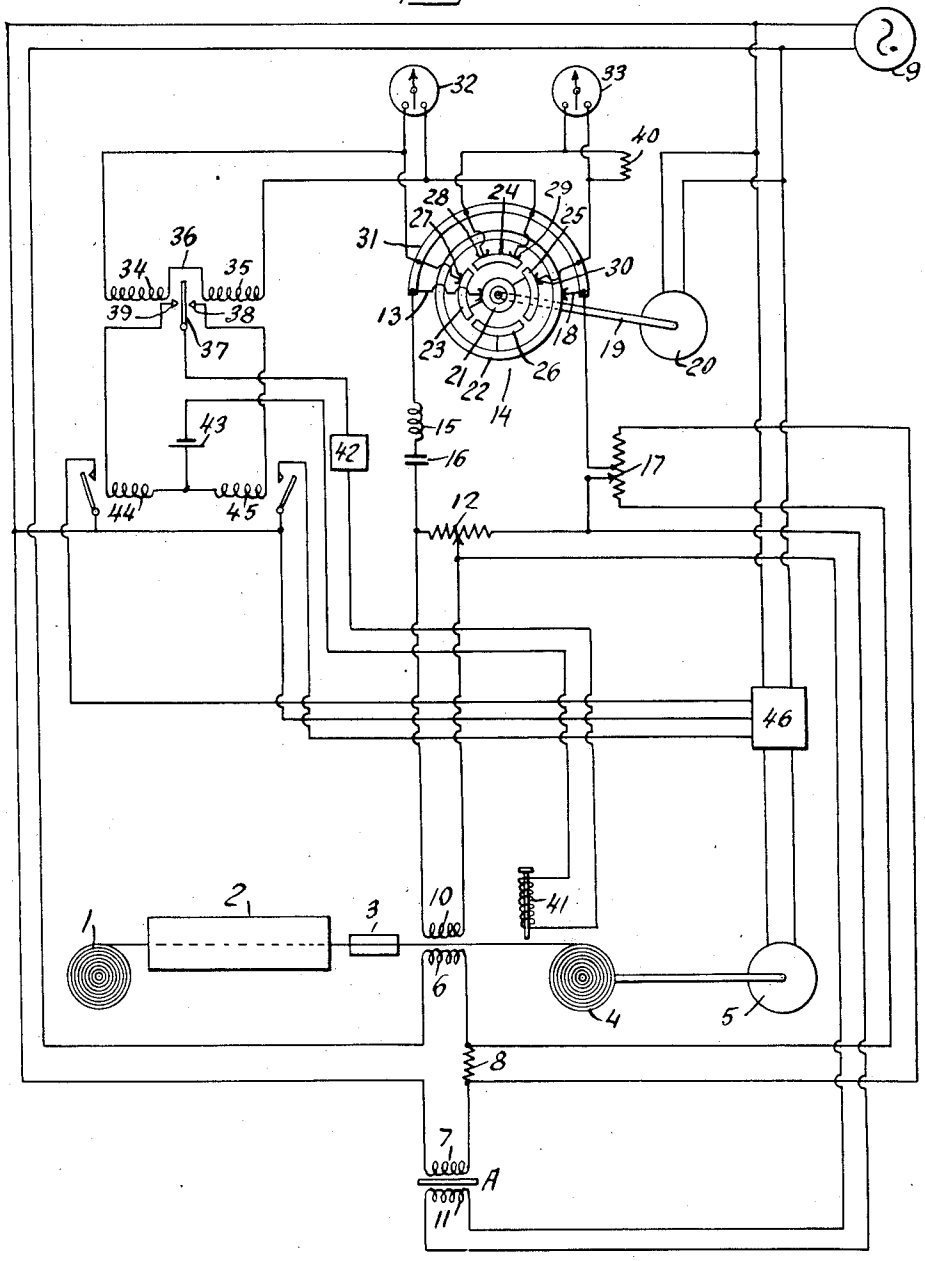
Jan. 10, 1939. A. A. ARCHIBALD 2,143,672

HEAT TREATMENT OF MAGNETIZABLE BODIES

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Fig. 1.



