passage of the wire from station to station, thereby reducing the wire to the required limit of size, while giving it a substantial increase in tensile strength. In this connection it will be remembered that in the ordinary process of wire manufacture when the wire having been partially reduced is then annealed in the usual manner the metal of the wire is then in such a state that the wire is of low strength and unable to endure the stress necessary for making more than a slight reduction in the first drawing-die. Therefore in practice it is by that system of manufacture considered important to slightly reduce the wire at the first drawing after the annealing in order to give the wire sufficient strength and stability for permitting it to be drawn through a second drawing-die for making a proportionately larger reduction. By means of my present improvements these serious objections are avoided, since the limited annealing is made in such manner as to retain sufficient strength in the wire after one drawing operation for drawing the wire through the die at the next operation, and so on through a relatively long series of consecutive reductions by a continuous process. By the old process an intermediate annealing between two series of single or non-consecutive wire-drawing operations not only involves the cost of such annealing, but also involves the loss in amount of reduction at the first wire-drawing operation, usually termed "drawing out." By my improved process this loss of reduction is avoided, since the wire is passed from station to station consecutively and the work of reduction is carried on during such continuous process in a manner not to require the intermediate and separate annealing operation. In carrying out my improvements I find that with steel of a medium carbon—say forty to sixty points—a speed increase of from fifty per cent. to one hundred per cent. over the speed ordinarily used in drawing wire from the same materials, with the usual reductions through dies in the open air in the old practice, will usually be sufficient to develop the necessary amount of wire-heating die action and that the lower speeds mentioned should be accompanied by such an amount of increase in reduction as to bring the amount of the treatment applied to the wire (considering the speed, reduction, and stability of the steel in any given case) up to approximately twice as much as would be considered desirable and proper under the old practice. One advantage of my invention is due, as I appreciate

hend, to the circumstance that the speed of approach of the wire toward the die is so high that transmission of heat in the wire from the die backwardly is substantially overcome, so that the die action is applied while the wire is cold and the metal is in a highly-stable condition, with the result that the amount of the treatment applied to the wire is "measured," so to speak, from a low baseline, and thus a reduction of the so-called "crystallization" effected without injuriously affecting the condition of the wire in other respects at that stage of the operation.

Having thus described my invention, I claim—

1. That improvement in the art of producing wire by subjecting the same to a plurality of wire-drawing operations in a continuous process, consisting in subjecting the wire to heat at a drawing-station by die action raised to a speed sufficient to heat the wire up to a point overcoming crystalline action, drawing the wire so heated directly into a cooling medium and thereby reducing the temperature to bring the wire to a condition of stability suitable for subjection to a subsequent drawing operation.

2. As an improvement in wire manufacture, the process of reducing the wire by successive operations in a continuous process which consists in first effecting a partial reduction of the wire, next further reducing the wire by drawing at a speed raising the temperature to the annealing-point, and then at once cooling the wire to restore it to proper condition for a subsequent reduction, and then reducing the wire by a subsequent drawing operation.

3. As an improvement in the manufacture of steel wire, the process of reducing the wire by successive operations in a continuous process which consists in first effecting a partial reduction of the wire by a drawing-die and afterward further reducing the wire by drawing, and also effecting the annealing of the wire preparatory to the subsequent drawing operation by subjecting the wire to die action and heating to a point substantially reducing the tendency to crystallization, and then rapidly cooling the wire prior to such subsequent reduction.

4. That improvement in the art of making steel wire, which consists in subjecting the wire to combined die action for reducing the size of the wire and to heating produced by carrying the die action to a speed sufficient to raise the heating to the point of substantial reduction of the tendency to crystallization, and drawing the reduced wire so heated into a cooling fluid of a temperature sufficiently low to complete the annealing of the wire, substantially as set forth.

5. The improved process herein described for reducing steel wire, which consists in carrying the die action for reducing the wire to

the point of heating the wire to a point beyond the line of crystallization and drawing the wire so heated directly into the cooling fluid.

6. The improved process herein described of reducing steel wire by a continuous process comprising three or more consecutive drawing operations, which consists in subjecting the wire to reduction by die action, next subjecting the wire to reduction and to heating by die action carried to a speed for raising the heat beyond the point of crystallizing action and drawing the wire so heated into a cooling fluid for quickly cooling the wire, and later subjecting the wire so modified by heating and immediate cooling to a subsequent reduction by die action.

7. The improved process herein described of reducing steel wire by a continuous process comprising five or more consecutive drawing operations, which consists in subjecting the wire at a first operation to reduction by die action; next subjecting the wire to reduction and to heating by die action carried to a speed for raising the heat beyond the point of crystallizing action and drawing the wire so heated through a cooling fluid for quickly cooling the wire; next subjecting the wire to further reduction by die action; and, later, subjecting the wire to reduction and to heating a second time by die action carried to a speed for raising the heat beyond the point of crystallizing action and drawing the wire so heated into a cooling fluid for quickly cooling the wire; and subjecting the wire so modified by heat and immediate cooling to a subsequent further reduction by die action.

8. The improved process herein described of reducing steel wire by a continuous process comprising a plurality of drawing operations which consists in subjecting the wire to reduction by die action to the point of inducing crystalline action, next subjecting the wire to reduction and to heating by die action carried to a speed for raising the heat to the point of reducing crystalline action and drawing the wire so heated into a cooling fluid for quickly cooling the wire, then subjecting the wire so modified by heating and immediate cooling to one or more subsequent reductions by die action carried to the point of inducing incipient crystalline action, and subsequently again subjecting the wire to reduction and to heating by die action similarly carried as before to the point of raising the heat beyond the point of crystallizing action, and then quickly cooling the wire, whereby the wire during the series of consecutive drawing operations is subjected to annealing treatment at successive points in the continuous process, substantially as specified.

9. That improvement in the art of reducing wire by subjecting the same to a plurality of wire-drawing operations in a continuous process, which consists in subjecting the wire to

successive reductions by die action carried to the speed of raising the heat beyond the point of crystallizing action and drawing the wire so heated through a cooling fluid for quickly
5 cooling the wire, such heat being carried to a point substantially less than required to eliminate the die temper of the wire, thereby to produce a limited annealing of the wire immediately following its reduction at one drawing-station preparatory to subjecting the wire to a similar and further treatment at a succeeding station whereby the die temper produced by the die action at one station is car-

ried forward through succeeding stations, and the wire finally delivered having increased 15 tensile strength produced cumulatively during the passage of the wire from station to station by the successive reductions accompanied by heating and limited annealing, substantially as described. 20

In testimony whereof I have affixed my signature in presence of two witnesses.

JAMES A. HORTON.

Witnesses:

FRED. J. DOLE,
R. M. PIERSON.