Feb. 16, 1932. W. B. COOLEY 1,845,241

MAGNETIC CONTROL SYSTEM

Filed Sept. 3, 1929 2 Sheets-Sheet 1

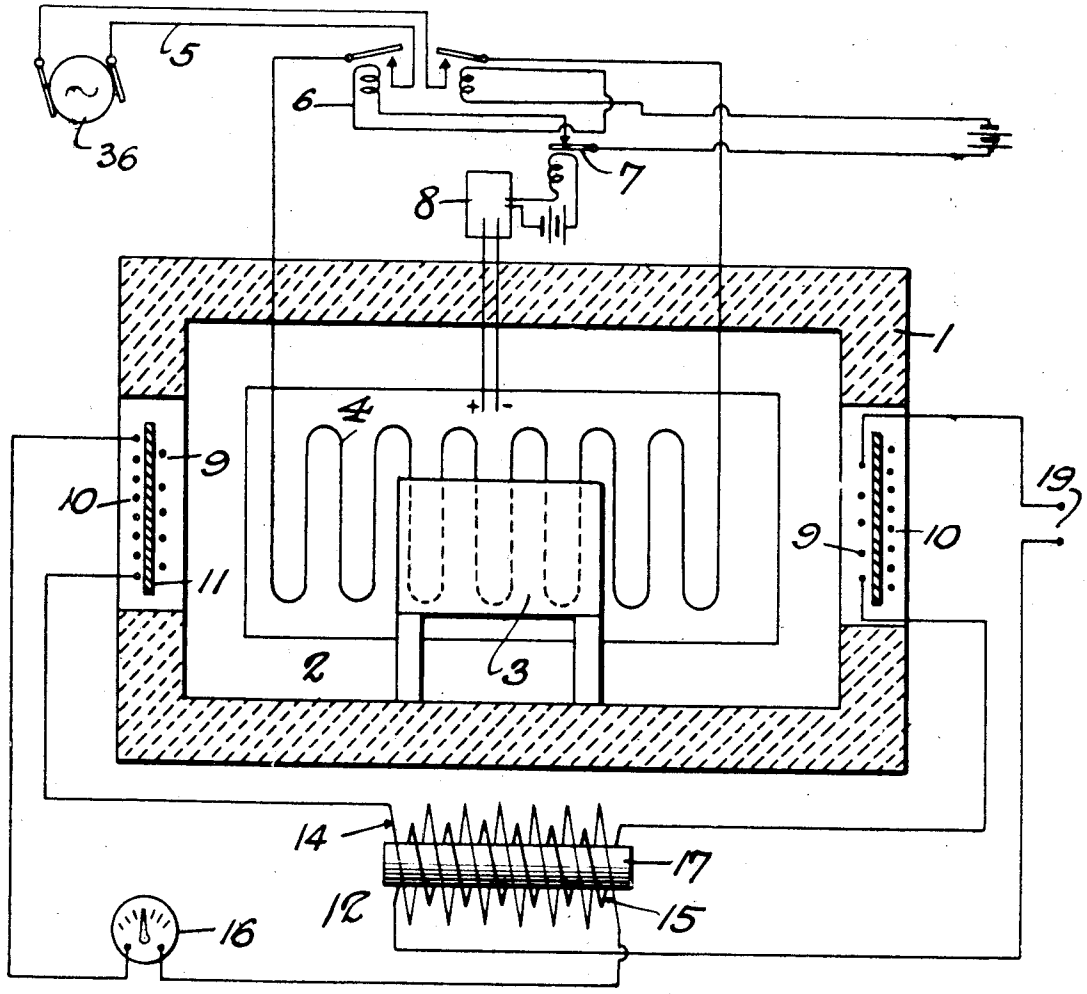


Fig. 1.

