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J. A. SEEDE

ELECTRIC HEATING

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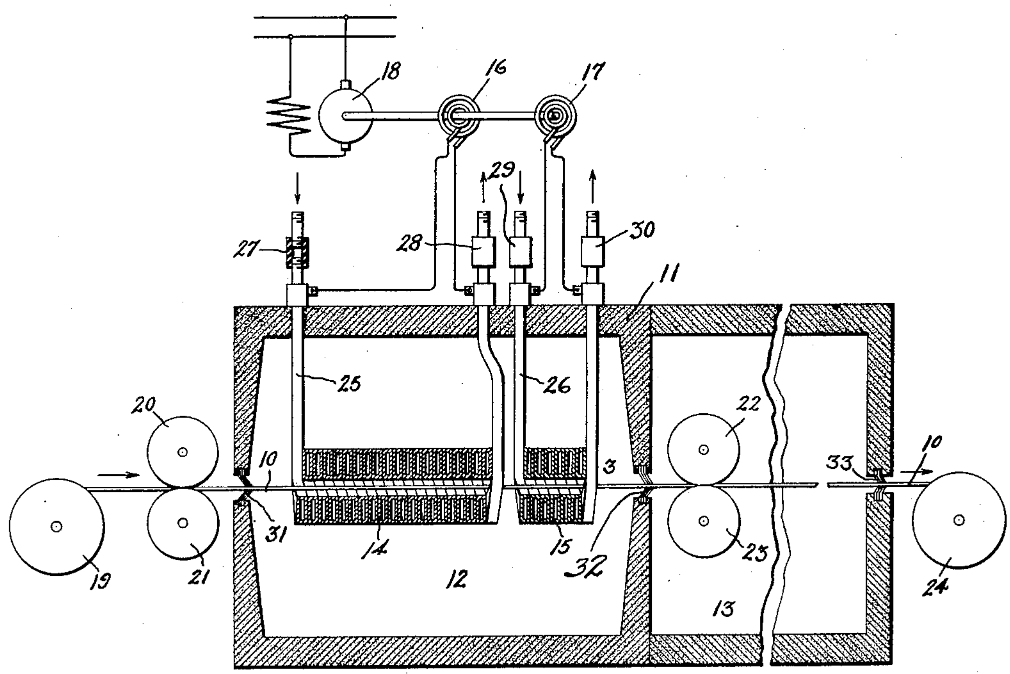

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UNITED STATES PATENT OFFICE.

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ELECTRIC HEATING.

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My invention relates to electric heating, more specifically to electric heating by subjecting the object to be heated to an alternating magnetic field, and has for its object the provision of a simple, reliable and efficient method and apparatus for electric heating.

My invention has particular application to the heating of articles made of magnetic materials and the like such as iron, by means of an alternating magnetic field and without core iron inter-linkage. With this method of heating it is desirable from the standpoint of efficiency of the generating apparatus to use as low frequencies as possible since the efficiency of the generating apparatus decreases rapidly with an increase in the frequency. On the other hand, with this method of heating it is difficult with the lower frequencies to heat magnetic metals to temperatures above the decalescent point of the metal. This is due to the fact that when the lower frequencies are used, a predominant amount of the total heat generated below the decalescent point is due to hysteresis, a relatively small amount being due to induced currents, while after the decalescent point has been reached and the metal becomes non-magnetic, heat is no longer generated by hysteresis and the heat must then be generated by the induced currents. Therefore, with the lower frequencies the rate of heat generation is very greatly reduced as soon as the decalescent point is reached. When higher frequencies are used, however, the metal can be heated readily to temperatures above the decalescent point, since with these higher frequencies a much larger proportion of the heat is generated by the induced currents and consequently the rate of heat generation is not so greatly reduced through the lack of hysteresis after the decalescent point has been passed. This follows from the fact that the rate of heat generation by hysteresis varies directly with the frequency, whereas the rate of heat generation by means of induced currents varies as the square of the frequency.

In carrying out my invention in one form I provide two electrical supply sources having different frequencies, and utilize the source of lower frequency to initially heat the article to a predetermined temperature which may be approximately the decalescent point of the material, after which the article is heated to the desired higher temperature by the source of higher frequency.

For a more complete understanding of my invention, reference should be had to the accompanying drawing, the single figure of which shows in diagrammatic form electric heating apparatus embodying my invention.

Referring to the drawing, I have shown my invention in one form as applied to the heating of attenuated articles. In the specific form shown my invention is applied to the continuous annealing of a steel strip 10. The heater comprises suitable heat refractory walls 11 forming two chambers, a relatively short heating chamber 12, and an elongated cooling chamber 13 communicating with the chamber 12. In the heating chamber are two magnet coils 14 and 15 which are energized from suitable alternating current supply sources, shown as alternators 16 and 17 driven by a suitable electric motor 18. The coils 14 and 15 are mounted in end to end relation so that their axes are coincident, and the steel strip 10 to be heated is passed continuously through the coils in an axial direction. As shown, the steel strip 10 is supplied from a reel 19 from which it passes at a uniform speed between guide rollers 20 and 21 and thence into the heating chamber 12, in which chamber it passes first through the coil 14 and then through the coil 15. After leaving the heating chamber the strip passes between suitable guide rollers 22 and 23 in the colling chamber, thence through the cooling chamber, and upon emerging from the cooling chamber it is wound upon a reel 24. It will be understood that the strip is moved continuously through the heating and cooling chambers in any suitable manner, for example by means of an electric motor (not shown) connected to turn the reel 24.

