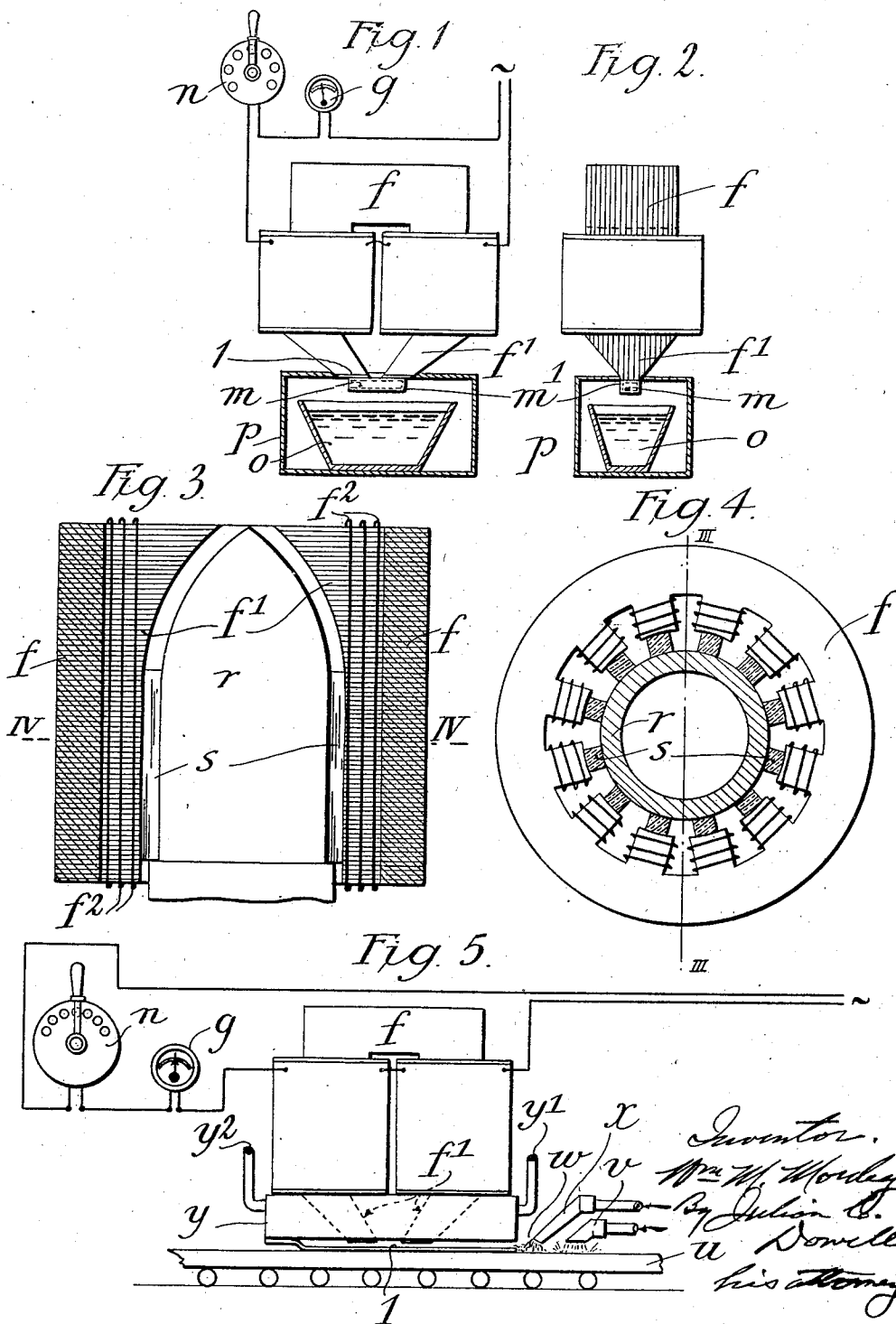


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HEAT TREATMENT OF ARTICLES OF IRON AND STEEL AND ALLOYS THEREOF,
APPLICATION FILED JUNE 2, 1920.

1,412,484.

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UNITED STATES PATENT OFFICE.

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HEAT TREATMENT OF ARTICLES OF IRON AND STEEL AND ALLOYS THEREOF.

1,412,484.

Specification of Letters Patent. Patented Apr. 11, 1922.

Application filed June 2, 1920. Serial No. 386,030.

To all whom it may concern:

Be it known that I, WILLIAM MORRIS MORDEY, a subject of the King of Great Britain and Ireland, residing at Westminster, England, have invented Improvements in or Relating to the Heat Treatment of Articles of Iron and Steel and Alloys Thereof, (for which I filed an application in Great Britain May 8, 1918, No. 17,117 of 1919,) of which the following is a specification.

In the specification of another application for Letters Patent filed by me, dated June 2nd, 1920, Serial Number 386,029, I have described the heat treatment of tramway and like rails formed of iron or steel or alloys thereof, either in situ after laying, or before laying, the object being to enable the heating of the rail to a high temperature to be effected in a simple, quick and convenient manner so that the physical condition of the rail can be altered and improved, and particularly for enabling a rail made of suitable steel to be heated to a sufficiently high temperature to admit of its being subsequently hardened and toughened by suitably cooling it.