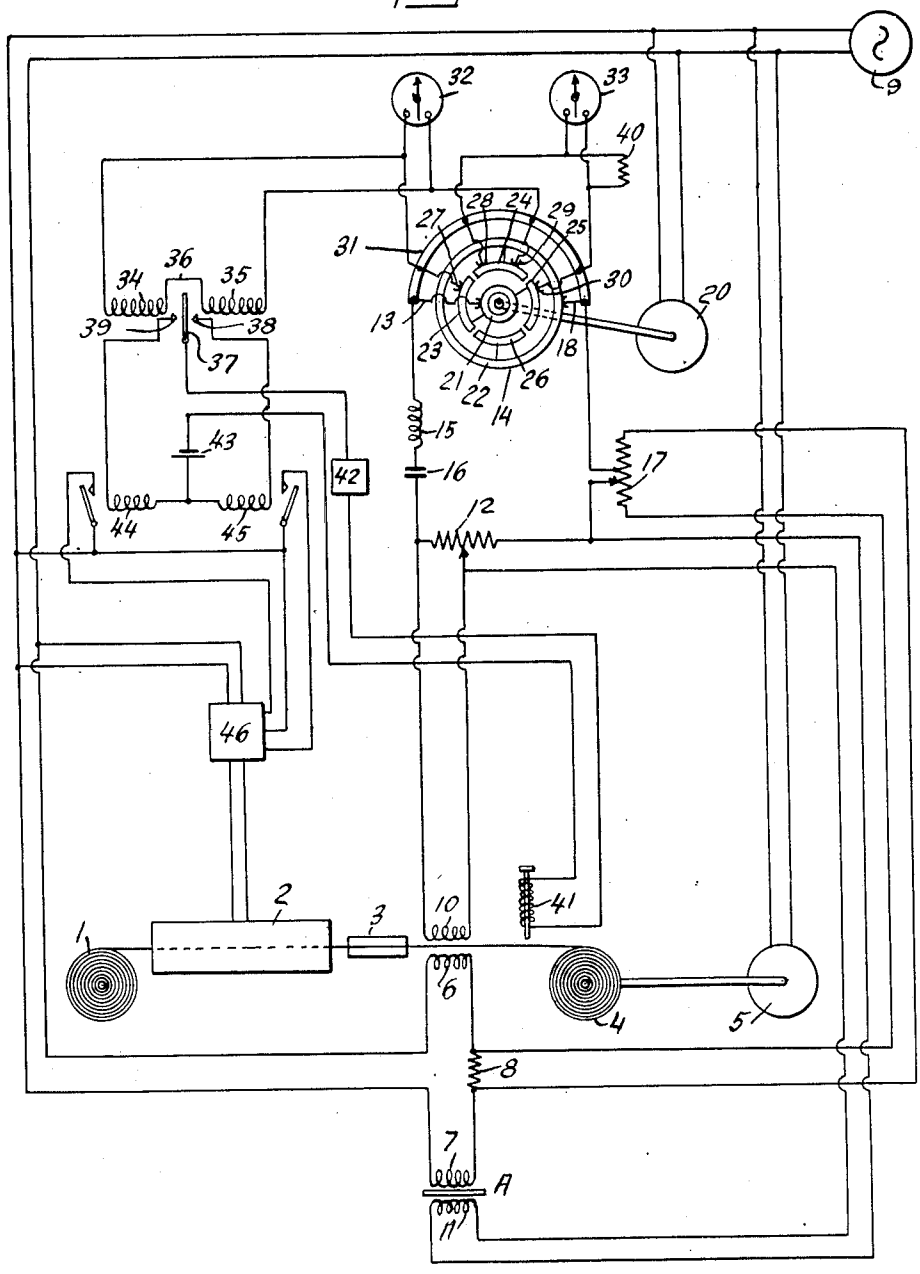
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Fig. 2.



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HEAT TREATMENT OF MAGNETIZABLE BODIES

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5 Claims. (Cl. 266—3)

This invention relates to the heat treatment of magnetizable bodies and has for an object the provision of a method and apparatus for automatic control of such heat treatment. More specifically the invention contemplates automatic control of heat treating processes for elongated magnetizable bodies such as strips or ribbons of iron or steel.

According to one practice in the heretofore customary art of heat treating elongated magnetizable bodies, strips of steel or the like are passed continuously and successively through a furnace and a quenching means, so that succeeding portions of the strips are first heated and then quenched to obtain the desired properties. An example of such practice is the heat treatment of strip steel destined to be manufactured into razor blades. Thin strip steel is unrolled from a reel and passed successively through a furnace and a quenching means. The quenched strip is then wound on a second reel, which is motor driven. The operation is continuous, so that while one portion of the strip is being rewound on the motor driven reel, succeeding portions are being heated or quenched. For practical purposes the process may be considered a continuous one, because one strip follows another through the apparatus. In effect, a ribbon of steel is continuously passing through the apparatus. As long as succeeding strips or succeeding portions of individual strips exhibit the same metallurgical and physical properties the control of the heat treatment is comparatively simple. It is merely necessary to establish the optimum heat treating temperature and time of treatment for the material and hold these constant.

