

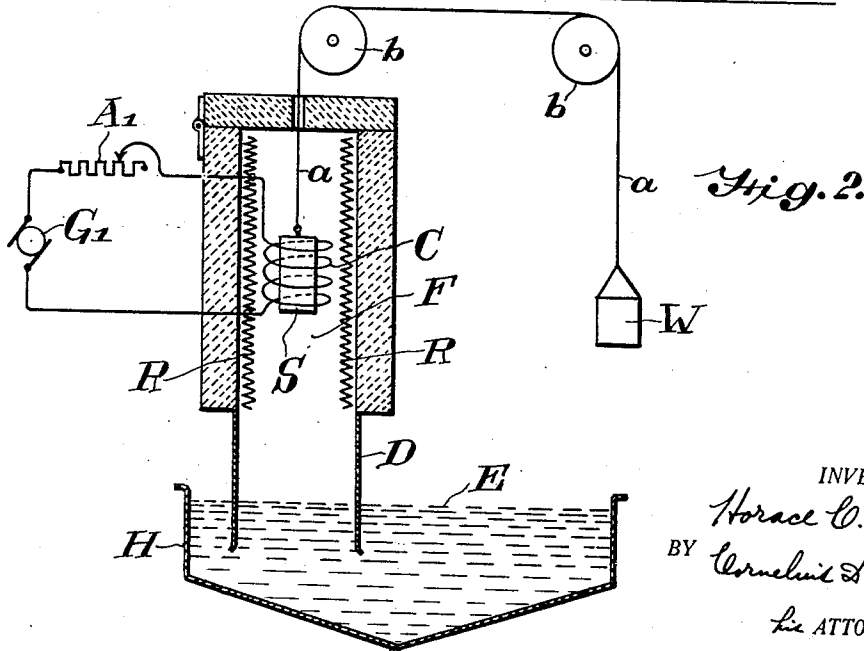
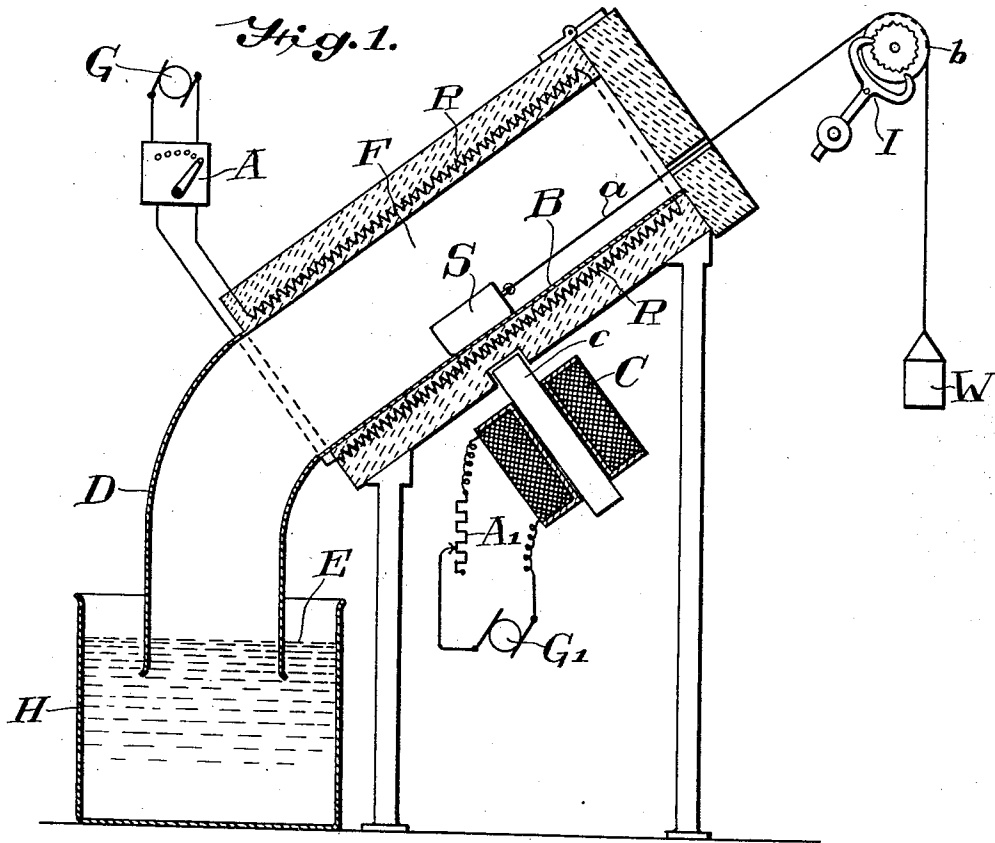
Oct. 28, 1930.

