W. M. MORDEY.

HEAT TREATMENT OF TRAMWAY AND OTHER RAILS.

APPLICATION FILED JUNE 2, 1920.

1,383,963.

Patented July 5, 1921.

2 SHEETS—SHEET 1.

Fig. 1.

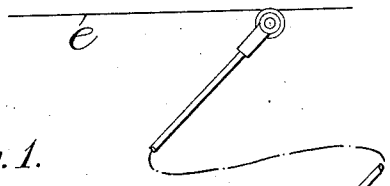

Fig. 2.

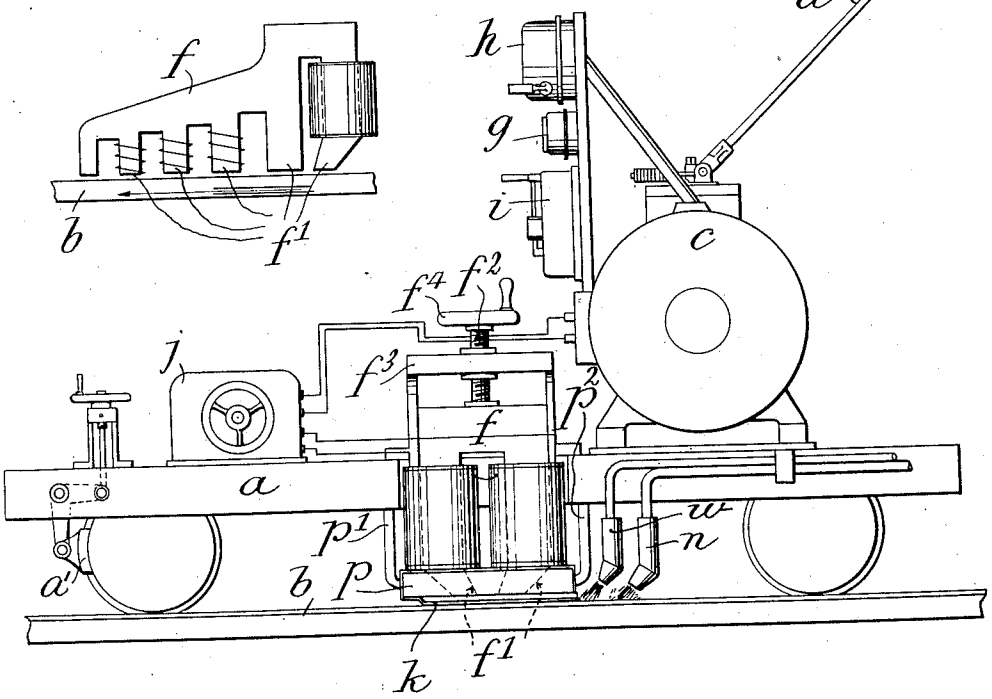

Fig. 3.

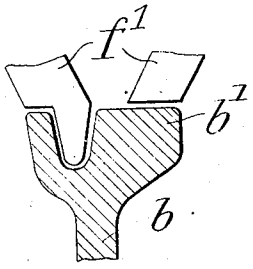

Fig. 4.

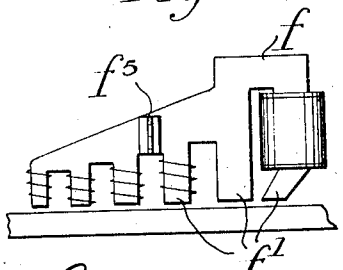

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Fig. 5.

