Dec. 8, 1942. W. H. WOOD ET AL 2,304,225

METHOD OF ELECTRICALLY HEATING WIRE AND THE LIKE AND APPARATUS THEREFOR

Filed Feb. 26, 1940

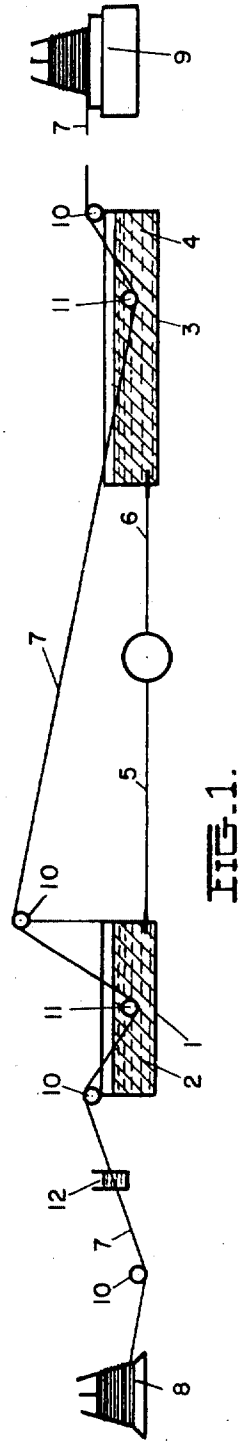


FIG. 1.

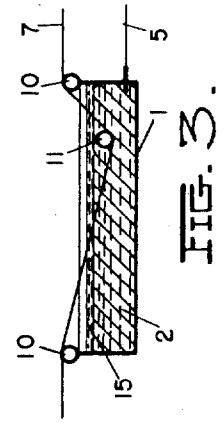


FIG. 3.

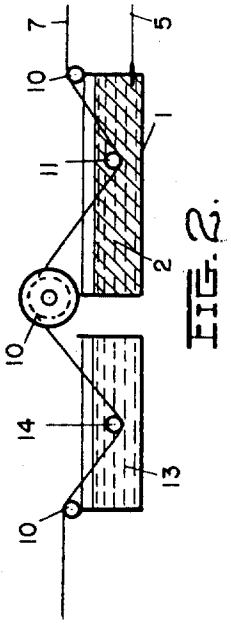


FIG. 2.

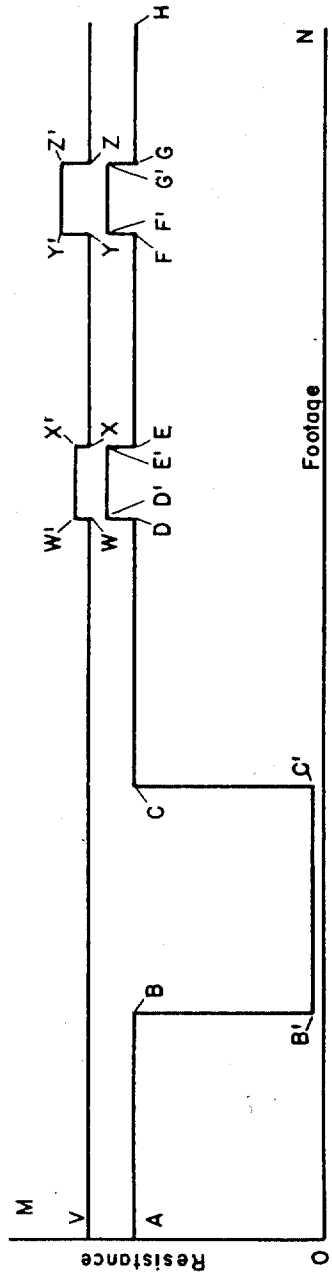


FIG. 4.

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Patented Dec. 8, 1942

2,304,225

UNITED STATES PATENT OFFICE

2,304,225

METHOD OF ELECTRICALLY HEATING WIRES AND THE LIKE AND APPARATUS THEREFOR

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Application February 26, 1940, Serial No. 320,774

7 Claims. (Cl. 219—11)

Our invention relates to improvements in methods of heating material by means of its resistance to the passage of an electric heating current therethrough and in apparatus for the practice thereof. The methods to which our improvements are directed are those in which material such as metal wire, rods, strip and the like is heated by passing such a current therethrough continuously as it is advanced at uniform speed past spaced electrodes through which such current is supplied to the material under treatment. During the past fifty years, efforts have been made repeatedly to devise a practical method whereby material could be so heated. It has been recognized that heating by such a method would offer many advantages, whether it was desired to fabricate the heated material in continuous operation, or to condition it by further steps of metallurgical practice. None of the methods developed by these efforts, however, has been accepted by industry.