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1,779,604

METHOD OF AND APPARATUS FOR HEAT TREATING MAGNETIZABLE METALS

Original Filed April 21, 1921 2 Sheets-Sheet 1



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Fig. 3.

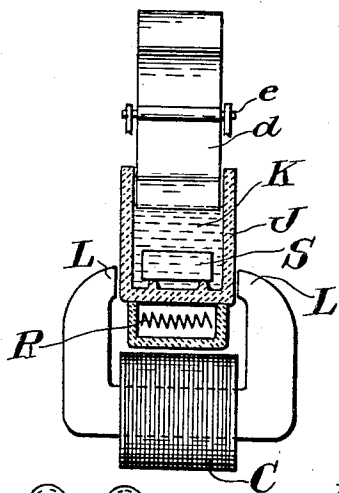


Fig. 4.

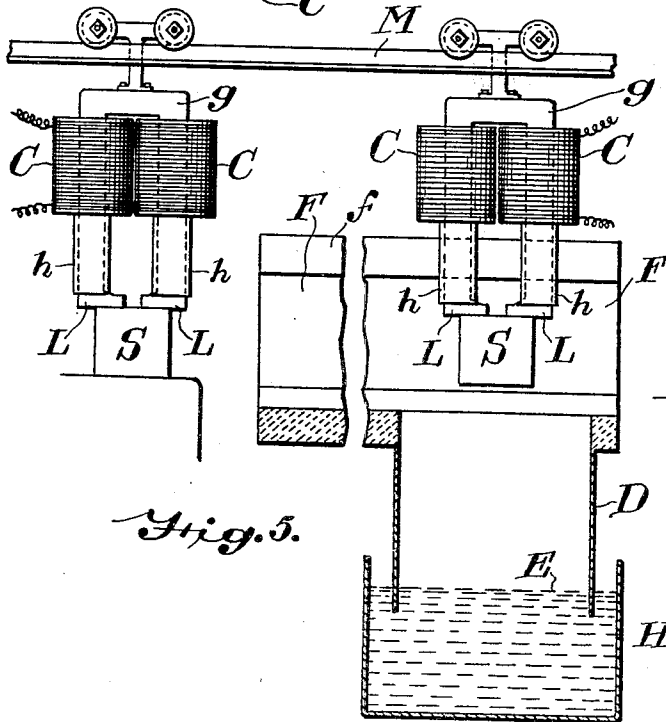
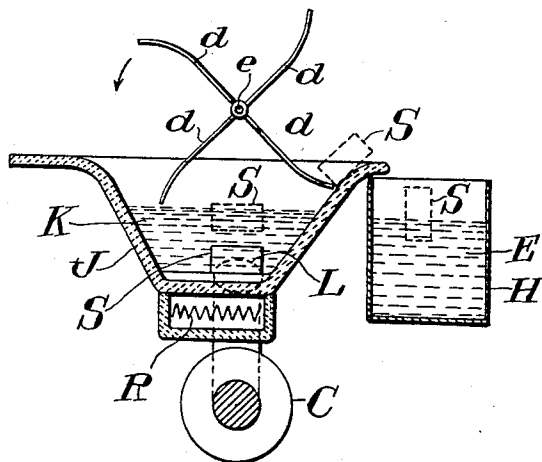


Fig. 5.

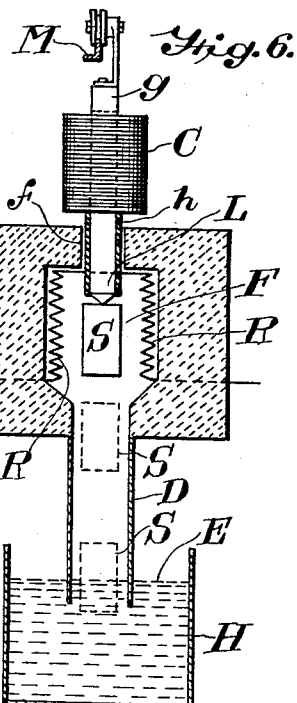


Fig. 6.

