

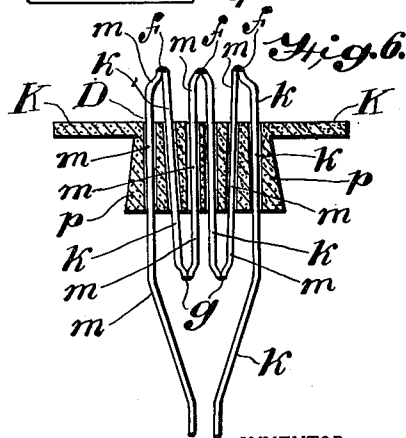
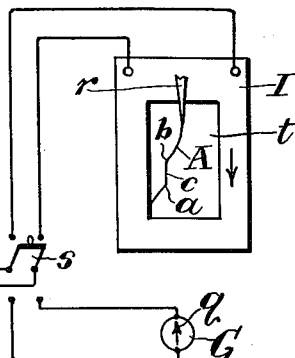
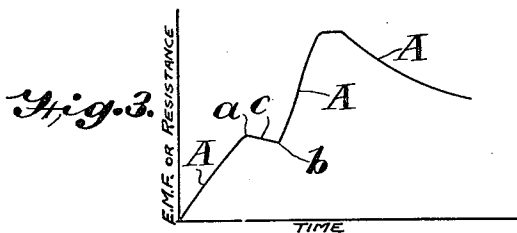
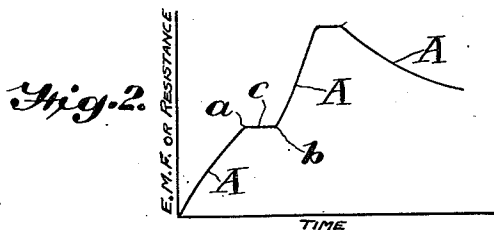
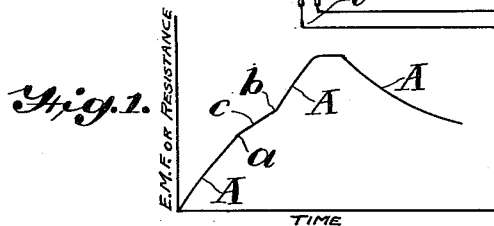
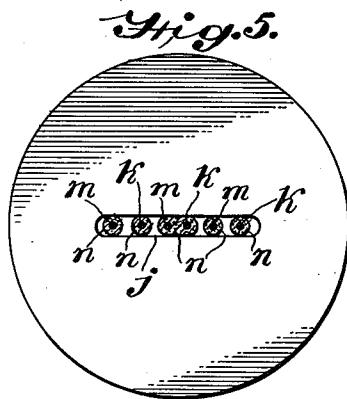
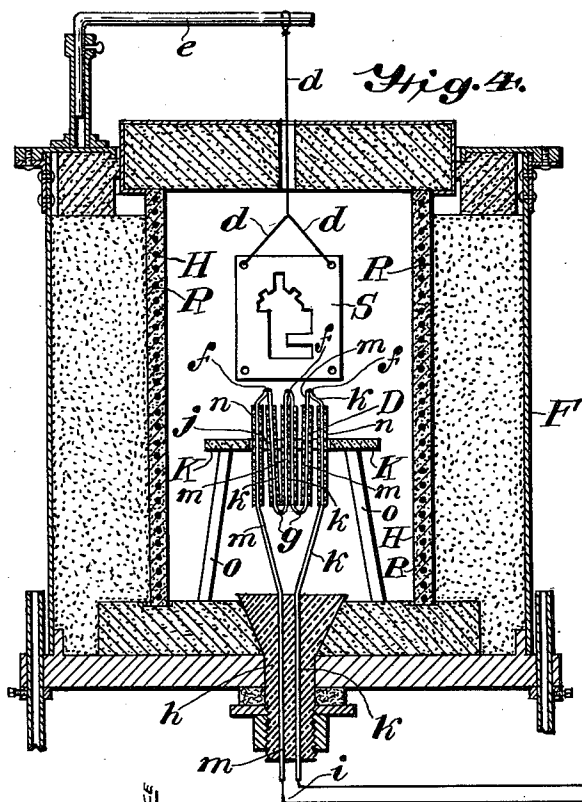
Sept. 27, 1927.