Our improvements are particularly useful when it is desired to heat material, such as metal wire, strip and the like uniformly to a high constant maximum temperature from which it is to be quenched or otherwise further treated. In conventional methods of heating for such purposes, gas-fired furnaces, baths of molten material at high temperatures, or muffle furnaces are used. In any of these the material under treatment is heated from the outer surface inwardly and not uniformly throughout its cross-section. Moreover, the rate of heating when using such conventional methods is slower than is desired for best practices for some purposes. Also, in gas-fired furnaces and similar means of heating by burning fuel, there is a definite tendency to injuriously affect the surface of the material, as is well understood in the art. In heating carbon steels this results in decarburized spots in the surface of the material.

Many attempts have been made to escape these disadvantages of conventional methods of heating by substituting a method heating by electrical resistance. Methods of heating material by its resistance to the passage of a heating current, as heretofore proposed, have developed other disadvantages, however, which have prevented the industry from accepting such proposed methods. Chief of these disadvantages, developed in methods of heating by electrical resistance as heretofore proposed, have resulted from arcing, which has caused pitting of the surface of the material, and from variation in density of current flow, which has produced non-uniform maximum temperature in the material. These variations in current flow, we have found, result in part from the arcing and in part from variations in conductivity of the surface of the material under treatment.

The pitting caused by arcing is particularly serious when the material under treatment is steel wire to be used in rope or in making springs. When wire is to be quenched as it reaches maximum temperature, the irregularity of maximum heating causes variations in the qualities of the wire which are highly objectionable. These disadvantages of heating by electrical resistance have been such under all proposed methods that such heating has never been accepted by those engaged in the heat treatment of steel wire and the like.

Of recent years it has been known that in heat treating steels by quenching to a definite temperature from a temperature at which the steel is austenitic, or the temperature of carbon solution, it is often very important that the quench be abrupt from the maximum temperature to the desired temperature of quench. This abruptness of quench cannot be secured by conventional methods of heating because there is always a brief interval between the zone of heating and the zone of quenching. Using resistance heating, this abrupt quench may be secured since the current may be supplied to the wire through a bath which is also the quenching medium.

It is an object of our invention to provide a method of heating metal, when in the form of wire, rod, or strip, progressively throughout its length to a desired constant maximum temperature.

It is a further object of our invention to provide a method of heating metal when in the form of wire, rod, or strip, progressively throughout its length to a desired constant maximum temperature without injuring the surface of such material by de-carburization or by pitting.

It is a further object of our invention to supply heating current to an advancing wire by a method which will avoid arcing of the heating current between the wire and electrode contacts.

And it is a further object of our invention to supply heating current to an advancing wire by a method which will prevent substantial variations of current densities flowing in the wire when a constant current is supplied thereto by spaced electrodes.

And it is also an object of our invention to provide apparatus suitable for the practice of our improved methods.

To the accomplishment of the foregoing and related ends, said invention then consists of the steps and of the apparatus hereinafter fully described and particularly pointed out in the claims.

We have discovered that the arcing and other difficulties, which have attended the use of slide or roller contacts in attempts at resistance heating of wire may be avoided by supplying heating current to the wire by means of contacts of molten metal. The advanced contact may be the molten metal of a quench bath. The molten metal in this bath should be a metal or alloy such as will be liquid at the temperature of the desired quench. It is old to use molten metal as an electrical contact, but heretofore a method has not been known using such molten metal contacts as the pair of electrodes between which an advancing wire is heated by its resistance to the passage of a heating current of electricity supplied through such molten metal. We have found that a method so using molten metal electrodes, avoids the arcing incident to old methods of resistance heating.

However, we have found that when heating wire of commercial grades by our above stated method, there will be a variation in density of current flow which variation will cause variations in the maximum temperature of heating. This variation of maximum temperature is highly objectionable, especially when it is desired to quench the heated wire at its maximum temperature, because it will cause a variation in the physical qualities in successive spans of the wire which variations are undesirable and often become intolerable. This variation in density of current flow results apparently from variations in the electrical conductivity between the molten metal and the wire under treatment.

Variations in electrical conductivity between the molten metal of the contact pots and the material is caused by variations in the surface conditions of the commercial wire treated. The resistance of the surface coating of such wire will be increased in those spans where there is a substantial deposit of scale or rust. Under usual conditions such deposits will occur infrequently and irregularly. They will, however, distinctly lower the maximum temperature reached by the wire under treatment. Similarly there will be spans of wire in which the surface coating of the wire will be so negligible that the molten metal of the bath will wet, or tend to wet, such spans. In these spans the electrical conductivity between the molten metal and the wire will be very much higher than in the spans which have the normal coating on the surface, and the maximum temperature of the wire as it enters the quench will be correspondingly higher.

