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1,534,874

W. S. SCOTT

HEAT SATURATION INDICATOR

Filed Aug. 11, 1923

Fig. 1.

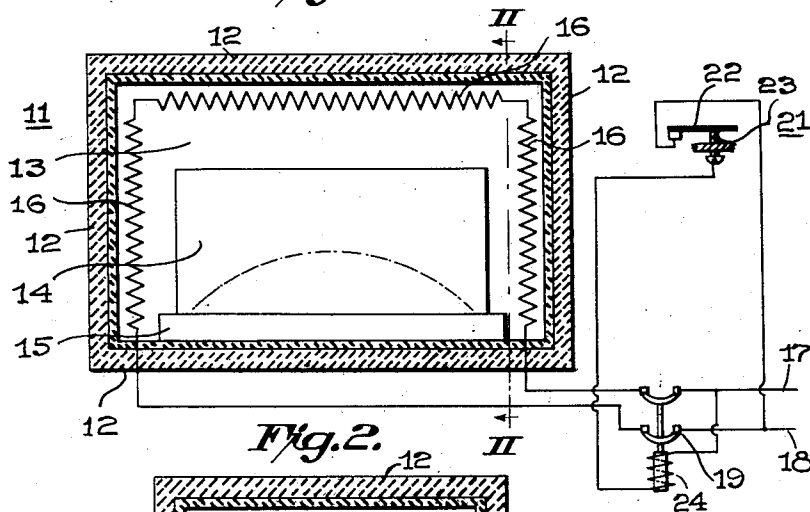


Fig. 2.

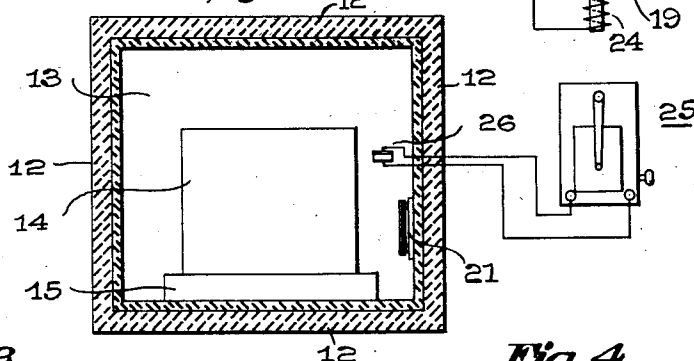


Fig. 3.

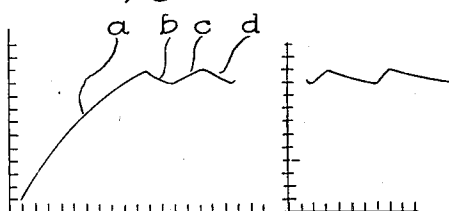


Fig. 4.

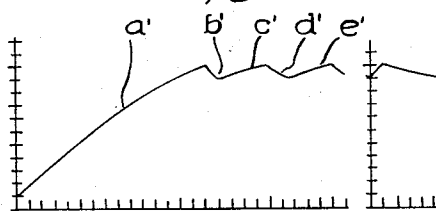


Fig. 5.



WITNESSES:

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HEAT-SATURATION INDICATOR.

Application filed August 11, 1923. Serial No. 656,867.

To all whom it may concern:

Be it known that I, WIRT S. SCOTT, a citizen of the United States, and a resident of Bozman, in the county of Talbot and State of Maryland, have invented a new and useful Improvement in Heat-Saturation Indicators, of which the following is a specification.

My invention relates to heat-treating furnaces and particularly to methods of heat treating.

The object of my invention is to provide a relatively simple means for, and a method, of determining when a mass of material to be heat treated has been uniformly heated throughout to a predetermined temperature.

The ordinary method of heat treating a mass of material comprises placing the material in a suitable furnace chamber that is provided with any desired type of heating means for raising the temperature of the material to a predetermined point, and that is further provided with means for determining the temperature thereof. Any desired amount of heat may be provided, at any desired temperature, which temperature is usually above that to which the mass of material is to be heated.

The outer surface or layers of the mass of material will be heated first, and the temperature of the innermost parts of the mass of material will be the last to reach a desired predetermined temperature. It is of course well known that the temperature of the mass of material will reach that of the furnace chamber or of the ambient air after a relatively long time, theoretically after an infinite length of time. In order to cut down the amount of time required to bring the mass of material to the desired temperature it is advisable to provide a heating means of relatively large capacity and of relatively higher temperature and to so regulate the heating means that the mass of material will attain a uniform predetermined temperature through its mass within a relatively short or at least a reasonable time.