C. A. MARTIN

1,643,582

TEMPERATURE RESPONSIVE APPARATUS

Original Filed Jan. 8, 1924 2 Sheets-Sheet 1



INVENTOR.

Charles A. Martin

BY

Cornelius L. Ebert
ATTORNEY.

Sept. 27, 1927.

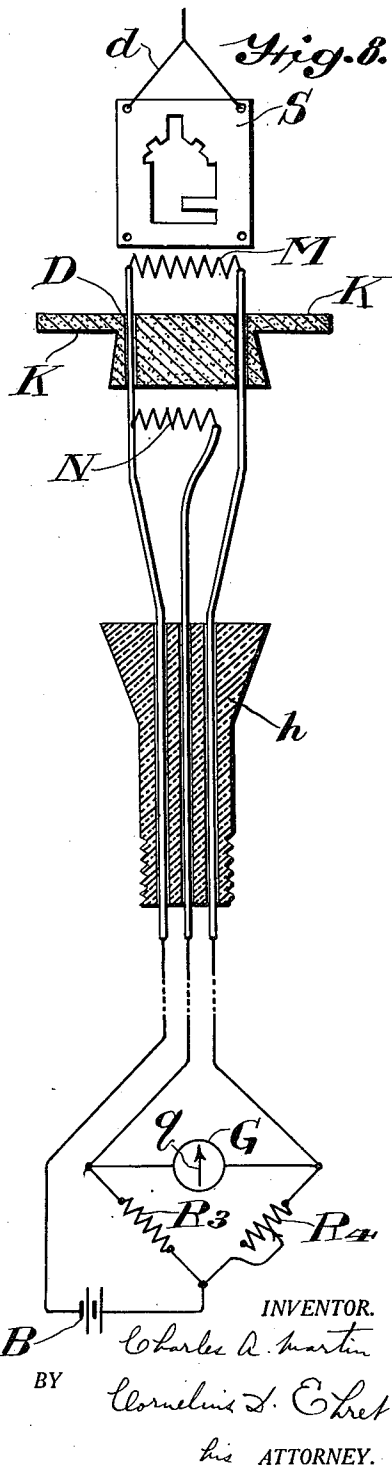
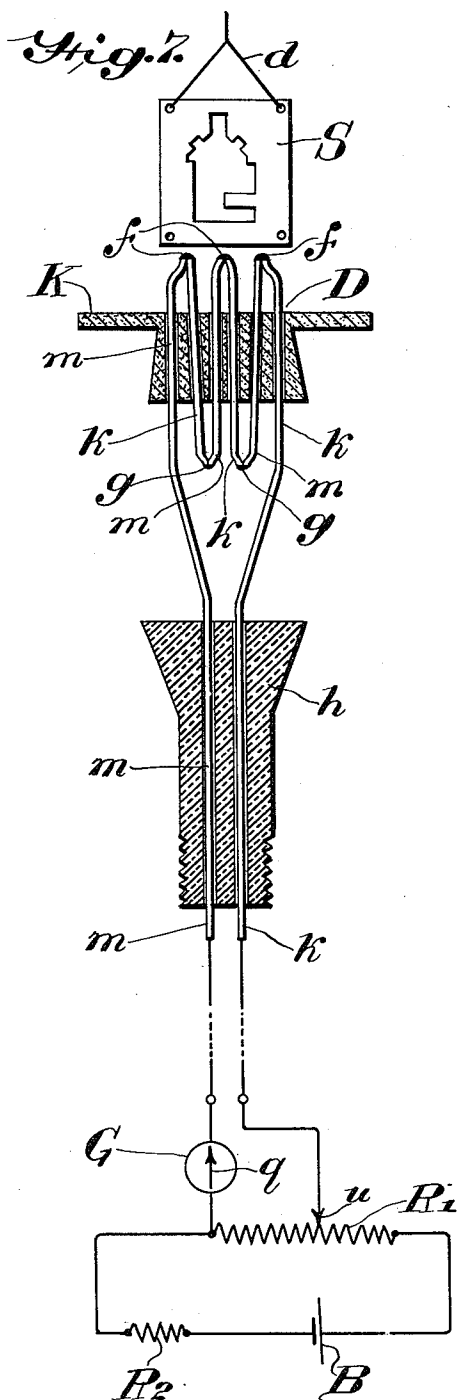
C. A. MARTIN

1,643,582

TEMPERATURE RESPONSIVE APPARATUS

Original Filed Jan. 8, 1924

2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE.

