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METHOD OF WIRE DRAWING

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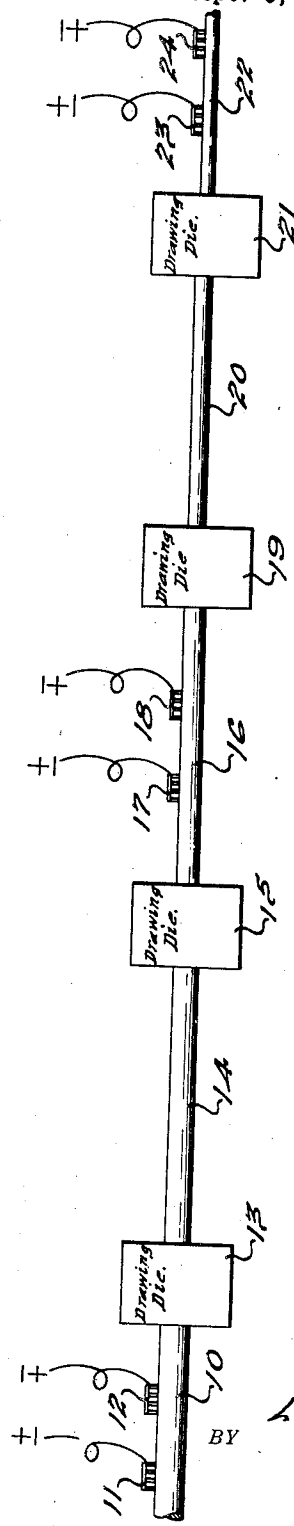


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## METHOD OF WIRE DRAWING

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6 Claims. (Cl. 148—12)

The present invention relates to a novel method of wire drawing and particularly to a novel method of heat treatment of the metal stock prior to the drawing operation and, if desired, subsequent thereto. Such heating normalizes the strains present in the metal stock or in the drawn wire and also reduces the normal resistance of the metal stock or the drawn wire to plastic flow during the drawing operations.

A principal object of the present invention is to provide a novel method of wire drawing in which a section of the metal stock is connected in an electrical circuit and is thereby heated uniformly throughout to temperatures sufficient to normalize the strains therein and to reduce the resistance of the metal stock to plastic flow during a subsequent drawing operation, and in which a careful and accurate control of the temperatures generated in the metal stock can be maintained at all times.

Another object of the invention is to provide a novel method of continuous wire drawing and heat treating of the wire stock or of the drawn wire, the method being particularly characterized by the economies present in the commercial use thereof and in the uniformity of the product produced thereby.

A further object of the invention is to provide in one of its embodiments a novel method of wire drawing in which the heat treatment of the wire may be effected by connecting the wire as the resistance element in an electrical circuit and heating said wire to the desired temperature by the flow of alternating electric current therethrough thereby producing a wire in which the strains are normalized and in which the wire is properly annealed or tempered without the use of quenching baths, the wire upon microscopic study showing finer crystalline formations which are more uniformly dispersed in the matrix than in wire drawn according to conventional methods. The wire is further characterized by a substantial freedom of surface scale and a high degree of resistance to rust or corrosion.

Other objects and advantages of this invention will appear in the following description and appended claims, reference being had to the accompanying drawing forming a part of this specification.

As distinguished from prior known processes the method of the present invention is characterized in that the wire is heated prior to drawing through the drawing die and in a preferred embodiment of the invention acts as the resistance element in an electrical circuit through which flows a controlled alternating electric current. During the drawing operation a temperature is maintained in the wire which is sufficient to reduce its resistance to plastic flow at normal atmospheric temperatures. After drawing, the wire may if desired be subjected to a further heating also as the resistance element in a separate electrical circuit through which also flows a controlled alternating electric current, for the purpose of normalizing such strains as may be present therein due to the drawing operation, or to anneal or temper the wire, as may be desired.