Now the present invention has reference to improvements in the heat treatment of articles of iron and steel and alloys thereof, of various kinds, other than rails, as for example plates, sheets, cylinders, shells, rods and other articles for the purpose of enabling special qualities or characteristics to be imparted thereto or to parts thereof.

For this purpose, such an article, which is hereinafter called a steel article, to distinguish it from a tramway or like rail (hereinafter called a rail) forming the subject of my said other application for patent, is heated by arranging it in the magnetic circuit of an alternate current electro-magnet which may be one phase or multiphase and is so constructed that an alternating magnetic flux will be induced in the steel article under treatment of sufficient value to set up eddy currents therein of such strength, aided to some extent by magnetic hysteresis, as to heat the steel article to the temperature required but not to a temperature exceeding the critical non-magnetic temperature of the particular steel of which the article is composed, use being made for this purpose of the fact that the generation of heat will then automatically cease to increase owing to the permeability of the heated steel article being then considerably reduced. After being

thus heated to the desired temperature, the article is suitably cooled to impart thereto the desired characteristics.

In or associated with the winding of the electro-magnet is placed an indicating instrument which may be an ammeter, or a voltmeter, or a wattmeter, or a power factor meter, to show when the heating of the article has reached the required temperature, which will vary more or less with different kinds of steel. An infallible indication of the desired temperature having been attained, will be given by the instrument, which will respond to the altered condition of the magnetic circuit.

In the accompanying illustrative drawings, Figs. 1 and 2 show respectively in side and end elevation and more or less diagrammatically, one way of carrying out the invention. Fig. 3 is a vertical section on the line III—III of Fig. 4 and Fig. 4 a horizontal section on the line IV—IV of Fig. 3, showing a modified arrangement. Fig. 5 shows in side elevation a further modified arrangement.

The invention can advantageously be applied to the heating and hardening of articles of steel of various kinds, particularly tools, gauges and other appliances made of tool steel. For this latter purpose, there is used, as shown in Figs. 1 and 2, a powerful alternate current electro-magnet *f* having poles *f*¹ which may vary in form and be interchangeable to suit various requirements. *n* is a switch for controlling the supply of alternate current to the electro-magnet. *g* is an instrument of one of the kinds hereinbefore described, for indicating when the article has reached the required temperature. In such an arrangement, the electro-magnet may, as in the example shown, be supported in any convenient way with a space below its poles. The article *m* to be hardened is, in this example, placed against the poles where it is held by magnetic attraction. The excitation of the electro-magnet is such that the article will be heated, as hereinbefore described, by eddy currents due to the magnetic flux traversing it, and, to a certain extent, by magnetic hysteresis. When the article attains the critical non-magnetic temperature, it may be allowed to fall off and may be allowed at once to drop into a suitable quenching bath *o* to harden it. To heat only one end portion of a tool or other article to the critical non-magnetic-tempera-

ture, the electro-magnet may be applied to that end portion only, such end portion on becoming non-magnetic being released and, it may be, allowed to fall off as above stated.

- 5 The other end portion of the article can be kept sufficiently cool in any desired way, as by exposure to the air, during the heating of the opposite end portion.

- To conserve heat and to prevent or diminish oxidation, the steel article may be surrounded or partly surrounded by a shield m^1 (Fig. 2) of heat insulating material, as for instance asbestos. Or part of the poles f^1 of the electro-magnet f and the steel article m to be heated, may, as shown in Figs. 1 and 2, be enclosed in a vessel p from which the air is exhausted, or in which an inert or reducing atmosphere is maintained. The article m may also in this case and as shown in Fig. 2, be provided with a shield m' .

- Figs. 3 and 4 show how the invention may be applied to the heat treatment of hollow iron and steel articles, such as shells or cylinders, the article shown in the example being an armour piercing shell r . In this case the electro-magnet f , built up of laminated iron sheets, is made of tubular shape with multiple poles f^1 arranged to surround and conform more or less to the shape of the shell and energized by windings f^2 , the electro-magnet being arranged to be placed over the shell or the shell to be inserted in the electro-magnet. The two may be separated from each other by means, such for instance as lengths s of asbestos.

- In the heat treatment of iron and steel and alloys thereof, such for example, as plates, sheets, rods and the like, but excepting tramway and other rails, the article and the alternate current electro-magnet may, when necessary, as for instance owing to the length of the article, be moved endways relatively to one another so as to heat successive portions of the articles along its length. Thus, in Fig. 5, f is a stationary alternate current electro-magnet of the kind referred to, and u an elongated article of one or other of the kinds referred to, for instance a plate, that is movable endways below the poles f^1 of the electro-magnet. The article u after being heated as described to the desired temperature, is rapidly cooled, as by water, or an air blast, issuing from a nozzle v to impart thereto desired characteristics.