CHARLES A. MARTIN, OF CHICAGO, ILLINOIS, ASSIGNOR TO LEEDS & NORTHRUP COMPANY, OF PHILADELPHIA, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA.

TEMPERATURE-RESPONSIVE APPARATUS.

Original application filed January 8, 1924, Serial No. 684,949, Patent No. 1,550,272, dated August 18, 1925.
Divided and this application filed August 29, 1924. Serial No. 734,837.

My invention resides in a composite or multiple temperature-responsive device comprising a plurality of thermo-couples, resistances, or equivalents, preferably comprised in a detachable or removable unit which may comprise in addition a baffle disposed between different of the thermo-junctions, resistances or equivalents.

My invention resides further in a temperature-responsive device comprising a plurality of serially connected thermo-couples the number of whose hot (or cold) junctions is greater than the number of cold (or hot) junctions disposed adjacent thereto, and at least one of whose cold (or hot) junctions is located at a distance from the aforesaid cold (or hot) junctions; and my invention resides further in a temperature-responsive device of this character in combination with a balancing circuit, such as a potentiometer, whose deflecting instrument, such as a galvanometer or equivalent, controls the mechanism of a recorder, control apparatus or equivalent.

My invention resides further in a temperature-responsive device comprising a plurality of current-restraining means, as resistances, or equivalent, disposed adjacent each other but more or less distinctly separated and preferably comprised in a detachable or removable unit which preferably includes also a baffle or equivalent disposed between the adjacent current-restraining means or resistances; my invention resides further in a temperature-responsive device of this character in circuit with a source of current and an indicating or measuring instrument, as a galvanometer or equivalent; more particularly, my invention resides in a temperature-responsive device of this character in a balancing circuit, such as a Wheatstone bridge; more particularly, my invention resides in a temperature-responsive device of this character in which different current-restraining means, or resistances or equivalents, are connected in different arms of a Wheatstone bridge; and my invention resides further in a combination of this character in which the galvanometer or equivalent of a Wheatstone bridge controls the mechanism of a recorder, control apparatus or equivalent.

My invention resides in apparatus of the character hereinafter described and claimed.

This application is a division from my application Serial No. 684,946, filed January 8, 1924, patented Aug. 18, 1925, No. 1,550,272.

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

Fig. 1 is a curve in the nature of a time-temperature curve, whereof the inflections at the beginning and end of a decalescence stage are not sharply defined.

Fig. 2 is a similar curve whereof the beginning and end of a decalescence stage are more sharply defined and joined by a portion of the curve resembling zero or at most slight increase in temperature with time.

Fig. 3 is a similar curve in which the points representing the beginning and end of a decalescence stage are even more sharply defined at the ends of a portion of the curve resembling actual decrease in temperature with time.

Fig. 4 is a vertical sectional view, parts in elevation, of a heat-treating furnace with my invention applied thereto.

Fig. 5 is a plan view, on enlarged scale, partly in horizontal section, of part of the structure shown in Fig. 4.

Fig. 6 is a vertical sectional view, partly in elevation, of a temperature-responsive device comprising a multiple thermo-couple with a baffle of modified structure.

Fig. 7 is a diagrammatic view of one of various circuit arrangements in which the multiple thermo-couple is utilizable in accordance with my invention.

Fig. 8 is a diagrammatic view of one of various circuit arrangements in which another form of my temperature-responsive device is utilizable.

While my invention is applicable in general for accentuating or rendering more easily discernible or observable changes in or the time of occurrence of change in rate of change of temperature, heat transfer or related effects, I shall for purposes of illustration describe its preferred field of application, to wit, in the practice of the method disclosed in Letters Patent No. 1,188,128, granted June 20, 1916 to W. J.

Wrighton, whereof it is characteristic that the time of occurrence of a more or less abrupt change in the rate of change of temperature or heat transfer at the beginning or end of a decalescence or recalescence stage in the heat treatment of steel or the like is determined without regard to the actual or absolute temperatures assumed by the steel or the surrounding medium by observing the change in rate of change of the effect produced by a temperature-responsive device disposed adjacent the steel under treatment.