The method of the present invention is shown diagrammatically in the accompanying drawing in which the single figure is a diagrammatic view showing a preferred embodiment of the present invention and a possible sequence of the heating and drawing operations in one embodiment of the present invention.

As shown in the drawing, **10** designates the initial metal blank which is of any suitable type of metal and of any desired size or shape. Preferably the metal is any suitable spring wire stock and is preferably in the form of a rod of any desired diameter. As used herein, the term "spring wire stock" refers to steel or steel wire containing sufficient carbon to permit subsequent tempering, if desired. Such stock usually contains approximately .50% to .70% carbon but the process of the present invention is capable of producing improved results with steel wire containing carbon within the range of approximately .15% to approximately 1.25% carbon. The surface of the rod is contacted by spaced electrodes **11** and **12**, preferably of the multiple contact type, which are electrically connected with a source of electrical energy, preferably 60 cycle or higher alternating electric current of either 110 or 220 volts, reduced through a transformer to approximately 6 to 40 volts and having amperages of approximately 100 to 2000 after being so reduced. The source of electrical energy or transformer is not shown on the present diagrammatic drawing. It is believed that current of even higher frequencies and either lower or higher voltages may be used with satisfactory results and I do not desire, therefore, to be limited to the frequencies or voltages of current specified herein.

The spacing of the electrodes or contacts **11** and **12**, together with the speed of drawing the wire and the intensity of the electric current, controls the amount of heat developed in the section of the blank 10 between the points of contact with the electrodes. For spring steel rod having a carbon content of .15% to 1.25% the temperature developed between these electrodes is preferably 800° F. to 1700° F. However, care should be exercised to avoid heating the rod so excessively that it cannot withstand being pulled to the drawing die. Also, the spacing of the electrodes relative to each other and to the drawing die 13, together with the speed of drawing the rod is preferably such that the rod enters the die at temperatures of approximately 350° F. to 450° F. It will be obvious that as the rod is moved through the drawing die 13, different portions of the rod are continuously brought into contact with the electrodes 11 and 12 and thus the whole rod is progressively heated prior to the time that it is passed through the drawing die 13. It is to be understood that conventional designs of wire drawing machines are intended to be used to effect the actual drawing and winding of the wire but that since all such machines utilize a drawing die of some type, the die only is indicated in the drawing herein.

In the embodiment here shown, the drawing die 13 is a reducing die and the metal blank 10 is reduced in its diameter as a result of its passage through the die 13. The reduced size of the metal blank after emerging from the die 13 is indicated diagrammatically at 14. If further reduction of the diameter of the wire is desired, it may be passed through a second drawing die 15 which further reduces the diameter of the wire as shown at 16.

It has been found that in the normal operation of the method herein disclosed and using a spring wire stock as previously described, sufficient heat will be developed in the metal blank by the first heating and the subsequent drawing operation that it will be maintained at temperatures sufficient to reduce substantially the resistance of the metal stock to plastic flow during two drawing operations. It is to be understood, however, that a heat treatment may be provided between the drawing die 13 and the drawing die 15 if this is found necessary by reason of the characteristics of the metal being drawn or if the space between the dies is such that the metal cools to such a point that the metal is cold at the time of the second drawing operation. The blank 10 when formed of spring steel stock containing carbon within the range of approximately .50% to approximately .70%, is preferably introduced into the drawing die 13 when at a temperature of approximately 350° to 450° F. and the reduced wire is preferably introduced into the second drawing die 15 at temperatures substantially within said range.