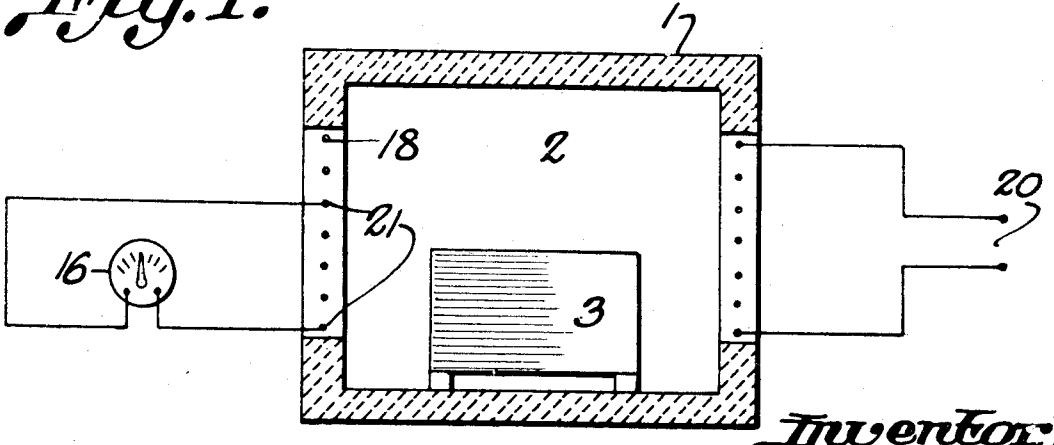


Fig. 2.

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Fig. 3.