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METHOD OF AND APPARATUS FOR HEAT TREATING MAGNETIZABLE METALS

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My invention relates to a method of and apparatus for heat treating magnetizable metals, such, for example, as iron, steel, or their magnetic or magnetizable alloys, and all herein referred to for brevity as steel.

The steel, in a single piece or in a plurality of pieces, according to circumstances or requirements, is raised in temperature to or beyond a critical point at which the steel with more or less abruptness loses its magnetic properties, such critical point corresponding with the critical point usually determined by pyrometers and temperature measuring devices, and to or beyond which the steel is commonly heated for hardening or other treatment; thereafter the steel is quickly or gradually cooled, as by quenching or otherwise, to ordinary temperature or suitable higher temperature, for purposes of hardening, annealing, refining the grain, normalizing, etc.

In accordance with my invention, the steel, while undergoing elevation in temperature as above referred to, is acted upon by a magneto-motive force, produced by an electromagnet, solenoid or equivalent, whereby it is either held stationary or retarded in its movement through the heating zone, and upon its loss of magnetic properties as aforesaid, starts from rest or increases in its speed of travel and leaves the heating zone and enters the cooling zone, as by entering a quenching liquid, or in general, into such surroundings as reduce its temperature to suitable degree and at suitable rate.

Further in accordance with my invention, the steel, while rising in temperature and subjected to magnetic force as above described, is acted upon by any suitable force, for example, gravity, tending to move it from the heating zone to the cooling zone; and further in accordance with my invention, while so acted upon by such force, it may be counterweighted or acted upon by opposing force to suitable degree, whereby the magni-

tude of the magnetic force required for holding it at rest or retarding its motion may be relatively small, and therefore inexpensively produced or maintained.

Further in accordance with my invention, the steel may itself form the core of a solenoid, coil or winding traversed by current which thereby holds the steel at rest in the heating zone or retards its movement through that zone until the magnetic critical point is reached, whereupon it will move out of the heating zone into the cooling zone; and further in accordance with my invention in this regard, the solenoid, coil or winding may be a source of heat which supplies part or all of the heat for raising the temperature of the steel, the current traversing the solenoid, coil or winding in such case performing the dual function of generating heat applied to the steel and producing magnetism for holding it or retarding it.

My invention resides in the method of and apparatus for effecting heat treatment as above referred to and as more fully herein-after described, and in further features of method and apparatus hereinafter described.

For an understanding of my method and an illustration of some of the various forms my apparatus may take, reference is to be had to the accompanying drawings, in which:

Fig. 1 is a representation of apparatus embodying my invention and suitable for carrying out my method.

Fig. 2 illustrates a modified method and apparatus.

Figs. 3 and 4 are side and end views, principally in section, of modified apparatus suitable for practicing a modification of my method.

Fig. 5 is a side elevational view, partially in section; and Fig. 6 is an end elevational view, partially in section, of modified apparatus suitable for practicing a modification of my method.

Referring to Fig. 1, F is the heating chamber or furnace in which the heat is evolved or to which heat is delivered by any suitable means. For example, combustion of oil, gas or other material may be effected and the hot gases delivered to or produced in the chamber F. In the example illustrated, heat is produced by passing current from the source G through the rheostat or current regulator A through the resistor or resistance conductor R. Within the furnace is preferably disposed a slide B, of material preferably non-magnetic and capable of withstanding the furnace temperatures. The slide B is preferably inclined at an angle suitably great to cause or allow the steel S, which is to be heat treated, to move downwardly along the slide under the influence of gravity. It will be understood, however, that the path of travel of the steel S may be vertical, or it may be horizontal or substantially so, in which case additional force, as applied by weight or any other suitable means, may be applied to the steel to move it through the furnace toward the left. In the example illustrated, the steel is connected by a wire *a*, passing over the pulley *b*, to a weight W, which to suitable extent counter-balances the steel S.

The steel, while still below the critical point, that is, while still magnetic or magnetizable, is disposed within the magnetic field produced by any suitable means, as for example, a permanent magnet, or as illustrated, a coil or winding C traversed by current from any suitable source, as the aforesaid source G or a separate source G¹, the current strength in either case being regulated by the rheostat or variable resistance A¹. The magnetic effect produced by the winding C upon the steel S may be increased by employing the magnetizable or iron core *c* which, however, is maintained at a temperature at which it does not lose its magnetism. Such temperature of the core *c* may be maintained either by suitably positioning it, as indicated, outside of the heat chamber, or it may be disposed within the heat chamber or in any other position and maintained cool by suitable cooling medium, as a stream of water.