It has been found by me that the time of occurrence of the critical or transformation point or points, or beginning and end of a decalescence or recalescence period or stage may be more sharply defined or rendered more easily observable by utilizing a multiple or composite temperature-responsive device, different elements or components of which are at different distances from or differently located with respect to the steel undergoing heat treatment; or, in general, so located with respect to each other that the rate of change of the difference between the temperatures they assume is small, negligible or zero until a critical point is reached when the rate of change of the difference between the temperatures markedly changes or even reverses in sense. Each component of the composite temperature-responsive device produces an effect whose magnitude is dependent upon the magnitude of the temperature, which may remain unknown, to which it is subjected, and the effects of the several components are combined to produce a joint effect whose rate of change markedly changes in accordance with a marked change at the time of occurrence of a critical point in the rate of change of the difference between the temperatures to which the components are respectively subjected. The composite temperature-responsive device behaves as a simple temperature-responsive device during the substantially regular change of temperature of the steel, but at the times of occurrence of the critical or transformation points and during the decalescence and recalescence stages behaves as a series of temperature-responsive devices whose effects are cumulative, and therefore greater than the effect of the single temperature-responsive device, thereby increasing or magnifying the effects of absorption or loss of heat by the steel with change in the rate of change of temperature thereof characteristic of the decalescence and recalescence stages.

My invention accordingly renders more useful the method of said Letters Patent No. 1,188,128 in general, and is of particular advantage when the steel under treatment is of a character whose critical or transformation points are not sharply defined, as in the case of low carbon steels or alloy steels. My invention is of particular advantage also in

cases where the mass or weight of the material under heat treatment is small, since the critical points obtained by my composite or multiple temperature-responsive device are more pronounced and sharply defined, while the critical points of a small piece or mass of steel are not clearly defined. For example, when a simple or single temperature-responsive device is employed, as in the method of said Letters Patent No. 1,188,128, the smallest pieces of steel or the like whose transformation points can readily be determined are of the order of five or six ounces in weight; while by my method there are readily determinable the times of occurrence of the critical points of pieces of the order of one-half or one-quarter cu. in., about three or about one and one-half ounces, or for example, a piece of drill rod one-quarter inch in diameter and two inches in length. My invention is of particular utility, therefore, when the article undergoing heat treatment is not only of small size or small weight, but the more so when in addition it is composed of alloy steel or low carbon steel.

Referring to Fig. 1, the curve A is of the nature of a time-temperature curve whose abscissae represent time and whose ordinates are electro-motive-forces, resistances or kindred effects dependent upon the temperature of a thermo-couple, resistance or equivalent temperature-responsive device disposed at the surface of or near the steel undergoing heat treatment. The actual or absolute temperatures of the curve A may be unknown, but nevertheless, as described in the aforesaid Letters Patent, the times of occurrence of the critical or transformation points *a* and *b* are determined and are observable, the portion *c* of the curve between the points *a* and *b* corresponding with the decalescence stage or period.

The curve A of Fig. 2 illustrates the results obtainable by my invention, to wit, the accentuation or increase in the apparent, though not true, rate of change of temperature of the steel at the beginning or end of or during the decalescence stage. As indicated at the points *a* and *b*, the changes in direction or inflections of the curve A are more marked, and therefore the times of occurrence of the points *a* and *b* are more readily discernible. In this example, during the decalescence period *c* the apparent change in temperature of the steel is zero, or there is at most a slight increase in temperature with time.

As indicated in Fig. 3, the time of occurrence of the decalescence stage is even more markedly accentuated, the apparent changes in the rate of change of temperature at the points *a* and *b* being greater than in Fig. 2, and during the decalescence period *c* the apparent rate of change of the steel is actu-

ally negative, that is, the temperature of the steel apparently decreases with time until the time corresponding with the point *b*, when its temperature again rises.

These effects are procurable by a composite or multiple temperature-responsive device of any suitable character, several of which are hereinafter described.

Referring to Fig. 4, *F* is a furnace or equivalent heater whose heating chamber, in the example illustrated, is the chamber within the member *H* in which heating is effected in any suitable way, as by combustion of oil, gas or other fuel; but preferably, as in the example illustrated, by heat evolved by the resistance conductor *R*, through which electric current of suitable magnitude is passed to effect substantially uniform or at least regular rise in temperature of the article *S* undergoing heat treatment, and which in the example illustrated is a steel die, but which obviously may be any other article of alloy steel, high or low carbon steel, or any other equivalent material which exhibits one or more critical or transformation points, the time of occurrence of which is to be determined. The article *S*, which represents generically either a single article or a group of articles, is supported in the heating chamber in any suitable way or by any suitable means, in the example illustrated by the supporting wire or chain *d* hung upon the arm *e*.