We have discovered that these variations in conductivity between a wire and the molten metal through which it is advanced may be so corrected as to secure what is practically a uniform conductivity and a resultant uniform temperature in the wire as it leaves the heating zone. This correction we secure by modifying the electrical resistance of the surface of the wire under treatment. On the wire as it passes through the molten metal of the contact pot to enter the heating zone, we maintain an "equalizing film," which markedly increases the surface contact resistance of the wire in those spans which otherwise would be wetted by the molten metal.

Said "equalizing film" is a material, which will adhere to wire, but to which the molten metal will not adhere. The material must be one which can be readily applied to the wire in a uniform film before the wire enters the molten metal of the contact pot, and if the temperature of the molten metal in the contact pot is such that it will decompose, or burn, the film, the material must be of a nature to leave as a deposit, an equalizing coating on the wire within the molten metal. Also the material, or its said deposit must be electrically conductive and it is preferable that the material should penetrate any pronounced accumulation of scale or rust and wet the metal of the wire thereunder.

Oils and greases are excellent materials for use as such an "equalizing film," but said term is used herein as including any material having the above particular characteristics. When an "equalizing film" is maintained on the wire, as specified, in the molten metal of the contact bath, there is uniform electrical resistance between such film and the molten metal, and substantially uniform electrical resistance between such film and the metal of the wire under treatment.

In the drawing, Figure 1 shows diagrammatically apparatus suitable for the practice of our improved methods. Figures 2 and 3 similarly show alternative forms of devices for applying the desired film on the wire before it enters the first contact pot. Figure 4 is a charted curve indicating generally the averaging effect of the film we use on the wire in the practice of our method.

The following description sets forth in detail an approved method of carrying out our invention, such disclosed method, however, constituting but one of the various ways in which the principle of the invention may be used, and describes apparatus by which our improved method may be practiced.

In an illustrative embodiment of our method as used in a steel works for heating steel wire to a temperature at which the steel is austenitic, and from which temperature it is further treated either for securing wire suitable for reduction by drafting, or alternatively for securing tempered wire for springs, we use a bath of molten lead in the first contact pot and in the second pot, which must be maintained at a desired temperature of quench, we use molten lead or a molten alloy having a melting point low enough to meet the requirements of the desired quench for the particular operation. A film of lubricating mineral oil is maintained on the wire as it enters the first contact pot.

Referring to the drawing, Figure 1 shows apparatus for the practice of our method. A contact pot 1 contains molten metal 2 and is maintained in spaced relation with a quench pot 3 containing molten metal 4. This molten metal 4 will be so chosen that it will be fluid at the desired temperature of quench, which temperature will vary, as is well understood, and will depend upon the characteristics desired in the wire under treatment. Electric cables 5 and 6 connect the molten metal in these pots 1 and 3 in series with a source of supply for a heating current of electricity. A wire 7 from a reel 8 is drawn through the molten metal in said pots 1 and 3 by a take-up reel 9. Sheave wheels 10 are so positioned that they guide the wire 7 from the reel 8 to the take-up reel 9, passing the wire through the molten metal of the pots 2 and 4 therebetween. In each bath of molten metal a sinker 11 holds the wire 7 beneath the surface of the molten metal. Intermediate the

reel 8 and the pot 1 the wire 7 is drawn through a wad 12 of oil soaked waste.

In operation the reel 9 draws the wire 7 through the molten metal of the pots 1 and 3 completing therebetween an electric circuit, the other parts of which are the cables 5 and 6 and the molten metal baths 2 and 4. The density of heating current supply is so adjusted to the speed of wire travel that the wire will enter the bath 4 at the temperature desired for quenching. Prior to entering the bath 2 the wire is covered with a film of lubricating mineral oil by passage through the wad of waste 12.

It will be understood that the wire 7, in commerial operation, may be subjected to further treatment between the quench bath 4 and the take-up reel 9 as for instance a further controlled quench, but such further treatment is no part of the invention disclosed herein.

Also it will be understood that, if the wire before being treated in said apparatus has been given a film coating of oil for protection, or has otherwise received an "equalizing film," the heating of the wire by the method described while maintaining thereon such "equalizing film" is within the scope of our disclosed invention.

Alternative apparatus for applying an "equalizing film" to a wire under treatment is shown in Figures 2 and 3. In the former the material used for such film is contained in a tank 13 within which the sinker 14 holds the wire 7 beneath the coating material. In the latter the material used, such for example as high flash oil, is maintained as a layer 15 on the molten metal 2 of contact pot 1. The wire 7 acquires the desired "equalizing film" as it passes through the oil layer 15 to the sinker 11.

Of materials useful for use as an "equalizing film" we prefer ordinary lubricating oil as having excellent qualities as defined, and as being readily obtainable at a slight cost. The oil removed from the crankcases of automobiles when changing oil has proved very efficient as an "equalizing film."