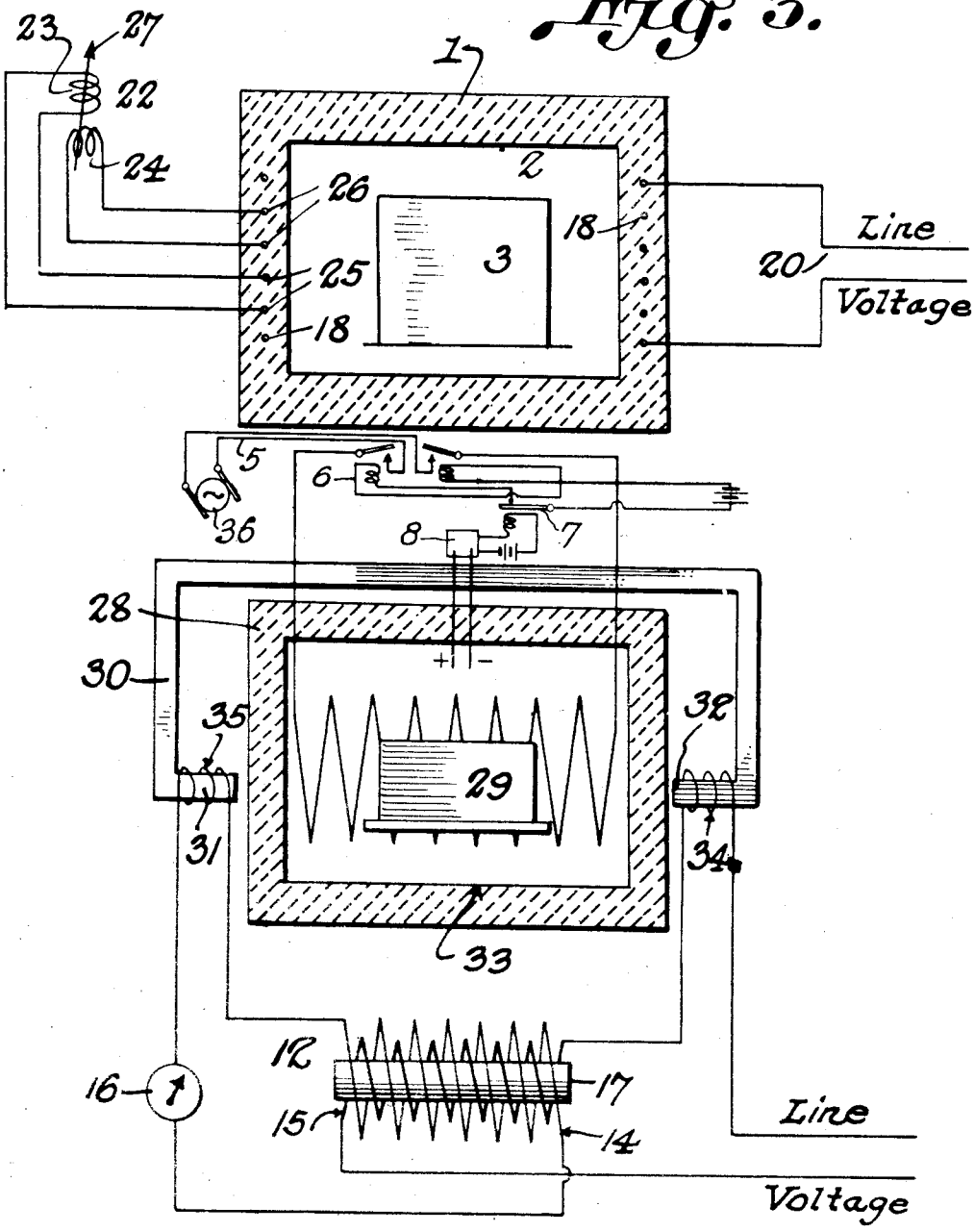


Fig. 4.

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UNITED STATES PATENT OFFICE

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MAGNETIC CONTROL SYSTEM

Application filed September 3, 1929. Serial No. 390,182.

My invention relates broadly to heat treatment furnaces and more particularly to a system for determining the condition of the material under heat treatment. It is a well established fact that the magnetic condition of steel is affected by the application of heat and that a certain relationship exists between such changeable magnetic conditions and the critical transformation points, or the decalescent and recalescent points of the steel. I utilize this relationship in attaining the objects of my invention.

One of the objects of my invention is to provide a system for electrically determining the time at which magnetizable material treated in a heat treatment chamber may reach a condition or reference point, from which subsequent operations can be determined, and where the electrically determining means is operatively independent of the source of heat which may be supplied to the heat treatment chamber.

Another object of my invention is to provide a magnetic system positioned adjacent material which is subjected to heat treatment in a heat treatment furnace, for determining the condition of the material under heat treatment operatively independent of the heat source which is applied to the furnace.

Still another object of my invention is to provide a magnetic system disposed adjacent material in a furnace for determining the condition of material which is subjected to heat treatment, the magnetic system being entirely independent of the heating means which is supplied to the furnace.

A further object of my invention is to provide a magnetic system inductively related to material in a furnace for determining the condition of material which is being subjected to heat treatment, and in combination therewith, but separate from the magnetic system, another system for automatically controlling the temperature of the furnace without affecting the magnetic system.

A still further object of my invention is to provide a magnetic system for controlling the time period over which material within the furnace is subjected to heat treatment in accordance with the condition of the material within the furnace and independently of means by which the material in the furnace may be heated.

Other and further objects of my invention will be understood from the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view through a heat treatment furnace showing the magnetic indicator system of my invention; Fig. 2 is a view showing a modified form of magnetic indicator system embodying the principles of my invention; Fig. 3 illustrates a further modified form of electrical indicator apparatus which may be employed in the system of my invention; and Fig. 4 illustrates still another method of applying the electrical indicator system to heat treatment furnaces embodying the principles of my invention.

My invention is directed to a magnetic indicator and control system for heat treatment furnaces, wherein the point at which the steel or other magnetizable metal under heat treatment changes its magnetic properties upon heating, may be detected so that heating may be discontinued, or the temperature modified, or the steel withdrawn, or permitted to remain in the furnace for definite subsequent periods at the discretion of the operator. My invention makes use of the principle that steel or other magnetizable metal changes its magnetic properties when heated to certain temperature, depending upon the analysis of the steel. This change of magnetic properties, occurring at a positive transformation or critical point in the steel, establishes when known, a reference point in the heat treatment. My invention provides for magnetically determining the point at which the steel or other metal under heat treatment changes its magnetic properties, or has reached a definite transformation point, so that the proper heat treatment can be determined, the magnetic determining means operating independently of the heating source.