Disposed at the surface of or adjacent the article *S* is the composite temperature-responsive device *D*, in this case being of the thermo-electric type comprising a plurality of thermo-couples in series with each other. In the example illustrated, the device *D* comprises three thermo-couples, three of whose thermo-junctions *f*, *f*, *f* may for convenience be termed the hot junctions, two of whose thermo-junctions *g*, *g* may be for convenience termed cold junctions, and whose third cold junction is remote, preferably outside of the furnace, at any suitable place, as, for example, either at *i*, at the switch *s*, at the galvanometer *G*, or at the instrument or recorder *I*, as may be suitable or desirable. Each couple comprises dissimilar metals, as well understood in the art, and in the example illustrated, the couples are formed of the wires *k* and *m*, of dissimilar metals, preferably large enough to be self-sustaining or supporting, and welded, soldered or otherwise joined to each other at the junctions *f* and *g*. The wire *k* to the right and the wire *m* to the left are preferably continued downwardly and extend through the plug or removable furnace bushing *h*, of lava or equivalent heat-resisting non-conducting material pierced with holes to accommodate the wires *k* and *m*, which at their lower or outer ends may be connected by conductors, copper or sim-

ilar conductors to the associated instrument, in which case the cold junction is at *i* at the ends of the wires *m* and *k*, where they emerge from the plug *h*, which carries the wires and the device *D*, forming therewith a unit. As well understood in the art, the connections from the lower ends of the wires *k* and *m* may be made by conductors of the same materials as the wires *k* and *m* to the switch *s* or beyond to either of the instruments, in which case the third cold junction is either at the switch *s* or either of the instruments *G* or *I*.

The junctions *f* and *g* are adjacent each other and in practice may be a distance apart of the order of several inches, for example, two inches. Surrounding the thermo-couple wires are tubes or bushings *n*, of clay or other suitable insulating material capable of withstanding high temperatures, the members *n* serving to prevent contact between adjacent couple wires *k* and *m*.

Upon a support *o*, of any suitable character, is disposed the baffle member *K*, having a slot *j* through which the multiple thermo-couple or device *D* extends, whereby as between the hot junctions *f* and cold junctions *g* there is introduced a heat-baffling effect or any equivalent effect for causing or allowing the hot and cold junctions *f* and *g* to assume somewhat different temperatures or to change in temperature at different rates, particularly when the piece *S* is passing through a transformation stage, as, for example, the decalescence stage *c* of Figs. 2 and 3. The baffle *K* may, as indicated on larger scale in plan view in Fig. 5, be in the form of a disk. It may be composed of any suitable material, as clay or the like, capable of withstanding the temperatures involved.

As indicated in Fig. 6, the baffle member *K* may be formed as a unit with the temperature-responsive device *D*, and therefore comprised also in the unit including the supporting plug *h* indicated in Figs. 4, 7 and 8. In the arrangement of Fig. 6 there is integral with the member *K* the extension *p* pierced with holes through which extend the thermo-couple wires *k* and *m*, which are spaced and insulated from each other by the member *p*.

Reverting to Fig. 4, upon throwing the switch *s* downwardly, the multiple thermo-couple is thrown into circuit with the instrument *G*, which may be of any character which will cause a deflection of its moving system, needle or pointer *q* under the influence of an impressed electro-motive force. The instrument *G* may be a galvanometer, and more particularly a voltmeter or millivoltmeter of any suitable type, such, for example, as the D'Arsonval type.

As the temperature in the heating chamber of the furnace rises substantially uni-

formly, or at least regularly, as indicated, for example, in the left hand portion of the curve A, Fig. 2, voltage readings may be taken at intervals and thereby the curve A plotted as the readings progress. When the piece S reaches a temperature at which transformation begins, the point *a* of Fig. 2 will have been reached. Then continuing to take readings of the galvanometer G and plotting them against time, the portion *c* of the curve A will be derived, the time of occurrence of the sharply defined or pronounced inflection at *a* indicating to the reader of the instrument G that the piece S has reached the transformation point. Again, upon continuing readings and plotting them against time, the deflections abruptly increase, as at the point *b*, whereupon the observer knows that the piece S has passed through the transformation period and is again rising in temperature at higher rate than during the period *c*. Accordingly, by simply taking readings of the instrument G and plotting them against time, the time of occurrence of the critical points is determined.