It has been proposed heretofore to produce steel strips having uniform metallurgical or physical properties throughout their length by holding the furnace temperature constant by some means such as thermostatic regulation and by maintaining a constant speed in the motor which draws the material through the furnace. Unfortunately, there is often a considerable variation in metallurgical or physical properties between succeeding strips. Furthermore, there is a lack of uniformity in metallurgical and physical properties between different portions of a single strip. As a result of these variations and lack of uniformity the conditions of heat treatment should be changed frequently if the tempered product is to possess uniform properties throughout its entire length, and for this reason it is not always possible to produce strips having uniform properties by holding the time and temperature of heat treatment constant.

As a result of my investigations I have found that it is possible to produce a high degree of uniformity in elongated magnetizable bodies which are heat treated in a continuous process. This result may be obtained by continuously subjecting the magnetizable body to magnetic analysis as it passes a point following quenching and automatically regulating the temperature or the time of heat treatment in response to variations in the magnetic analysis. Metallurgical or physical properties of the material being treated are manifested by the presence or absence of certain magnetic characteristics. According to a presently preferred practice of my invention I pass the quenched magnetizable material, such as razor blade strip, through the field of a primary coil of a magnetic analysis device. Deviations in the metallurgical or physical characteristics of the magnetizable material are continuously indicated by fluctuations in current induced in a secondary circuit of the magnetic analysis device. When excessive deviations from the desired properties are encountered the secondary circuit actuates a mechanism for changing the temperature of heat treatment. The mechanism may also be utilized to regulate the speed at which the strip is conveyed through the furnace. At the same time the fluctuation in current in the secondary circuit actuates a marker relay which stamps the strip undergoing analysis at the point where an excessive deviation in properties is encountered.

My invention will be better understood by referring to the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a schematic representation of a heat treatment apparatus according to my invention for automatically changing the time of heat treatment of the material in response to variations in the magnetic analysis of the product of the heat treatment.

Fig. 2 is a schematic representation of a modified heat treatment apparatus of my invention which is adapted for automatically changing the temperature of heat treatment in response to variations in the magnetic anaysis of the heat treated product.

Referring to Fig. 1, it will be seen that a reel 1 is provided for carrying the material such as strip steel which is to be heat treated in a furnace 2 and subsequently cooled in the quenching blocks 3. The furnace may be heated electrically

or by means of a gas flame, and it may be of any convenient design which permits continuous passage of the strip steel or other material therethrough. The quenching blocks are adapted for the rapid and continuous cooling of material passed through them. A second reel 4, driven by a motor 5 is provided for receiving the heat treated strip after it has been quenched. The motor serves to remove the strip from reel 1, pull it through the furnace and the quenching blocks and wind it on the reel 4.

One primary coil 6 of a magnetic analysis apparatus is located at a point between the quenching blocks and the reel 4 so that the magnetizable material passes through the electromagnetic influence of the coil. This primary coil is connected in series with a fixed resistance 8, a substantially identical primary coil 7, and an alternating current source 9.

A pair of substantially identical secondary coils 10 and 11 are placed respectively in inductive relationship with the primary coils 6 and 7 and are connected in series opposition. One end of each secondary coil is connected to opposite ends of a potentiometer 12. The other ends of the secondary coils are both connected to the slider of this potentiometer.

One end of the potentiometer 12 is connected to an input brush 13 of a synchronous commutator 14, through a filter, which may be a suitable inductance 15 in series with a suitable capacitance 16. The other end of the potentiometer 12 is connected to the slider of a center tap potentiometer 17, the ends of which are connected with the primary coil circuit 6, 7, 8, 9 on either side of the fixed resistance 8. The center tap of potentiometer 17 is connected to a second input brush 18 of the synchronous commutator.

The synchronous commutator is mounted on a shaft 19 of a synchronous motor 20 which is connected to the alternating current source. The synchronous commutator comprises an inner contact ring 21 electrically connected to one end of the potentiometer 12 by the input brush 13 through the filter, an outer contact ring 22 which is electrically connected to the center tap potentiometer 17 through the input brush 18, and two pairs of commutator segments 23, 25 and 24, 26. The segments of each pair are diametrically opposed. The commutator segments 23, 25 are electrically connected to the inner contact ring, and the other pair of commutator segments 24, 26 are connected to the outer contact ring. The commutator is also provided with two pairs of output brushes 27, 29 and 28, 30, which are spaced around the periphery of the commutator at fixed angles of 45° between adjacent brushes. The angle between the output brushes of each pair is 90°. The output brushes are so placed that brush pair 27, 29 is in contact respectively with commutator segments 23, 24 when brush pair 28, 30 is in contact respectively with commutator segments 24, 25. Input brushes 13, 18 and output brushes 27, 29, 28, 30 are mounted on a rotatable brush holder 31 which is angularly adjustable around the periphery of the commutator.