The magnetic force exerted upon the steel S is sufficient either to hold it stationary or suitably to retard its passage through the heating chamber until it has risen to such degree in temperature that it loses its magnetism, whereupon the control thereon by the magnetic field completely or substantially vanishes, and thereupon the steel will start from rest or increase its speed and eventually pass through the chute D into the liquid E in the quenching tank H.

It will be understood, however, that my invention is not limited to quenching the steel, but comprehends any cooling or change of temperature to any suitable degree at any suitable rate, said degree and rate depending

upon the results desired, which may be either hardening, annealing, refining of grain, normalizing, etc.

In the example as illustrated, the rate of movement of the steel S through the furnace F, or its rate of movement after starting from rest upon reaching the magnetic critical point, may be time controlled, as by the escapement structure indicated at I.

It will be understood, as herein more particularly described in connection with Fig. 2, that the magnetic field acting upon the steel S may be produced by a coil or solenoid winding within which the steel is held or through which the steel passes and is retarded. Thus, the solenoid C or its equivalent may be disposed within the furnace chamber, and in such case it will have no core *c*, the steel under treatment acting as its core. Or the heater conductor R may be disposed in the form of a coil or solenoid through which the steel passes, the current traversing the conductor then producing all or a part of the furnace heat and in addition producing a magnetic field for control of the steel.

In Fig. 2 there is disposed within the furnace or heating chamber F the solenoid winding or coil C traversed by current from any suitable source, as G¹, and controlled as to strength by any suitable method or means, as by the variable resistance or rheostat A¹. The coil C accordingly produces a magnetic field, and within this field the steel S to be heat treated is held at rest so long as it exhibits magnetic properties or so long as it is substantially magnetizable, that is, until it rises in temperature to the magnetic critical point. Heat is delivered to the steel in any suitable way. For example, the furnace F may be heated by combustion of oil, gas or other material, or it may be electrically heated by passing current through the heating resistor or resistance R. The current traversing the coil C also produces heat, and such heat may be the only heat produced or delivered to the steel; or in addition to the heat produced by the coil C, auxiliary heat may be supplied to the furnace F; or heat may be supplied to the furnace F substantially or entirely exclusively of the coil C. The conductor of the coil C may be of any suitable material, such as nichrome, such as utilized in electric furnaces or heating devices, or may be of any other suitable material.

It will accordingly be understood that the coil C may be used principally or substantially solely for producing the magnetic field, or it may be utilized in addition for producing substantially the entire or only a part of the heat employed for raising the temperature of the steel S.

The steel S may be more or less completely counter-balanced by the counterweight W attached to the steel by the wire *a* passing

over pulleys *b*. By so using the counter-weight *W*, the number of ampere turns, and therefore the current, may be smaller to hold the steel *S* at rest in the position indicated, or for suitably retarding its descent in case it passes slowly downwardly through the furnace *F* and is simply retarded in its descent by the magnetic field produced by the coil *C*. In either case, when the magnetic properties of the steel have completely or substantially completely vanished, that is, when the steel has been suitably raised in temperature, it will descend through the chute *D* into the liquid *E* in the quenching tank *H*, or be in any other way cooled, and the rate and degree of cooling may as aforesaid be anything suitable or desirable.

While in Fig. 2 the steel is indicated as moving vertically, it will be understood that it may move downwardly along an inclined plane as in Fig. 1.

The movement of the steel *S* may be timed or controlled, as for example, by an escapement such as *I* of Fig. 1, or any equivalent means.

Referring to Figs. 3 and 4, there is contained in the vessel *J*, preferably of non-magnetic material, a mass *K* of molten metal or alloy of higher specific gravity than that of the steel *S* and of a melting point substantially lower than the critical temperature to which the steel is to be raised. Accordingly, the steel tends to float upon the molten metal *K*. It is held submerged therein, as indicated in Fig. 3, by the magnetic field produced by the coil or solenoid *C*, traversed by current of suitable magnitude from any suitable source. The magnetic field is directed and intensified by employment of suitable core structure having the poles *L* brought suitably adjacent external to the vessel *J* to the submerged steel *S*. Heat is imparted to the steel *S* from the molten metal *K*, to which heat is imparted by any suitable means, as by heat applied to the vessel *J*. In the example illustrated, the heat is electrically applied by the heating resistance *R* traversed by current of suitable magnitude from any suitable source.