The wire 16 after the passage through the second drawing die 15 is then brought into contact with spaced electrodes 17 and 18, which are connected with a source of alternating current electrical energy, preferably 60 cycle or higher alternating current of 110 or 220 volts, reduced through a suitable transformer to the desired voltages and amperages. The wire 16 of reduced diameter contacting the spaced electrodes 17 and 18 becomes the resistance element in the electrical circuit thus completed and the wire is heated to whatever extent desired by the flow of electric current therethrough. Since the wire 16 is of a reduced diameter as compared to the blank 10, it will be apparent that the spacing of the electrodes, the speed of travel of the wire, and the intensity of the electric current should all be regulated so as to develop a desired amount of heat in the wire. At this stage it has been found that the heat developed in the wire should be sufficient to normalize the strains in the wire and which, together with the heat generated during the drawing operation, will provide sufficient residual heat in the wire so that the wire will enter the drawing die 19 at a temperature of approximately 350° to 450° F.

When the blank wire 16 is drawn through the drawing die 19, it is again reduced in diameter as indicated in the drawing by the numeral 20. As in the case of the previous drawing operation, it has been found that the residual heat in the wire 20, together with any heat generated during the drawing operation, will be sufficient that it will enter the drawing die 21 within a normal time interval at a temperature within the range of approximately 350° to 450° F. If for any reason the temperature falls below such range, it is desirable to provide a heat treatment of the wire by the electrical resistance method herein disclosed at some point between the drawing die 19 and the drawing die 21.

In the method herein disclosed the wire is assumed to be of the desired dimension when it passes through the die 21 and is represented by the numeral 22. After the final drawing operation the wire may be in such a condition as to be suitable for its intended use without further heat treating. If, however, a final heat treating is desired to normalize the strains in the wire or to subject it to a subsequent annealing or tempering operation, the wire 22 may be brought in contact with the spaced electrodes 23 and 24 which are electrically connected with a source of electrical energy, preferably 60 cycle or higher alternating current of 110 or 220 volts, reduced through a transformer to approximately 6 to 40 volts. It is preferably that the wire be heated at a temperature of approximately 800° to 1700° F. for the purpose of normalizing the strains therein and annealing the wire. If it is desired to temper the wire, the temperatures used should be within the range to temper the particular wire stock used. Such temperatures may be created and controlled in the wire by regulating the spacing of the electrodes 23 and 24, taking into consideration the size of the wire 22 and the speed of its travel in contact with the said electrodes and the intensity of the current passed therethrough.

It has been found that during the final tempering of the wire, amperages of approximately 50 to 800 and voltages of approximately 6 to 40 volts of a 60 cycle alternating electric current will give the desired heating of the wire within a time interval of approximately 1 second. For steel wire stock having a carbon content of approximately .15% to 1.25% this temperature is preferably 300° F. to 600° F. A shorter time interval may be used by increasing the frequencies of the current. Wire resulting from any of the drawing operations is found to be properly annealed if treated for time intervals of approximately 1 second at amperages of approximately 100 to 2000 and suitable voltages of a 60 or more cycle alternating electric current. It is to be understood, however, that such factors will vary with different sizes and types of wire and that the foregoing data has been computed from runs made using spring wire stock drawn to various diameters. In general it has been found that the lower the carbon content of the wire subjected to heat treatment, the higher the current consumption required to develop a given temperature in a given time, and the higher the carbon content, the lower the current consumption required to develop a given temperature in a given time.

If during any heating operation, temperatures are generated in the wire to such a point as to weaken it and cause it to elongate or break during the drawing operation, it is to be understood that the wire should be allowed to cool prior to any attempted drawing to temperatures sufficinetly low so that the heated wire will posssess sufficient strength to withstand without breaking the forces imposed thereon during the drawing operation.

It will thus be seen that an advantage of the present process resides in the fact that accurate and careful control of the heat treating operations may be effected at each step in the process. Such control may be effected by placing the wire drawing operations under the observation of trained operators who may vary the intensity of the electric current flowing through the said circuits, or it may be accomplished automatically by the use of thermocouples or similar heat measuring instruments which will register the temperature of the wire at a point just prior to the passage of the wire into any of the drawing dies and the tempering of the wire during the final annealing or tempering operation. Also it is to be observed that the wire is heated uniformly as the heat is generated directly in the body of the wire.