In the system of my invention, a heat treatment furnace is provided with any form

of heating means such as gas, or other fuel, or resistors which are electrically energized. In magnetic relationship to the heat treatment chamber, and independent of the heating means, I provide a magnetic system which may include a primary coil and a secondary coil inductively related when energized. In such circuits, the secondary circuit may include an indicator, or a control device, or a signaling device, and such circuits may be magnetically coupled through a compensator. In lieu of a primary and secondary system which is magnetically coupled, I may provide a single winding surrounding the heat treatment chamber and apply to the indicator or control apparatus, potential differences which exist across any selected number of turns and affected by the change in potential of the circuit due to the influence of the material under heat treatment within the chamber. I may provide an indicator apparatus which is highly sensitive by reason of the independent energization of separate windings of the indicator apparatus being energized from different positions along the coils which surround the material in the heat treatment chamber.

In other furnaces I may provide a magnetic circuit magnetically related to the heat treatment chamber in which the air gap, thus included, is changed by the introduction into the air gap of magnetizable material to be heat treated, thereby changing the magnetic conditions. Predetermined magnetizing force may be supplied to the magnetic circuit and the change in magnetic conditions, or the critical transformation points of the material to be heat treated, may be detected by an indicator and thereby the character of subsequent heat treatment to be given material within the chamber may be determined.

Referring to the drawings, in Fig. 1 reference character 1 designates a furnace structure which encloses a heat treatment chamber 2 in which the steel or other magnetizable metal 3 is placed. Any form of heating source may be applied to the furnace and for the purpose of illustrating my invention, I have shown a resistor 4 disposed within the furnace and electrically connected to a supply source 36 connected to line 5 through magnetic switches 6. The closing and opening of magnetic switches 6 is controlled by a relay 7 which is actuated by pyrometer 8 in accordance with the temperature in the heat treatment furnace, cutting on or off the heating energy to the resistor 4. As heretofore pointed out any form of heating source may be applied to the heat treatment chamber in so far as my present invention is concerned, as my invention is applicable to all forms of heat treatment furnaces independent of the character of the heat source. A primary coil 9 is shown surrounding the furnace chamber 1, the primary coil 9 being in inductive relation to the secondary coil 10 where the coils are insulated by means of insulation member 11. I provide a compensator 12 which includes secondary winding 14 and primary winding 15 inductively related one to the other, the primary winding 15 being connected in series with the primary coil 9 while the secondary winding 14 is connected in series with the secondary coil 10. An indicating apparatus such as galvanometer 16 is connected in series with the secondary winding 14 and secondary 10, and is responsive to voltages in secondary coil 10 to indicate the magnetic condition of the material 3 within the heat treatment chamber 2. The galvanometer 16 by having contacts, not shown, may actuate a pilot light, an alarm bell, or other form of indicator. The potential supplied at terminals 19 energizes primary winding 9, and the magnetic field which is thus established permeates the steel or magnetizable metal charge 3 which is under heat treatment.

By the proper adjustment of the compensator which includes movable core member 17, galvanometer 16 may be deflected to a predetermined or zero condition indicating a position of balance of the magnetic flux through the furnace chamber without the charge 3 in position therein. Upon introduction of the charge 3, the galvanometer or indicator 16 is deflected by virtue of the increased flux which passes through the furnace chamber in the path partially closed by the steel or magnetizable charge 3. Under conditions of continued heat treatment, the charge 3 changes its magnetic properties and when that transformation point is reached, the heated cycle can be concluded or can be determined by the arrangement illustrated in Fig. 1. The operator by noting the change of magnetic properties of the charge 3 by reading the galvanometer or indicator 16, can cut off the supply of heating energy from the circuit 5, by any suitable means such as the customary switch, or he may elect to soak the charge for any subsequent time.