In practice, however, it is generally preferable and more usual to employ a curve drawing recorder, as I, of any suitable character, such, for example, as disclosed in Leeds Patent 1,125,699, involving a potentiometer with which is associated a galvanometer, in series with which through the switch *s* is the multiple thermo-couple D. A suitable arrangement of this character is indicated in Fig. 7, where the potentiometer comprises the source of current or battery B delivering current through the resistance R^1 , the magnitude of the current being suitably adjusted by employing, if desirable, a second resistance R^2 . The one terminal of the multiple thermo-couple is connected through the galvanometer G to one terminal of the resistance R^1 , and the other terminal of the multiple thermo-couple is connected to the contact *u* adjustable along the resistance R^1 to such position that the fall of potential between the contact *u* and the left end of the resistance R^1 is equal and opposite to the electro-motive-force produced by the composite thermo-couple, in which case the deflection of the galvanometer G is zero. The needle *g* of the galvanometer G controls the recorder mechanism, which effects adjustment of the contact *u* along the resistance R^1 and produces a record.

The marker *r* of the recorder draws upon the recorder sheet or paper *t*, moving in the direction of the arrow, the curve A, on which are readily discernible the inflection points *a* and *b* and the intervening portion *c* corresponding to the decalescence stage of the piece under treatment.

In kind, the above described operation is the same as described in the aforesaid Let-

ters Patent No. 1,188,128. However, as explained in connection with Figs. 2 and 3, the critical points and decalescence stage are more clearly and sharply defined or much more pronounced, and therefore more readily discernible, particularly by less skilled furnace operators or heat treaters.

During the period of heat treatment in advance of the point *a* on the curve A, Fig. 2, for example, the rise in temperature within the heating chamber is substantially uniform or at least regular, and suitably slow, with the result that the temperatures of the hot junctions *f* and cold junctions *g* are the same, or nearly so, and in any event, so nearly so that the junctions *g* are during this period substantially ineffective as cold junctions, with the result that the electro-motive-force produced by the multiple couple is practically that due to a single couple whose hot junction is within the furnace and whose cold junction is at *i*, *s*, G or I, external to the furnace. In other words, since the temperature of the couples *g* is the same or substantially the same as the temperature of the hot junctions *f*, the situation is the same, as regards two of the three couples of the composite temperature-responsive device, as if they were absent or were producing no substantial electro-motive-forces because the two junctions of each are at substantially the same temperature.

However, when the piece S enters into the transformation period, it continues to absorb heat without rise in temperature, or at least with decreased rate in rise in temperature notwithstanding the continuance of delivery of heat at substantially the previous rate into the heating chamber, with the result that the hot junctions *f*, closer to the piece S than the junctions *g*, either discontinue rising in temperature, or at any rate, continue to rise in temperature at a lower rate than before, while the junctions *g* continue to rise in temperature at a different or higher rate than the junctions *f*, with the result that the total electro-motive-force produced by the three thermo-couples in series with each other either continues to increase at a slower rate, remains of fixed magnitude as indicated during the period *c* of Fig. 2, or actually decreases with time, as indicated by the period *c* of Fig. 3. In any event, the point *a* of the curve becomes more pronounced than in the case of Fig. 1, where but a single or simple temperature-responsive device is employed. When the piece S has completed the transformation period, it proceeds again to rise in temperature at an increased rate, either uniform or at least together, with the result that the point *b* becomes sharply defined or pronounced, as indicated in Figs. 2 and 3, the junctions *f* and *g* for the period beyond the

point *b* continuing to rise in temperature at substantially equal rates, though their actual temperatures may be somewhat different, as in the first portion of the curve A before reaching the point *a*.

The presence of a baffle member K, which may or may not be used, accentuates the difference in rate of rise or change of temperature of the hot junctions *f* and cold junctions *g*, particularly throughout the transformation period *c*; it impedes heat transfer and equalization of temperatures between junctions *f* and *g*.