Output brushes 27, 29 are connected to the poles of an integrating galvanometer 32, and the other output brushes 28, 30 are connected to the poles of a similar integrating galvanometer 33. Output brush pair 27, 29 is also connected to the field coils 34, 35 of a galvanometer type relay 36. This galvanometer relay is provided with a moving arm 37 and two contact points 38, 39, on either side of the arm. Between the other brush pair 28, 30 and the integrating galvanometer 33 is connected a shunt containing a fixed resistor 40, the impedance of which equals the impedance of the field coils 34, 35 of the galvanometer type relay.

The moving arm of the galvanometer relay is connected in series with the field coil of a marker relay 41 and a delay switch 42 to a pole of a direct current source 43 such as a dry cell. The delay switch may be of any convenient form which will operate to open the direct current circuit for a predetermined interval of time, and then close it again. Many such mechanisms driven by electric or spring motors are on the market. The other pole of the direct current source is connected in parallel with the contact points of the galvanometer relay through the field coils of two auxiliary relays 44, and 45.

The motor 5 which drives the reel 4 is connected to a speed controller mechanism 46, which may be of any convenient design. The controller mechanism is connected by two separate leads to the contact points of the auxiliary relays and by a common lead to the moving arms of these auxiliary relays and to the source of alternating current. The controller mechanism is also connected directly with the alternating current source by two other leads.

As can be seen in Fig. 2, the furnace temperature, instead of the speed of the furnace, can be regulated if the controller mechanism is connected to the furnace instead of to the reel motor. In such case the controller may be a rheostat with which to regulate the current supplied to an electric furnace, or it may be an electrically controlled valve in the gas feed line of a gas-fired furnace.

The operation of the apparatus shown in Fig. 1 may be described as follows:

The material to be heat treated, for example thin flexible steel strip, is pulled off reel 1, passed successively through the furnace and the quenching blocks and rewound on reel 4 so that new sections of quenched strip are continuously passing through the field of the primary coil 6. A suitable standard A, such as a piece of heat treated strip steel which possesses the characteristics that are desired in the product of the heat treating operation, is placed in inductive relationship with the other primary coil 7. If the apparatus is in balance, and there is no difference in the magnetic or physical characteristics between the standard and the section of the steel strip immediately adjacent primary coil 6 no current will be induced in the secondary circuit, because the two secondary coils are connected in series opposition and the current induced in one secondary coil neutralizes that induced in the other. If, however, the properties of the standard and the section of the strip undergoing analysis differ, a current will be induced in the circuit containing the two secondary coils. The effect of any stray currents or other electromotive forces not due to differences between the physical or metallurgical properties of the standard and the strip are compensated for by changing the adjustment of the potentiometer 12 and by introducing a potential 90° out of phase with the induced potential in the secondary coils through the center tap potentiometer 17. The compensated secondary current is then filtered and broken up by the synchronous commutator into components displaced from each other by constant phase angles. The two components are indicated respectively by the integrating galvanometers, and one

component serves to actuate the galvanometer relay arm. Movement of the galvanometer relay arm to either side serves to close the direct current circuit containing the marker relay and the auxiliary relays. The marker relay operates to mark the strip undergoing analysis near a point where the deviation from the accepted metallurgical or physical properties occurs and the auxiliary relays serve to close the controller circuit and change the speed of the reel motor to increase or decrease the rate at which the strip is pulled through the furnace.

The function of the fixed resistance **40** shunted between the output brushes **28**, **30** and the galvanometer **33** is to balance the galvanometer circuits by equalizing the impedances therein.

The function of the delay switch **42** in the direct current circuit is to prevent "hunting", that is, excessive regulation. This is accomplished by rendering the control mechanism inoperative for a fixed period of time after each adjustment is made, so that the effect of changing either the rate of travel of the strip through the furnace or the furnace temperature may be felt at the primary coil of the magnetic analysis circuit which is inductively associated with a section of the strip. It has been found that increased uniformity of product and less strain upon the control apparatus are obtained when a delay mechanism is incorporated in the circuit.