The coil 14 is supplied with a relatively low frequency current from the supply source 16, for example current at a frequency of 500 cycles, and the strip 10 in passing through this coil is heated to approximately its decalescent point at which point it becomes non-magnetic. This temperature for certain steel is approximately 730° C. It will be understood that the article being heated need not necessarily be heated to the decalescent point in the coil supplied with the lower frequency, since it may be found to be desirable in some cases to transfer the article to the higher frequency coil before it has actually reached this point or continue the heating somewhat above the decalescent point before using the higher frequency coil. The temperature of the strip is further raised to the desired annealing temperature in passing through the coil 15, which coil is supplied by the source 17 with a relatively high frequency current such, for example, as a current of 2,000 cycles or more. For steel, an annealing temperature of approximately 900° C. may be used.

Since the coil 14 in heating the strip to approximately the decalescent point imparts more heat to the strip than the coil 15, for the temperatures previously referred to, the coil 14 is elongated in an axial direction and as shown has greater length than the coil 15. With the coil 14 thus elongated, the strip is subjected to its field for a sufficient length of time to be heated to the decalescent point.

Preferably the coils 14 and 15 are wound from flat conductors 25 and 26 which are placed edgewise with respect to the axes of the coils so as to provide for the desired number of turns without producing an excessively long coil. The flat conductors are also preferably made hollow, as shown, so as to constitute ducts through which a cooling liquid, such as water, may be circulated to prevent overheating of the coils. It will be understood that the turns of the coils are suitably electrically insulated from one another. In order to provide for the circulation of water through the coils, rubber hose couplings 27 to 30 inclusive may be slipped over the ends of the conductors, which are brought out through the wall of the heating chamber, and suitable connections made in turn with the hose couplings to a suitable source of water supply. As shown, the hose couplings 27 and 29 will be connected to the source of water supply, the couplings 28 and 30 being connected to a drain, whereby water will be caused to circulate through the conductors in the general direction of movement of the strip 10 as indicated by the arrows. The object in providing the hose couplings 27—30 inclusive is to electrically insulate the coils from the water supply apparatus. Any suitable coupling which will at the same time act as an electrical insulator may be used.

In passing through the cooling chamber 13 the strip is cooled to a temperature such as 350° C. at which excessive oxidation and scaling will not take place in the open air, and to prevent oxidation therein the cooling chamber is preferably filled with an inert gas, such as hydrogen. The heating chamber 12 also is preferably filled with an inert gas to prevent oxidation in this chamber. In order to prevent the escape of gas, wipers 31, 32 and 33 are provided in the opening through which the strip enters and leaves the heating and cooling chambers.

While I have shown my invention as applied to the continuous annealing of strip steel, it will be understood that my invention has general application in the heating of articles of various shapes and made of various materials which are electrically conducting and act as resistors for currents induced in them. Furthermore, my invention may be used in heating for various purposes other than annealing, for example it may be used in the heating of metals for forging purposes and it may be used in the melting of metals, the desired maximum temperature being obtained as described by means of the current of higher frequency.

While I have described my invention as embodied in concrete form and as operating in a specific manner in accordance with the provisions of the patent statutes, it should be understood that I do not limit my invention thereto, since various modifications thereof will suggest themselves to those skilled in the art without departing from the spirit of my invention, the scope of which is set forth in the annexed claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of heating resistors, which consists in subjecting the resistor to the action of a plurality of alternating magnetic fields of different frequencies, the field of higher frequency being used to complete the heating operation.

2. The method of heating resistors, which consists in heating the resistor to a predetermined temperature by subjecting it to an alternating magnetic field of relatively low frequency, and then heating the resistor to a higher temperature by subjecting it to a magnetic field of relatively high frequency.

3. The method of heating magnetic articles, which consists in heating the article to approximately the decalescent point by subjecting it to an alternating magnetic field of relatively low frequency, and then heating the article to a higher temperature by subjecting it to a magnetic field of relatively high frequency.

4. The method of heating articles made of magnetic material, which consists in heating the article to approximately the decalescent point mainly by the hysteresis effect produced by a magnetic field of relatively low frequency, and then heating the article to a higher temperature by means of induced currents produced by a magnetic field of relatively high frequency.

5. The method of heating attenuated articles, which consists in passing tthe article through a coil supplied with relatively low frequency current wherein the article is heated to approximately the decalescent

point, and then passing the article through a coil supplied with relatively high frequency current to heat the article to a higher temperature.

6. Electric heating apparatus comprising a pair of magnet coils, means for supplying currents of different frequencies to said coils, and means whereby the article to be heated is first subjected to the magnetic field of the coil supplied with the lower frequency current so as to be heated to a predetermined temperature, and then subjected to the magnetic field of the coil supplied with the higher frequency current so as to be heated to a higher temperature.

7. Electric heating apparatus comprising a pair of magnet coils, means for supplying currents of different frequencies to said coils, means for passing the article to be heated through said coils, and cooling means for said coils.

8. Means for heating articles made of magnetic material, comprising a pair of magnet coils, means for supplying currents of different frequencies to said coils, and means for passing the article to be heated first through the coil supplied with the lower frequency wherein it is heated to approximately the decalescent point, and then through the coil supplied with the higher frequency wherein it is heated to the desired higher temperature.

9. Means for heating attenuated magnetic material, comprising heat refractory walls forming a heating chamber and an elongated cooling chamber, a pair of magnet coils placed end to end in said heating chamber with their axes coincident, and means for passing the material to be heated continuously first through said coils in said heating chamber and then through said cooling chamber, said coils being so arranged that the material passes first through the coil supplied with the lower frequency in which it is heated to approximately the decalescent point, and then through the coil supplied with the higher frequency in which it is heated to the desired higher temperature.

In witness whereof, I have hereunto set my hand.

JOHN A. SEEDE.