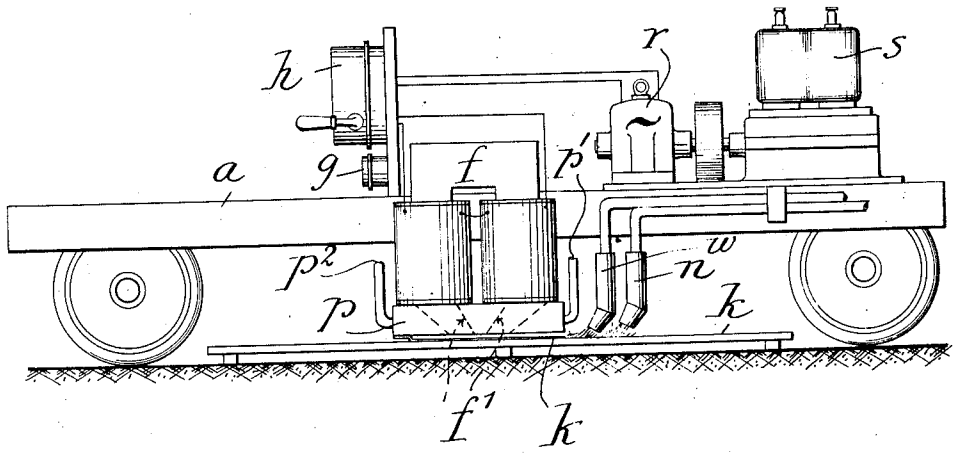
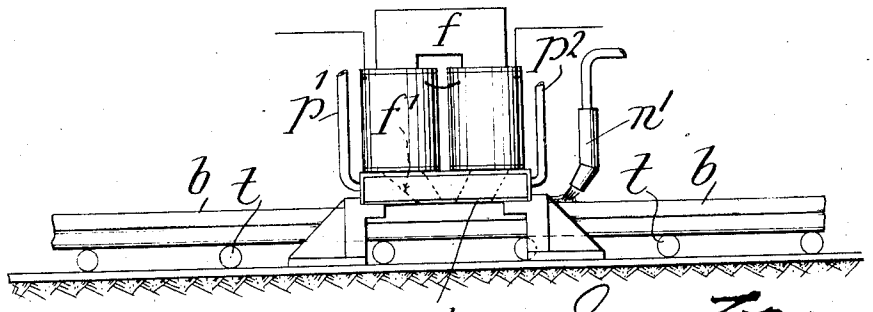


Fig. 6.



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UNITED STATES PATENT OFFICE.

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HEAT TREATMENT OF TRAMWAY AND OTHER RAILS.

1,383,963. Specification of Letters Patent. Patented July 5, 1921.

Application filed June 2, 1920. Serial No. 386,029.

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 Tramway and other Rails, for which I have filed application in Great Britain, May 8, 1918, application No. 7752, of which the following is a specification.

It is known that the wearing surfaces of tramway or other rails can be hardened and toughened and the wearing properties thereof improved, by heating the rails to a sufficient temperature and depth and cooling them at a moderate rate.

The present invention has for its object to enable the heating of tramway and other rails either *in situ* after laying, or before laying, to a high temperature to be effected in a simple, quick and convenient manner to enable the physical condition of such rails to be altered and improved, and particularly for enabling rails made of suitable steel to be heated to a sufficiently high temperature to admit of their being subsequently hardened and toughened by suitable cooling.

For this purpose, successive portions of a tramway or other rail are heated by bringing them one after the other into the magnetic circuit of an alternate current electro-magnet, which may be one phase or multiphase, so constructed and of such strength, that an alternating magnetic flux will be induced in each portion of the rail 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 metal composing it to the temperature required but not to a temperature exceeding the critical non-magnetic temperature of the particular metal of which the rail is composed, use being made, for this purpose, of the fact that, at this point, the generation of heat will automatically cease to increase owing to the permeability of the heated material being then very considerably reduced.

Each portion of rail after being heated to the desired temperature is suitably cooled to impart thereto the desired characteristics.

The invention can advantageously be applied to the heat treatment of rails of various kinds made of iron or steel or of iron or steel alloys, all hereinafter included in the term rail.

The following is a general description of the application of the invention for the purpose set forth, in connection with which it has the advantage that an electrical indication is given when the desired temperature has been attained. There is also the further advantage that the alternating current used in carrying out the heating process can be made to afford, according to the invention, a means of electrically propelling the vehicle carrying the heating apparatus along the track, as required by the process of the heating of the rails.