In Fig. 2, I have illustrated a single winding 18 across which magnetizing potential is supplied at terminals 20 for establishing a magnetic flux through the charge 3 within the furnace. The difference of potential along the winding 18 may be observed by the connection of galvanometer or indicator 16 through the selected turns indicated at 21. This arrangement serves as an auto-transformer where a selected potential variable in accordance with the magnetic condition of the charge 3 is supplied to the indicator 16.

In Fig. 3, I have shown the winding 18 having different sections of its turns connected to the windings of a power factor meter 22. Winding 23 of the power factor meter 22 connects to selected turns of the winding 18

such as designated at 25, while winding 24 of power factor meter 22 connects to section 26 of the winding 18. Relative movement of windings 23 and 24 operates indicator 27 for enabling the magnetic condition of the charge 3 within the furnace to be observed.

In Fig. 4, I have shown the principles of my invention applied to a comparatively large size furnace designated at 28 having a charge 29 disposed therein. A magnetic circuit indicated at 30 is formed around the furnace terminating in pole pieces 31 and 32 which may establish a magnetic field through the furnace chamber 33 and the charge 29 located therein. A magnetic winding 34 is provided to establish a permanent field through the furnace chamber 33, and has in series the primary 15 of a compensator 12, the charge 29 being aligned with the path of the magnetic lines of force. While means heretofore described for establishing a flux may be employed, I have found that the positive magnetic circuit 30 may increase the strength of the magnetic field in the air gap, especially in large furnaces, and renders the variation of such field due to changes in the magnetic conditions of the charge 29, observable with greater accuracy. By means of secondary winding 35 which is disposed on pole piece 31 and connected in series to the secondary 14 of a compensator 12, energy may be supplied to an indicator 16. Compensator 12 has an adjustable core 17 for balancing purposes as described under Fig. 1. The effect by the charge, and subsequent determination is the same as under Fig. 1. The same form of temperature control apparatus is employed in the modified form of furnace as is illustrated in Fig. 1 and the same reference characters used to describe the temperature control equipment in Fig. 1 have been used to designate corresponding parts in the temperature control apparatus shown in Fig. 4.

While I have described my invention in certain of its preferred embodiments, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

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

1. In combination, a furnace having a heating chamber, work to be heated located in the said chamber, a source of electric energy, a coil enclosing said chamber connected to said source and establishing a magnetic path including said work as a part thereof, a source of heat independent of said source of energy comprising heating elements disposed adjacent the work in said chamber, a second coil located in inductive relation with said first coil, and means responsive to change in the inductive effects of the first coil and connected in series with said second coil.

2. In a furnace, a heat treatment chamber for housing and subjecting a charge of magnetizable material to a heat treatment, a pair of coils surrounding said chamber, means coupling said coils one to the other, a source of potential for supplying electrical energy to one of said coils through said coupling means, indicating means connected to the other of said coils, and electrical means independent of said coils for supplying heat to the magnetizable charge within said chamber, said indicating means being controlled directly in accordance with the properties of said magnetizable charge under the action of heat treatment from said electrical means.

3. In a furnace, a heat treatment chamber for receiving a charge of magnetizable material, means for supplying heat to said charge within said heat treatment chamber, a pair of coils surrounding said chamber, one of said coils being energized to excite the other of said coils for producing a magnetic flux through said magnetizable charge, heating elements in said chamber, an independent power supply circuit for energizing said heating elements, means in circuit with said last mentioned coil for indicating the magnitude of flux passing through said charge for determining the change in magnetic properties of said charge in accordance with the heat treatment to which said charge is subjected.

4. In a furnace a heat treatment chamber arranged to receive a charge of magnetizable material, means for subjecting said magnetizable material to heat, independent means for subjecting said charge to magnetic flux and means controlled by the magnitude of the magnetic flux passing through said charge for indicating the magnetic condition of the charge under the variable effects of heat treatment thereof.