It will accordingly be understood that when the hot and cold junctions *f* and *g* are at the same temperature or at a predetermined small difference in temperature during the initial portion of the heating period before the point *a* is reached, the multiple couple in effect operates substantially as a single couple as regards the electro-motive-force produced; yet when the transformation period is reached, due to the difference in distance between the hot and cold junctions from the piece S, the difference in temperature between the hot and cold junctions *f* and *g* increases or becomes more marked, though both hot and cold junctions may be at the time increasing in temperature, with the result that the rate of change of the electro-motive-force impressed upon the reading instrument or recorder is to greater extent changed at the inflection points *a* and *b* than in the case a single or simple thermo-couple were employed, thereby effecting an amplification or magnification of the change in the rate of change of temperature of the piece.

Since the multiple thermo-couple is of such structure and employed under such conditions that its total electro-motive-force is not materially different from or is of the same order of magnitude of that of a single thermo-couple, the scale of the recorder chart or paper *t*, measured transversely thereof at right angles to its direction of movement, is practically the same as in the case of use of a single or simple thermo-couple. While the recorder paper *t* need not be graduated transversely in temperatures or electro-motive-forces or equivalent units, it may be, if suitable or desirable. A feature of advantage and importance is that the temperatures or electro-motive-forces indicated by the recorder upon its chart or paper *t* when a single thermo-couple is employed will not differ greatly from the temperatures or electro-motive-forces indicated when using the multiple thermo-couple if the cold junctions *g*, *g* of the latter are properly positioned or disposed with relation to the hot junction *f*.

By the arrangement described, some, preferably all but one, of the cold junctions of the multiple couple are disposed adjacent

the hot junctions, with the result that the magnitude of the electro-motive-forces effective upon the indicating or recording instruments is of the same order of magnitude as that of a single thermo-couple, and yet makes possible accentuation and sharper definition of the inflection points. The structure and mode of operation are therefore distinguishable from the case where a multiple thermo-couple is employed with all of its cold junctions remote from its hot junctions, in which case the electro-motive-force effective upon the indicating or recording instruments will simply be multiplied.

In advance of the point *a*, Fig. 2 for example, and after the point *b*, the difference between the temperatures at the hot junctions *f* and the cold junctions *g* is small or zero, or in any event, substantially constant, and the rate of change of the difference between these temperatures is substantially constant or zero, and the multiple thermo-couple is in effect substantially a simple or single thermo-couple having one hot junction and one remote cold junction; at and between the points *a* and *b*, however, the difference between the temperatures at the hot junctions *f* and cold junctions *g* becomes finite or increases, or reverses in sense, the rate of change of the temperature difference between junctions *f* and *g* markedly changes in magnitude, and the multiple thermo-couple now behaves as a plurality of couples serially related and having substantial difference of temperature between its hot junctions *f* and cold junctions *g*, causing to be added to or subtracted from the electro-motive-force due to the single couple whose cold junction is remote or external to the furnace an electro-motive-force equal to the sum of the electro-motive-forces of those of the component couples whose cold junctions are *g*. The greater the number of thermo-couples having their cold junctions *g* adjacent the hot junctions *f* as compared with the number of thermo-couples having their cold junctions remote or external to the furnace, the greater will be that electro-motive-force which is added to or subtracted from the electro-motive-force of the thermo-couples whose cold junctions are remote or external to the furnace, and the more sharply will the critical points be defined. It will accordingly be understood that it is preferable to have but one cold junction remote or external to the furnace and to have a large number of component couples with their cold junctions within the furnace adjacent but spaced from the hot junctions *f*. While in the example illustrated there is a total of three thermo-couples, one of which has its cold junction remote or external to the furnace and two having their cold junctions at *g* within the furnace, the effects described may be further accentuated by increasing the number of

couples having their cold junctions g within the furnace. It will be further understood that my invention is present if there are utilized but two thermo-couples, having one cold junction at g within the furnace and the other cold junction remote or outside the furnace.

While the employment of a multiple thermo-couple is preferred, it shall be understood that the principle of my invention is inherent in the employment of composite or multiple temperature-responsive devices of other characters, whether or not electrical.