The invention will be readily understood from the following description with the aid of the accompanying drawings, wherein Figure 1 shows in side elevation and diagrammatically, apparatus suitable for carrying it into practice. Fig. 2 is a side elevation showing a different construction of electro-magnet. Fig. 3 shows in transverse section a modified arrangement of the pole pieces of the electro-magnet in relation to the rail to be heated. Fig. 4 shows in side elevation a modified construction of electro-magnet. Figs. 5 and 6 are side elevations showing two modified arrangements of apparatus embodying the invention.

Referring first to Fig. 1, on a vehicle a suitable for running on the rails b of a tramway is mounted a rotary transformer or motor generator c, that receives, through suitable means, as for instance a trolley pole d, direct current from a trolley wire e, or other supply conductor, and converts it into alternate current. If a supply of alternating current is available either from the trolley wire e or otherwise, a rotary transformer will of course not be required. Carried by the vehicle a and supported immediately above one or each of the rails b is a powerful laminated alternate current electro-magnet f having its poles f^1 close to the rail. Suitable means are provided for adjusting the position of the magnet vertically in relation to the rail to suit requirements for working and transport. For this purpose, a screw f^2 jointed to the electro-magnet f may extend through a stationary support f^3 and be provided with an adjusting wheel f^4. The winding or windings of the electro-magnet are traversed by the alternating current or currents received from the rotary transformer, an alternating magnetic flux being thereby induced in the head of the rail b under and between the poles f^1

of the electro-magnet, the magnetic circuit being completed locally through the head of the rail. As a consequence of this, the portion of the rail so acted on is heated by eddy currents and to some extent by magnetic hysteresis. The poles f^1 may be of any suitable form and may be arranged to send the magnetic flux horizontally through a portion of the head of the rail, and may be tapered to concentrate the induction as shown in Fig. 1. Or they may, as shown in Fig. 3, be arranged to send the flux through the upper portion of the rail head b^1 from side to side thereof, that is to say at right angles to the length of the rail b.

As the required temperature is attained, the vehicle a is moved along, preferably at an even rate, and the heated portion of the rail is allowed to cool, cooling being quickened, if necessary, as by a water spray or air blast, caused to impinge on the rail as through a nozzle n (Fig. 1) arranged near to the part of the rail being heated.

The electro-magnet f may, in some cases be a multiphase electro-magnet and be formed like a straightened out circumferential portion of the stator or field of a multiphase induction motor, but preferably graduated in section and in winding, to comply with the conditions hereinafter explained. When the electro-magnet, or part of it, is thus made, as shown diagrammatically in Fig. 2, it may be used to propel the vehicle a by the reaction set up between it and the eddy currents in the rail b, the speed being controllable, as for example by variation of the excitation of part of the electro-magnet, or of the air gap between the poles f^1 and the rail, or by a friction brake a^1 (Fig. 1) on the vehicle.

By the extension of the electromagnet in the direction of travel, as shown in Fig. 2, the heating may be effected in a more gradual manner over a considerable length of rail, the poles being graduated in strength, those that cause the final and greatest heating being much the stronger in order to act effectively. The electro-magnet may, as shown in Fig. 4, be made in parts mounted to turn sidewise relatively to one another, as about a joint f^5, or the poles in the middle portion of an electro-magnet, such as shown in Fig. 2, may be broadened horizontally in a lateral direction, to suit curves in the rail under treatment.

It is only necessary that a very short portion of the rail head should at any time attain the highest temperature required, so long as each portion successively attains it.

In or associated with the winding of the electro-magnet f—is placed an indicating instrument g, which may be an ammeter, or a voltmeter, or a wattmeter, or a power factor meter, to show when the heating of the rail 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.