5. In a heat treatment furnace, a heat treatment chamber for receiving a charge of magnetizable material, means for subjecting said charge to heat, separate means for subjecting said magnetic charge to a path of magnetic flux of which said charge forms a part, and means disposed in said path of magnetic flux for determining the magnetic properties of said charge under the variable effects of heat treatments thereof.

6. In combination, a furnace having a heating chamber, work to be heated located in said chamber, a source of electric energy, a coil enclosing said chamber connected to said source to establish a magnetic field passing through said work, a source of heat independent of said source of energy, and a means responsive to changes in the voltage between two or more turns of said coil for indicating the condition of said work.

7. In combination, a furnace having a heating chamber, work to be heated located in said chamber, a source of electric energy, a coil enclosing said chamber connected to said source to establish a magnetic field passing through said work, a source of heat independent of said source of energy comprising heating elements arranged adjacent said work and energized from a power supply circuit independent of said first mentioned source of electric energy, and means responsive to change in the inductive effects of said coil and connected in electrical relation to said coil for indicating the magnetic condition of said work.

8. In a heat treatment furnace, a heating chamber for receiving a charge of magnetizable material, means for applying heat to said heat treatment chamber, a winding disposed around said heat treatment chamber for subjecting the magnetizable charge within said chamber to a magnetic flux, and means connected to selected turns of said winding for indicating the magnetic permeability of said charge.

9. In a heat treatment furnace, a heat treatment chamber for receiving a magnetizable charge, means for applying heat to said charge, a winding surrounding said heat treatment chamber for subjecting said charge to a magnetic flux and circuits connected with selected turns of said winding for determining the magnetic permeability of said charge.

10. In a heat treatment furnace, a heat treatment chamber for receiving a magnetizable charge, means for applying heat to the charge within said heat treatment chamber, a winding surrounding said heat treatment chamber for subjecting said charge to the passage of magnetic flux and means connected to selected turns along said winding for indicating the magnetic permeability of said charge throughout the process of heat treatment thereof.

11. In an electric furnace, the combination with a heating chamber having heating elements therein, work to be heated located in said chamber, a source of electric current connected with said elements, means automatically responsive to changes in the chamber temperature for controlling the flow of said current through said heating elements, a coil excited by an electric current independently of said heating elements to establish a magnetic field through said work, a secondary coil in inductive relation with said first coil, and means responsive to changes in the inductive effects of said primary coil and connected in electrical relation with said second coil for indicating changes in the magnetic properties of the work in said chamber.

12. In a heat treatment furnace, a heat treatment chamber for receiving a magnetizable charge, a power source, electrical means connected with said power source for subjecting said charge to heat, a magnetic system comprising a primary and secondary winding surrounding said heat treatment chamber for establishing a path of magnetic flux through said magnetizable charge, a device for indicating the magnetic permeability of said charge connected in circuit with said secondary winding, a contactor disposed in series with said power source and said electrical means, and a relay system for controlling said contactor in accordance with the temperature of the furnace.

13. In a heat treatment furnace, a heat treatment chamber for receiving a magnetizable charge, a power source, an electromagnet constituting a magnetic circuit disposed about said heat treatment chamber for establishing a path of magnetic flux passing through said magnetizable charge, a meter connected with said electromagnet for indicating the magnetic properties of said charge, an electrical heater in said heat treatment chamber for subjecting said charge to heat, circuit connections for supplying heating current from said power source to said electrical heater, a contactor disposed in series with said circuit connections and a relay system for controlling said contactor in accordance with the temperature of the furnace.

14. In combination, a furnace having a heating chamber, work to be heated located in said chamber, a source of electric current, a primary coil located adjacent to said chamber and excited by said current to produce a magnetic field passing through said work, a secondary coil having a current induced therein by said magnetic field, a meter responsive to changes in the inductive effects of said first coil connected in series with said second coil and a source of heat in said heating chamber independent of said primary and secondary coils.

In testimony whereof I affix my signature

WILLIAM B. COOLEY.