When the steel reaches the aforesaid critical point, it is no longer held submerged by the magnetic field, and it rises to the surface of the bath *K*, as of lead, as indicated in dotted lines in Fig. 4, whereupon it is removed and cooled at suitable rate to suitable degree, in the example illustrated the steel being delivered to the liquid *E* in the quenching tank *H*. This delivery from the vessel *J* may be effected manually, or automatically, as indicated, by the arms *d* rotating about the axis *e* and driven by any suitable source of power, not shown.

Referring to Figs. 5 and 6, the furnace *F* heated in any suitable way, as by resistance conductor *R* traversed by current, has the longitudinally extending slot or channel *f*

through which extends the core structure *g* magnetized by suitable winding or windings *C*. In the example illustrated, the core structure has the poles *L*, *L*, adapted to be presented to the steel *S* and thereby hold it attracted.

At the left of Fig. 5 the magnet structure, which travels along the rail *M*, is presented to the steel *S*, which is attracted to and held by the poles *L*. The magnet structure thus holding the steel is then passed from left toward the right, the poles *L* extending through the slot or channel *f* and so carrying the steel *S* into the furnace and longitudinally thereof. The steel may continuously move through the furnace *F* from left toward the right, or may be held in the position indicated at the right of Fig. 5. In either event, the steel upon reaching the critical temperature loses its magnetism and falls into the cooling zone, as through the chute *D* into the liquid *E* in the quenching tank *H*.

As indicated at *h*, the poles *L* are surrounded by refractory material of very poor heat conductivity, thus preventing the magnetic cores from themselves losing magnetism due to rise in temperature. It will be understood that in lieu of or in addition to employment of the heat insulating material *h* the poles may be cooled, as by circulating through or adjacent them a cooling medium, as water.

In the methods indicated in Figs. 3 to 6 inclusive, as in Figs. 1 and 2, and characteristic of my method in general, the rate and degree of cooling of the steel may be anything suitable or desirable. And it shall be further understood that the temperature of the steel may, before cooling, as for soakage purposes, be for a suitable length of time maintained substantially at the critical temperature or at any suitable higher temperature.

It shall further be understood that my method is not limited to the particular examples of procedure hereinbefore described, except where so expressly stated in the appended claims. It shall further be understood as to my apparatus that it is not limited to the examples hereinbefore described, but may take various other suitable forms.

What I claim is:

1. The method of heat treating steel, which consists in passing it through a heating zone to raise its temperature, retarding its progress by the action thereon of a magnetic field through which it passes until it reaches a temperature at which it becomes non-magnetic, and cooling it at a time determined by the time it becomes non-magnetic.

2. The method of heat treating steel, which consists in passing it through a heating zone to raise its temperature, retarding its progress by the action thereon of a magnetic field through which it passes until it exceeds the temperature at which it becomes non-magnetic, and cooling it at a time determined by

the time the control thereof by said magnetic field ceases.

3. The method of heat treating steel, which consists in so disposing it that it tends to move under the influence of gravity, opposing such movement by incompletely opposing the force of gravity acting thereon by a counterweight, subjecting it to the action of a magnetic field to restrain its movements until it attains a temperature at which it becomes non-magnetic, and thereafter cooling it.

4. The method of heat treating steel, which consists in so disposing it that it tends to move under the influence of gravity, opposing such movement by incompletely opposing the force of gravity acting thereon by a counterweight, subjecting it to the action of a magnetic field to restrain its movements until it exceeds the temperature at which it becomes non-magnetic, and thereafter cooling it.

5. The method of heat treating steel, which consists in heating the same while under the influence of a force tending to move it to a cooling region, opposing said force by a magnetic field in which it is disposed and by which it is acted upon, increasing its temperature to a point at which the effect thereon of said magnetic field ceases, subjecting it to a time control, and thereafter cooling it at a time determined by the time said effect thereon of said field ceases.

6. The method of heat treating steel, which consists in so disposing it that it tends to move under the influence of gravity, opposing its movement by a magnetic field in which it is disposed and by which it is acted upon until it attains a temperature at which it becomes non-magnetic, subjecting it to a time control, and thereafter cooling it at a time determined by the time it becomes non-magnetic.

7. Apparatus for heat-treating steel comprising a heating chamber and a cooling chamber, and means producing a magnetic field acting upon said steel to retard movement thereof through said heating chamber and allowing acceleration when it attains the non-magnetic condition to effect its cooling in said cooling chamber at a time determined by the time of its attainment of said non-magnetic condition.