In lieu of employment of thermo-couples, the composite temperature-responsive device may, as indicated in Fig. 8, comprise the resistances M and N , having substantial temperature co-efficients, preferably both positive, and either equal or unequal. These resistances form with the plug h a removable and detachable unit which may include also a baffle member K . As indicated, the resistance M is placed nearer the piece S undergoing heat treatment than resistance N . These resistances may be used in any suitable circuit arrangement for making manifest changes in resistance or effects dependent upon changes in resistance. The result will be in general the same as that hereinbefore described when using a multiple thermo-couple, to wit, the transformation points will be more sharply defined and more easily determinable as to time of occurrence. In the example illustrated, however, the resistances M and N are connected in two adjacent arms of a Wheatstone bridge in whose other arms are included the resistances R^3 and R^4 . As indicated, the connections are effected with the resistances M and N by three conductors only, since one conductor connects with both resistances. The conductor which connects with both resistances may be one of the conjugate conductors of the bridge, in which is included the source of current or battery B , while in the other conjugate conductor is connected the galvanometer G , which may control a recorder mechanism, as in the aforesaid Leeds Patent No. 1,125,169, in which case the resistance R^4 is varied by the recorder to restore balance, and in restoring balance produces a record.

Before the piece S reaches the transformation stage, the resistances M and N increase in temperature, and therefore in resistance, regularly or substantially uniformly, or at any rate, at substantially equal rates, with the result that the unbalancing of the bridge and its re-balancing by the recorder progresses with regularity or substantial uniformity, thereby describing that portion of the curve A , Fig. 2, for example, to the left of the inflection point a . When the transformation point is reached, however, the resistance N will continue to rise in temperature, while the resistance M will increase in

temperature at a slower rate than before, with the result that the bridge will be sharply unbalanced, and to re-balance, the recorder marker will move abruptly transversely of the recorder sheet, thereby sharply defining the critical or transformation point a . At the end of the transformation period the resistance M will rise in temperature at higher rate than during the transformation period c , and there will result then the sharp inflection at the point b .

Here again the difference between the temperatures to which the resistances M and N are subjected is small, zero, or at least constant before the critical point a , and after the critical point b , and the change in the rate of change of the difference between these temperatures at the time of occurrence of the critical points is magnified or accentuated as to its effect upon the indicating or recording instruments, thereby rendering the critical points more easily observable.

It is characteristic of my invention in general, and of all the arrangements hereinbefore described, that there is produced at different localities around or adjacent the piece or pieces undergoing heat treatment a plurality of effects whose magnitudes depend upon the temperatures at those localities, and those effects are combined to produce a joint effect in the rate of change of whose magnitude are caused accentuated and sharply defined abrupt changes at the times of occurrence of the critical points due to changes in the rate of change of the difference between the temperatures at the different localities at the times of occurrence of the critical points.

What I claim is:

1. A thermo-couple unit comprising a plurality of serially connected thermo-couples comprising hot and cold junctions adjacent each other, a support for said thermo-couples, and a pair of conductors of the materials of said couples extending through said support to a cold junction remote from said couples.

2. A thermo-couple unit comprising a plurality of serially connected thermo-couples having less than all of their cold junctions disposed adjacent the hot junctions, and a baffle member carried by said couples and disposed between hot and cold junctions thereof.

3. A thermo-couple unit comprising a plurality of serially connected thermo-couples having less than all of their cold junctions disposed adjacent the hot junctions, and a baffle member disposed between hot and cold junctions of said couples and having perforations through which the elements of said couples extend.

4. A thermo-couple unit comprising a plurality of serially connected thermo-couples having cold junctions located, re-

spectively, adjacent to and remote from the hot junctions.

5 5. A thermo-couple unit comprising a plurality of serially connected thermo-couples having cold junctions located, respectively, adjacent to and remote from the hot junctions, and a baffle disposed between said hot junctions and the adjacent cold junctions.

10 6. A composite temperature-responsive

device comprising a plurality of temperature-responsive devices spaced from each other, a common support therefor forming therewith a detachable and removable unit, and a member included in said unit and disposed between said temperature-responsive devices for impeding equalization of temperature between said devices. 15

CHARLES A. MARTIN.

CERTIFICATE OF CORRECTION.

Patent No. 1,643,582.

Granted September 27, 1927, to

CHARLES A. MARTIN.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, in the heading, line 6, for Serial No. 684,949, read Serial No. 684,946; same page, line 97, for the misspelled word "disconcernible" read "discernible"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of May, A. D. 1928.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.