While the terms "tempered," "annealing" and "normalizing" are usen somewhat loosely in this art, the terms as used herein are intended to designate any heat treating operation which has for its purpose or effect the elimination of stresses and strains in the wire due to the wire drawing operations and to the heat treatment of the finished wire to impart desired strength and resiliency characteristics thereto.

While the scientific phenomenon underlying the present invention is in part unknown to me, I believe that the results achieved in carrying out the present invention are due in part to a molecular rearrangement affecting the crystalline structure of the metal being drawn. Since metal such as steel is a dispersion of crystalline particles in a dispersion medium which is solid at normal atmospheric temperatures, the heating of such metal tends to decrease its resistance to plastic flow and to permit a more ready rearrangement of the crystals herein. The size and shape of the crystalline particles, together with the distribution of the crystalline particles in the dispersion medium, determine the physical characteristics of the wire resulting from any drawing operation.

It is my belief that the heating of the wire or the metal stock prior to the drawing operation to a point where its resistance to plastic flow at normal atmospheric temperatures is reduced, causes the metal to take on more readily the shape imparted to it by the drawing operation. At the same time the heating by the use of alternating electric current subjects the internal crystalline structure of the metal to the pulsations of the current flow as it alternates in flowing in its path from the electrodes through the wire. In other words, since, as the name implies, the current alternates between the negative and positive poles and is reversed in the preferred instance 60 times per second, it will be seen that the crystalline particles are subjected to the driving force of the electric current in rapidly alternating directions. It is my belief that this tends to cause the particles to move in their heated dispersion medium to such an extent that the crystalline particles rubbing against each other and against the matrix tend to assume a generally uniform size and shape which results in a more uniform structure of the metal. This rapidly alternating flow of the electric current also tends to assure a more uniform distribution of the particles in the mass. Photomicrographs of the metal stock before and after the heat treatment, using the spaced electrodes and alternating electric current as previously disclosed, has shown that such heat treatment produces a more uniform size and shape of the crystalline structures in the steel and a more equal dispersion of the particles in the matrix than are shown to have resulted from a heat treatment of the same wire by the application of external heat to the wire, as for example in an annealing oven, or the like.

It has also been observed that while the flow of the electric current through the wire tends to impart a slight magnetic property to the wire as a result of the heat treatment, it is not as magnetic as if treated with direct current and that this magnetism is readily dissipated. The wire may be subsequently drawn through the drawing dies without the formation of scale. It is my belief that the high degree of resistance of the completed wire to rust and corrosion when the wire is made in accordance with the present invention is undoubtedly due to the more uniform distribution of the crystalline particles in the metal and the more uniform size of these particles which effect a reduction of the size of the inter-crystalline or inter-particle spaces on the surface of the wire and, since this results in a reduction of the porosity of the surface of the wire, tends to retard the formation of rust or corrosion thereon.

It is also my belief that the compression forces exerted on the wire by the drawing dies while the wire is in the heated condition, further reduces the porosity of the heat extended surface of the wire, and the contraction of the surface of the wire upon subsequent cooling after it has passed through the final heat-treating operation still further closes the pores of the wire surface.

It is to be understood that I do not desire to be limited by the foregoing statements of my belief as to the scientific phenomenon underlying the present invention, nor do I desire to be limited to the particular sequence of steps herein disclosed as a preferred embodiment of the present invention.

It is to be understood that if desired the heating of the wire may be effected by heating in a furnace of the electrical induction type, although some of the advantages of the present method, particularly as regards accurate heat control, may be lost or impaired. It has been found that in practical commercial use, 60 cycle alternating current gives superior results to a 25 cycle alternating current and it is believed that frequencies above 60 will give a still further improved result.