Guided by the indication of the instrument g, the rate of forward movement of the vehicle a can be controlled so that a magnetic portion of the rail b is constantly coming into the field of the electro-magnet f, while the portion that has been heated sufficiently to become non-magnetic, or nearly so, is constantly passing out of that field. In this way a continuous and uniform thermal effect is produced on the rail and a steady load imposed on the electrical plant used. The indication of the instrument g being a sufficient guide to the proper rate of forward movement of the vehicle, it is not necessary to directly observe the rail itself, or its degree of heat. So far as is practicable, the portion of the rail that is being heated may therefore be covered or shielded in any convenient way as for instance by asbestos or other suitable material, to lessen oxidation of the rail and to conserve heat. Such a shield, shown at k in Fig. 1, may be attached to the electro-magnet f so that it will be moved along therewith by the vehicle. Such a shield may be arranged, as shown, to prevent the water spray or other coooling medium used for subsequently cooling the rail and issuing for example from the nozzle n, from coming in contact with the portion of the rail that is being heated in the field of the electro-magnet.

The successively heated portions of rail are suitably cooled, as for instance in the manner described, for imparting to the rail the required characteristics. It will be understood that the heating of the rail, and also the cooling of the rail, are effected in a continuous or progressive manner and not in intermittent steps or stages.

Or, the heating of the rail may be effected partly by electro-magnetic means as described, so as to preheat the rail to any desired temperature up to the critical non-magnetic temperature, and partly by supplementary heating means such as a suitable flame extending from a nozzle w so as afterward to raise the temperature of the rail to the critical non-magnetic temperature, or, if desired to a higher temperature. The flame nozzle w will be arranged near to the magnet poles f^1 and be followed closely by the nozzle n from which the cooling medium issues against the heated portion of the rail.

A frequency sufficiently high may be used to insure that the heat shall be mainly produced at or near the surface of the rail. The frequency may be varied as one means of

controlling the depth or penetration of the heat in the rail.

Suitable switching and controlling devices are arranged in the respective direct current and alternate current circuits to regulate the speed, frequency and output of the rotary transformer or motor generator. Thus, in Fig. 1, *h* is a starting and controlling switch for the rotary transformer *c*; *i* a main switch in the rotary tranformer circuit and *j* a controller for the alternate current electromagnet *f*, the indicating instrument hereinbefore referred to being shown at *g*.

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 *p* through which and inlet and outlet pipe p^1 and p^2 water is caused to flow. Also, means may be provided to minimize heating of the poles by heat radiation from the portion of the rail for the time being under treatment. For this purpose the shield *k* (Fig. 1) hereinbefore referred to, made say of asbestos cloth, may be used. The laminæ of the poles should, preferably, be insulated with very thin mica.

If a supply of alternating current is available either from the trolley wire *e* or other supply conductor the rotary transformer *c* is dispensed with and the alternating current supplied direct to the switch *h*. If a suitable supply of electric energy is not available from an overhead or other supply conductor, the alternate current required may be provided by an alternator *r*, (see Fig. 5) mounted on the vehicle and driven by any suitable means, as for instance by an internal combustion engine *s*.

The electro-magnet or magnets, and the means for supplying alternate current thereto, may, as in the examples shown, conveniently be on the same vehicle.

For treating rails before they are laid, it may be convenient to fix the electro-magnet or magnets and to move each rail relatively to it, as shown for example in Fig. 6, where *f* is a stationary electro-magnet and *b* a rail carried by rollers *t* and capapble of being moved endwise below the poles f^1 and a water nozzle n^1 for the purpose hereinbefore described.

No claim is herein broadly made to the heating of iron or steel or alloys thereof by placing said metal in the field of an alternate current electromagnet.

What I claim is:—

1. The process for the heat treatment of a tramway or other rail for the purpose herein set forth, which consists in causing the rail to pass longitudinally through a magnetic field set up between the magnetic poles of a powerful alternate current electro-magnet so that successive longitudinal portions of the rail will successively form between the said poles part of the magnetic circuit of the magnet core and will have induced in each of them in succession a magnetic flux and consequent 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 rail is composed, the successive portions of the rail thus heated being successively cooled.