8. Apparatus for heat-treating steel comprising a heating chamber, means for controlling the rate of passage of the steel through said chamber, and means producing a magnetic field acting upon the steel and so disposed as to decrease said rate of passage while the steel is magnetic and to thereafter permit increase of its rate of passage in response to its attainment of the non-magnetic condition.

9. The method of heat treating steel, which consists in so disposing it that it tends to move under the influence of a force, opposing such tendency to move by another force and a magnetic field in which the steel is disposed and acting thereon to oppose its movement,

raising its temperature while under said tendency to move until its magnetism becomes substantially zero, whereby it thereafter moves in response to attainment of the non-magnetic state, and thereafter cooling it.

10. The method of heat treating steel, which consists in so disposing it that it tends to move under the influence of gravity, partially opposing such tendency to move by another force, assisting said other force by a magnetic field in which the steel is disposed and acting thereon, raising the temperature of the steel while under said tendency to move until its magnetism becomes substantially zero, whereby it thereafter moves under the influence of gravity, and thereafter cooling it.

11. The method of heat-treating steel, which comprises so disposing it that it tends to move under the influence of a force, incompletely opposing said force by a second force, subjecting it to the action of a magnetic field which opposes said first named force until it attains a temperature at which it becomes non-magnetic, and thereafter cooling it.

12. The method of heat-treating a steel piece, which comprises heating the piece while so disposed that it tends to move from the heating zone under the influence of a force functioning independently of the absolute weight of the piece, opposing movement of the piece by magnetism acting directly thereon until its temperature has been raised to a point where its magnetism is substantially zero, whereby said loss of magnetism automatically releases the piece from the heating zone.

13. The method of heat-treating a steel piece, which comprises heating the piece while so disposed that it tends to move from the heating zone under the influence of a force functioning independently of the absolute weight of the piece, opposing movement of the piece by magnetism acting directly thereon until its temperature has been raised to a point where its magnetism is substantially zero, and upon automatic release of the piece as thus effected passing the same to a cooling region.

14. The method of heat-treating a steel piece, which comprises heating the piece while so disposed that it tends to move from the heating zone under the influence of a force other than the gravitational tendency of the piece, opposing movement of the piece by magnetism acting directly thereon until its temperature has been raised to a point where its magnetism is substantially zero, whereby said loss of magnetism automatically releases the piece from the heating zone.

15. The method of heat-treating a steel piece, which comprises heating the piece while so disposed that it tends to move from the heating zone under the influence of a force different from the absolute weight of the piece, opposing movement of the piece

by magnetism acting directly thereon until its temperature has been raised to a point where its magnetism is substantially zero, whereby said loss of magnetism automatically releases the piece from the heating zone.

16. The method of heat-treating a steel piece, which comprises heating the piece while so disposed that it tends to move from the heating zone under the influence of a force less than the absolute weight of the piece, opposing movement of the piece by magnetism acting directly thereon until its temperature has been raised to a point where its magnetism is substantially zero, whereby said loss of magnetism automatically releases the piece from the heating zone.

17. The method of heat-treating a steel piece, which comprises heating the piece while so disposed that it tends to move from the heating zone under the influence of a weight, opposing movement of the piece by magnetism acting directly thereon until its temperature has been raised to a point where its magnetism is substantially zero, whereby said loss of magnetism automatically releases the piece from the heating zone.

18. The method of heat-treating a steel piece, which comprises heating the piece while so disposed that it tends to move from the heating zone under the influence of a weight less than the weight of the piece, opposing movement of the piece by magnetism acting directly thereon until its temperature has been raised to a point where its magnetism is substantially zero, whereby said loss of magnetism automatically releases the piece from the heating zone.

19. The method of heat-treating a steel piece, which comprises so disposing the piece that it tends to move under the influence of its own weight, opposing movement of the piece by a force differing but slightly from the weight thereof, and subjecting the piece to the action of a magnetic field of sufficient intensity to overcome the difference between the effect of the weight of the piece and the said force, thereby restraining movement of said piece until it attains a temperature at which it becomes non-magnetic.

20. Apparatus for heat-treating steel, comprising a heating chamber, means comprising a weight controlling departure of a steel piece from said chamber, and magnetic field producing means holding the piece to be treated at rest in said heating chamber and releasing it in response to attainment by the piece of the non-magnetic condition.

In testimony whereof I have hereunto affixed my signature this 16 day of April, 1921.

HORACE C. KNERR.