In starting the apparatus it is necessary to balance the secondary circuit of the magnetic analysis device. This is accomplished by placing substantially identical magnetizable objects respectively in the fields of the two primary coils, and adjusting the potentiometers until the galvanometers both show no deflection. The standard in the field of primary coil is then replaced by the strip of heat treated steel or other magnetizable material to be tested, and thereafter any deviations from the accepted standard in primary coil will serve to actuate the automatic speed control mechanism.

By adjusting the position of the brushes by moving the brush holder the strength and character of the current in the galvanometer circuit may be varied so that the sensitivity of the apparatus may be conveniently adjusted.

It will be understood that the operation of the apparatus shown in Fig. 2 is substantially the same as that of Fig. 1, the sole difference being that the temperature of the furnace is regulated instead of the speed of the material being heat treated.

It will be understood that changes in the apparatus will occur to the man skilled in the art without departing from the principles of my invention.

I claim:

1. In an apparatus for heat treating an elongated magnetizable body having a furnace, a quenching means, and means for conveying said elongated magnetizable body successively through the furnace and the quenching means, the improvement which comprises a primary circuit connectable to an alternating current source and containing a pair of primary coils disposable respectively in inductive relationship with a standard of known magnetism affecting properties and with successive quenched portions of said elongated magnetizable body, a secondary circuit containing a pair of coils disposed respectively in inductive relationship with said primary coils, a synchronous commutator connected in said secondary circuit and adapted to break up current in said secondary circuit into a plurality of components displaced from each other by constant phase angles, and means for varying the temperature of the furnace in response to changes in a single phase displaced component of the current flowing in said secondary circuit.

2. In an apparatus for heat treating an elongated magnetizable body having a furnace, a quenching means, means for continuously conveying said elongated magnetizable body successively through the furnace and the quenching means, the improvement which comprises a primary circuit connectable to an alternating current source and containing a pair of primary coils disposable respectively in inductive relationship with a standard of known magnetism affecting properties and with successive portions of said elongated magnetizable body, a secondary circuit containing a pair of secondary coils disposed respectively in inductive relationship with said primary coils, a synchronous commutator connected in said secondary circuit and adapted to break up current in said secondary circuit into a plurality of components displaced from each other by constant phase angles, and means for varying the speed of the conveying means in response to changes in the phase displaced current flowing in said secondary circuit.

3. In an apparatus for heat treating an elongated magnetizable body having a furnace, a quenching means and means for conveying said elongated magnetizable body successively through the furnace and the quenching means, the improvement which comprises a primary circuit connectable to an alternating current source and containing a pair of primary coils disposable respectively in inductive relationship with a standard of known magnetism affecting properties and with successive quenched portions of said elongated magnetizable body, a secondary circuit containing a pair of coils disposed respectively in inductive relationship with said primary coils, a synchronous commutator connected in said secondary circuit and adapted to break up current in said secondary circuit into a plurality of components displaced from each other by constant phase angles, and means for varying the amount of heat introduced into successive portions of the elongated magnetizable body passing through the furnace in response to changes in one of the phase displaced components of the current flowing in said secondary circuit.

4. In an apparatus for heat treating an elongated magnetizable body having a furnace, a quenching means and means for conveying said elongated magnetizable body successively through the furnace and the quenching means, the improvement which comprises a primary circuit connectable to an alternating current source and containing a pair of primary coils disposable respectively in inductive relationship with a standard of known magnetism affecting properties and with successive quenched portions of said elongated magnetizable body, a secondary circuit containing a pair of coils disposed respectively in inductive relationship with said primary coils, means connected in said secondary circuit for breaking up current flowing therein into a plurality of components displaced from each other by constant phase angles, means for varying the amount of heat introduced into successive portions of the elongated magnetizable body in the furnace in response to changes in the phase displaced components of the current flowing in said secondary circuit and means for interrupting

the operation of said means for varying the amount of heat introduced in the successive portions of the magnetizable body for a relatively short interval of time after said operation.

5. In an apparatus for heat treating an elongated magnetizable body having a furnace, a quenching means and means for conveying said elongated magnetizable body successively through the furnace and the quenching means, the improvement which comprises a primary circuit connectable to an alternating current source and having a primary coil disposable in inductive relationship with successive quenched portions of said elongated magnetizable bodies, a secondary circuit containing a coil disposed in inductive relationship with the primary coil, means connected in the secondary circuit for breaking up a current flowing therein into a plurality of components displaced from each other by constant phase angles, and means for varying the amount of heat introduced into successive portions of said elongated magnetizable body in the furnace in response to changes in a single phase displaced component of the current flowing in said secondary circuit.

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