2. For the heat treatment of a tramway or other rail for the purpose herein set forth, heating in a progressive manner, successive portions of the rail to a high temperature by causing each portion in turn to be brought into and form part of the magnetic circuit of the magnetic core of a powerfully energized alternate current electro-magnet having its magnetic poles arranged near to the rail so that there will be induced in each portion of the rail that is, for the time being, in the magnetic field, an alternating magnetic flux of sufficient value to set up in said portion of rail eddy currents of such strength as to heat such portion of rail to the desired degree limited by the critical non-magnetic temperature of the particular metal used, and suitably cooling the successive heated portions of rail, substantially as described.

3. In the heat treatment of a rail according to claim 1, energizing the electro-magnet by alternate current of high frequency to limit the depth of heating in the body of the rail under treatment, substantially as described.

4. For the heat treatment of a tramway or other rail, heating the metal partly by eddy currents set up therein according to claim 1 and partly by supplementary heating means, consisting of flame.

5. For carrying out the method of heat treating 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 through which the rail to be treated can pass and a winding adapted to powerfully energize the magnetic core and thereby generate heat in the portion of the rail for the time being in the magnetic field between the said poles and forming part of the magnetic circuit, a 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 magnet core and portion of rail, when the heating of the said portion of rail has reached the desired temperature.

6. For carrying out the method of heating a rail according to claim 1, a vehicle provided with a powerful alternate current electro-magnetic system having its poles so ar-

ranged that they can be brought close to the head of the rail to be heated so that the part of the head adjacent to the said poles will be in the magnetic circuit of the electro-magnetic system, means for causing alternate current of such strength to traverse the winding of the electro-magnetic system as to produce in the part of the head of the rail between the said poles a powerful alternating magnetic flux that will raise such part to a high temperature and means for cooling said heated portion of rail, substantially as described.

7. Electrical heating apparatus according to the preceding claim, wherein the electro-magnetic system is of multiphase type and is adapted to propel the vehicle by the reaction set up between it and the eddy currents produced in the rail, substantially as described.

8. Electrical heating apparatus according to claim 6, provided with an alternate current electro-magnetic system having multiple poles adapted to act on a considerable length of the rail, said poles being graduated in strength, substantially as described.

9. Electrical heating apparatus according to claim 6, wherein the vehicle carrying the alternate current electro-magnet is provided with means for minimizing oxidation of the portion of the rail being heated and to conserve heat and also, to prevent the cooling medium used for cooling a heated portion of the rail from coming in contact with the heated portion of the rail while in the field of the electro-magnet, substantially as described.

10. Electrical heating apparatus according to claim 6, wherein the vehicle is also provided with supplementary means for producing heat, for heating to a higher temperature the successive portions of a rail that have been heated preliminarily by the electro-magnetic system, substantially as described.

11. Electrical heating apparatus according to claim 6, wherein the electrical equipment of the vehicle comprises an electro-magnetic system adapted for use as herein set forth, a direct current supply conductor and a rotary converter adapted to receive direct current from said supply conductor and convert it into alternate current for use in the electro-magnetic system, substantially as described.

12. For carrying out the method of heating a rail according to claim 1, the combination with a rail of a powerful alternate current electro-magnetic system having poles in close proximity to said rail, said rail and electro-magnetic system being relatively movable in relation to one another in the longitudinal direction, and means for supplying alternate current to and energizing said electro-magnetic system whereby a powerful magnetic flux will be caused to pass through and heat the head portion of said rail, substantially as described for the purpose set forth.

13. For carrying out the method of heating a rail according to claim 1, the combination with a rail of a powerful alternate current electro-magnetic system having poles in close proximity to said rail, said rail and electro-magnetic system being relatively movable to one another in the longitudinal direction, means for supplying alternate current to and energizing said electro-magnetic system whereby a powerful magnetic flux will be caused to pass through and heat the head portion of the said rail, and an indicating device adapted to be influenced by the alternate current supplied to said electro-magnetic system and whereby an indication of the degree of heating of the rail portion of the rail under treatment can be determined, substantially as described.

Signed at London, England, this 17th day of May, 1920.

WILLIAM MORRIS MORDEY.