The electrodes used in a process embodying the present invention are preferably of the multiple contact type, which will provide a plurality of contacts with the surface of the wire, any single contact being capable of carrying the entire current load. In this manner a definite electrical contact between the electrodes and the surface of the wire is assured at all times.

It is to be understood that the initial metal stock may be in any desired form, such as a billet or the like, and the invention is not necessarily limited to the drawing of the wire from a cylindrical rod or from a wire of larger diameter.

It is also to be understood that while the term "wire" has been employed throughout this specification, it is not intended that the term should limit the use of the present invention to the drawing of wire having a circular cross section, as the invention may be applied to the drawing of continuous strips of metal of any desired cross section.

The use of alternating electric current instead of direct current is desirable in the present method and contributes to the improved results in that such current is readily controlled by a transformer to give any desired voltage, and further in that its use eliminates a great deal of arcing between the electrodes and the wire since the reversal of the direction of current flow tends to choke out the flow of current over the arc path. Also, the wire under treatment when heated exerts an automatic regulating effect on the current due to its choking action which is not present when direct current is used.

I claim:

1. In a process of drawing carbon steel wire having a carbon content of .50% to .70%, the steps of electrically heating a continuously moving wire to a predetermined temperature by two stationary electric contacts, and thereupon passing the wire through a drawing die, said die being disposed at such a predetermined distance beyond the second contact that a portion of the wire heated between said contacts enters said drawing die at a temperature of 350° to 450° F.

2. In a process of drawing carbon steel wire having a carbon content of .50% to .70%, the steps of heating a continuously moving wire by two stationary electrodes maintained in contact with the moving wire and connected to a source of alternating electric current, whereby the wire is subjected to a simultaneous action of heat and current alternations, and thereupon passing the wire through a drawing die, said die being disposed at such a distance from the last contacted electrode that successive portions of the wire heated between said electrodes enter said drawing die at a temperature of substantially 350° to 450° F.

3. In a process of drawing carbon steel wire having a carbon content of .50% to .70%, the steps of heating a continuously moving wire by two stationary electrodes maintained in contact with the moving wire and connected to a source of alternating electric current having a frequency of approximately 60 cycles per second, whereby the wire is subjected to a simultaneous action of heat and current alternations, and thereupon passing the wire through a drawing die, said die being disposed at such a distance from the last contacted electrode that successive portions of the wire heated between said electrodes enter said drawing die at a temperature of substantially 350° to 450° F.

4. In a process of drawing carbon steel wire having a carbon content of .50% to .70%, the steps of heating a continuously moving wire to a temperature within the range of approximately 800° to 1700° F. by two stationary electrodes maintained in contact with the moving wire and connected to a source of alternating electric current having a frequency of approximately 60 cycles per second, whereby the wire is subjected to a simultaneous action of heat and current alternations, and thereupon passing the wire through a drawing die, said die being disposed at such a distance from the last contacted electrode that successive portions of the wire heated between said electrodes enter said drawing die at a temperature of substantially 350° to 450° F.

5. In a process of drawing carbon steel wire having a carbon content of .50% to .70%, a plurality of stages, each of said stages comprising the steps of heating a continuously moving wire by two stationary electrodes maintained in contact with the moving wire and connected to a source of alternating electric current, and thereupon passing the heated wire through a drawing die so disposed with respect to the last contacted electrode that successive portions of the wire heated between said electrodes enter said drawing die at a temperature of 350° to 450° F.

6. In a process of drawing carbon steel wire having a carbon content of .50% to .70%, a plurality of stages, each of said stages comprising the steps of heating a continuously moving wire by two stationary electrodes maintained in contact with the moving wire and connected to a source of alternating electric current having a frequency of approximately 60 cycles per second, and thereupon passing the heated wire through a drawing die so disposed with respect to the last contacted electrode that successive portions of the wire heated between said electrodes enter said drawing die at a temperature of substantially 350° to 450° F., said wire after passing the drawing die being reheated by the electrodes of the successive stage.

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