- Or the heating of the steel article u may be effected partly by electro-magnetic means as described, so as to preheat it to any desired temperature up to the critical non-magnetic temperature, and partly by supplementary heating means, such for example as a suitable flame w (see Fig. 5) extending from a nozzle x , so that the temperature of the article can be raised to the critical non-magnetic temperature, or, if desired even to a higher temperature. The flame nozzle x ,

when used, will be arranged near to the magnet poles f^1 and be succeeded closely by the nozzle v from which a cooling medium issues against the heated portion of the article.

The alternating current used may have a frequency sufficiently high, in some cases, to ensure that the heat shall, when required, be mainly produced at and near the surface of the article. The frequency may be varied as one means of controlling the depth of penetration of the heat in the article.

Cooling arrangements are or may be provided to prevent overheating of the poles or other parts of the electro-magnet as for example by arranging the poles f^1 to extend in a water tight manner, through a box y (Fig. 5) through which, and inlet and outlet pipes y^1, y^2 , water is caused to flow. Also, means may be provided to minimize heating of the poles of the electro-magnet by heat derived from the article, or portion thereof, for the time being under treatment. For this purpose, non-conducting material for instance lengths of asbestos s (Fig. 4) or sheet asbestos 1 (Fig. 5) may be arranged between the poles f^1 and the article or articles being heated. The laminæ of the poles are preferably insulated with very thin mica.

What I claim is:—

1. The heat treatment of an iron or steel article other than a rail for the purpose of altering and improving the physical condition of the metal of which the article is composed, such treatment consisting in arranging the article in a magnetic field set up between the magnetic poles of a powerful alternate current electro-magnet so that the article will form part of the magnetic circuit of the magnet core and will have induced in it a magnetic flux and consequently eddy currents of such strength as thereby to become heated to the desired temperature limited by the critical non-magnetic temperature of the metal of which the article is composed, and afterwards cooling the said article.

2. In the heat treatment of an iron or steel article, other than a rail, according to claim 1, cooling the said article rapidly after it has been heated to the desired temperature.

3. In the heat treatment of an iron or steel article, other than a rail, according to claim 1, energizing the electromagnet by alternate current of high frequency to limit the depth of heating of the article under treatment, substantially as described.

4. For carrying out the method of heat treating an iron or steel article, other than a rail, according to claim 1, apparatus comprising an alternate current electromagnet having a core terminating in two adjacent magnetic poles spaced apart to form between them a magnetic field in which the article to be treated is arranged and a winding adapted to powerfully energize the mag-

netic core and thereby generate heat in the portion of the article for the time being in the magnetic field between the said poles and forming part of the magnetic circuit, a
 5 current supply conductor for said winding and an indicating device associated with the said current supply conductor and adapted to show, in consequence of the altered condition of the magnetic circuit including the
 10 magnet core and portion of the article under treatment, when the heating of the said portion of the rail has reached the desired temperature.

5. For carrying out the method of heat
 15 treating an iron or steel article, other than a rail, according to claim 1, apparatus comprising an alternate current electro-magnet having a core terminating in two adjacent magnetic poles spaced apart to form between
 20 them a magnetic field in which the article to be treated is arranged, a winding adapted to powerfully energize the magnetic core and thereby generate heat in the portion of the article for the time being in the magnetic
 25 field between the said poles and forming part of the magnetic circuit, and means for protecting the said article from oxidation during the heating thereof.

6. For carrying out the method of heat
 30 treating an iron or steel article, other than a rail, according to claim 1, apparatus comprising an alternate current electromagnet having a core terminating in adjacent magnetic poles spaced apart to form between
 35 them a magnetic field, a steel article arranged to be heated by the magnetic flux passing through said field and non-magnetic material covering said article whilst it is being heated.

40 7. For carrying out the method of heat

treating an iron or steel article, other than a rail, according to claim 1, apparatus comprising an alternate current electro-magnet having a core terminating in adjacent magnetic poles spaced apart to form between
 45 them a magnetic field in which the article to be heated is arranged so that it will form part of the magnetic circuit of the said magnet core, and nonconducting material between said magnetic poles and the article
 50 being heated.

8. For the heat treatment of a steel article, other than a rail, heating the article partly by eddy currents set up therein electro-magnetically, and partly by flame, for
 55 the purpose set forth.

9. The heat treatment of an article formed of tool steel, for the purpose of heating and hardening it, by applying the article to the poles of an alternate current electro-magnet, energizing said electro-magnet and
 60 thereby heating the article by alternating magnetic flux caused to pass through it and when heated to the critical non-magnetic temperature rapidly cooling it.

10. The heat treatment of an article formed of tool steel, for the purpose of heating and hardening it, by applying the article to the poles of an alternate current electro-magnet, energizing said electro-magnet and thereby heating the article by alternating magnetic flux caused to pass through it and when heated to the critical non-magnetic temperature allowing the article automatically to fall off of the poles of the electro-magnet and into a cooling medium.
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Signed at London, England, this 17th day of May, 1920.

WILLIAM MORRIS MORDEY.