In Figure 4 the scale shows pictorially, but not in true proportion, the effect the "equalizing film" has upon the electrical resistance between the molten metal and the metal of the wire. The base line ON represents wire footage and the right line OM represents surface contact resistance. The surface contact resistance in the ordinary run of a wire is shown by the lines AB, CD, EF and GH. The span BC represents a portion of the wire so clean that the molten metal has wet it causing the resistance to drop to the line B'C'. The spans DE and FG represents spans having deposits of scale and rust which increase the resistances which are represented by D'E' and F'G'.

When an "equalizing film" is maintained on the wire the resistance is averaged. There will be no wetting of the wire by the molten metal and the line ABB'C'CD will become the line VW with substantially no variation of resistance therein. In the span DE the film penetrates the scale or rust and wets the wire. The resulting surface contact resistance is represented by the line W'X'. In the span FG the film does not penetrate the scale or rust and the resistance is represented by the line Y'Z'.

In the drawing Figure 4 is not to scale but merely indicates pictorially the general effect of using the "equalizing film." It will be noted that the resistance without the film varies from the line B'C' to the line F'G' but that the resistance varies when using the film only from the line VW to the line Y'Z'.

Other modes of applying the principles of our invention may be employed instead of the one explained, change being made as regards the method or apparatus herein disclosed, provided the steps or elements stated by any of the following claims or the equivalent of such stated steps or elements be employed.

We therefore particularly point out and distinctly claim as our invention:

1. In the method of heating metal material, in the form of wire and the like, in successive uniform cross-sections continuously to a desired maximum temperature by passing a heating current of electricity therethrough, between contact pots of molten metal in spaced relation, as such wire is advanced through the molten metal of such pots at constant speed, the improvement which includes the following step: maintaining on the surface of such material, covering same as it enters the molten metal of the first contact pot, a film coating of oil.

2. The method of heating metal material, in the form of wire and the like, including the following steps: advancing such material at a constant speed into and through molten metal contained in contact pots in spaced relation; passing through such material, while so advancing, in the span defined between the molten metal of such pots, a heating current of electricity having a density of current flow such as will heat the material to a desired temperature as it leaves the span defined between the surfaces of molten metal in such contact pots, such current being supplied to such material through the molten metal of such pots; and maintaining on the surface of such material, covering same as it enters the first contact pot, a film coating of an adhering substance providing and maintaining, between the metal of the material and the molten metal, a continuous electrically conductive layer having substantially uniform electrical resistance throughout.

3. The method of heating metal material, in the form of wire and the like, including the following steps: advancing such material at a constant speed into and through molten metal contained in contact pots in spaced relation; passing through such material, while so advancing, in the span defined between the molten metal of such pots, a heating current of electricity having a density of current flow such as will heat the material to a desired temperature as it leaves the span defined between the surfaces of molten metal in such contact pots; supplying such current to such material through the molten metal of such pots; and maintaining on the surface of such material, covering same as it enters the molten metal of the first contact pot, a film coating of oil.

4. The method of heating metal material, in the form of wire and the like, including the following steps: advancing such material at a constant speed into and through molten metal contained in contact pots in spaced relation; passing through such material, while so advancing, in the span defined between the molten metal of such pots, a heating current of electricity having a density of current flow such as will heat the material to a desired temperature as it leaves the span defined between the surfaces of molten metal in such contact pots; supplying such current to such material through the molten metal of such pots; and

maintaining on the surface of such material, covering same as it enters the first such contact pot, an equalizing film, whereby the electrical resistance between such film coated material and the molten metal of the contact pots is substantially constant throughout the length of such material.

5. In a method of heating elongated metal material such as wire and the like, the steps which consist in advancing such material at substantially uniform speed into and through spaced molten metal contacts; passing a heating current of electricity through the span of material defined between such contacts; and applying to the surface of such material in advance of the first contact an oil film.

6. Apparatus for heating wire and the like advanced therethrough in continuous operation, comprising a contact pot of molten metal; a second contact pot of molten metal in spaced relation with said first pot; means operative to apply a film of oil to the surface of such wire before it enters said first contact pot; means operative to maintain an electrical potential between the metal in said pots; and means in each of said pots operative to hold a wire beneath the surface of the molten metal while such wire is drawn successively through said pots.

7. Apparatus for heating wire and the like advanced therethrough in continuous operation, comprising a contact pot of molten metal; a second contact pot of molten metal in spaced relation with said first pot; means operative to apply an equalizing film to the surface of such wire before it enters said first pot; means operative to maintain an electrical potential between the metal in said pots; and means in each of said pots operative to hold a wire beneath the surface of the molten metal while such wire is drawn successively through said pots.

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