It is further obvious that the character of the material, that is whether it is composed of metals or minerals in some particular

combination, or any other material, such as refractory products, will have an effect upon the length of time required to bring the mass to a uniform temperature. The shape of the mass also has an effect, that is, if a relatively thin plate or member is to be heated having at least one heat path of relatively short length, such mass will be heated to a uniform temperature in a much less time than would be required, for instance, for a cube or a sphere of the same volume.

It is, therefore, highly desirable to be able to determine accurately and quickly when any given and possibly irregular mass of material to be heat-treated, has been uniformly heated without relying upon the experience or judgment of the operator.

In practicing my invention, I provide a furnace structure that may be heated by any suitable heating means and I provide further a thermostatic controlling device for the heating means that is effective to maintain the temperature of either the heating means itself or of the furnace chamber within predetermined temperature limits.

I provide a device for recording the temperature of a part of the furnace structure during the time that the temperature controlling means is effective to maintain the temperature of the furnace chamber and of the furnace structure within predetermined temperature limits.

A curve of temperature is taken, by means of the temperature recording device, of the furnace structure when it is not charged and a corresponding curve of temperature is taken by the temperature recording device when a mass of material to be heat treated is placed within the furnace.

A comparison of certain portions of the two curves, that is, the one of the empty furnace structure and the other with a charged furnace structure, permits of determining accurately and quickly when the mass of material to be heat treated has been uniformly heated throughout its mass.

In the single sheet of drawings,

Figure 1 is a view, in vertical longitudinal section, of a furnace structure and a schematic diagram of connections of an electric

heating means with which the method of embodying my invention may be practiced,

Fig. 2 is a view, in vertical lateral section, of a furnace structure, taken on the line II—II of Fig. 1, and having associated therewith a temperature recording device,

Fig. 3 is a temperature curve of an empty furnace structure,

Fig. 4 is a temperature curve of a charged furnace structure, and

Fig. 5 is a portion of a temperature curve on an enlarged scale.

A furnace structure 11 comprises a plurality of side, top, bottom and end walls 12 of any suitable or desired material and construction. The walls will usually comprise an outer layer of a heat-insulating refractory material and an inner layer of a suitable high-temperature resisting refractory material enclosing a furnace chamber 13 of any suitable or desired contour and dimensions. Any suitable means for permitting the insertion in, and removal from, the furnace of a mass of material 14 to be heat treated therein may be provided. A suitable supporting means for the mass 14 may be provided on the floor of the furnace chamber. By material is meant any substance that may require heat-treatment, metallic, refractory-solid or even liquid.

As the details of construction of the furnace form no part of my invention, which in its broadest aspect, is applicable to any type of furnace structure, and may be applied to furnaces already installed, no further details of the furnace structure are thought to be necessary.

A heating means for the furnace chamber comprises one or more electric heating elements 16 that may be of any suitable or desired type and that may be mounted in the furnace chamber in any suitable or desired manner. While electric heating means are illustrated, I do not desire to be limited thereto, as any suitable heating means comprising a heating fluid, or solid or gaseous fuel may be employed.

The heating elements 16 are suitably energized from a supply circuit comprising conductors 17 and 18. A circuit interrupting means 19 is located between the supply circuit conductors and the heating elements 16. A thermal controlling device 21 is located in operative relation to any desired part of the furnace structure, and is shown in Fig. 2 of the drawing as being mounted on a side wall of the furnace. It may comprise a suitable bimetallic strip 22 when employed for such temperatures as will permit the use of a bimetallic strip, the free end of which operatively engages, or is disengaged from, an adjustable contact member 23. A coil 24 controls the position of the contact bridging members of the circuit interrupting device 19, the coil 24 and the thermal controller 21

being connected in series circuit relation and across the supply circuit conductors 17 and 18. If the temperature of the furnace chamber is relatively high, as is necessary in the heat treatment of steel, for instance, any other suitable thermally-operable means may be provided that will withstand the relatively high temperature.

I have indicated a temperature recording device 25 that is actuated by a second thermally influenced means 26 which may comprise a suitable thermo-couple.

The temperature recording means 25 may be of any suitable or desired type that is effective to make a record of the temperature within the furnace structure, or in fact, of any part thereof or even of the mass of metal obtained entirely upon the location of the thermally controlled means 26.

Fig. 3 illustrates, on a relatively reduced scale, a curve of temperature that is obtained by the temperature recording device 25 when the heating elements 16 are suitably energized and are suitably controlled by the thermally operable means 21 to maintain the temperature within predetermined temperature limits.

When the heating means is first energized, the part *a* of the curve in Fig. 3 is drawn by the temperature recording device 25, and the temperature of the furnace structure and of the thermally operable device 21 is raised until it reaches a predetermined maximum temperature, at which temperature the device 21 is effective to cause an interruption in the supply of heat of the furnace structure. As the furnace structure has not been uniformly heated to substantially the same temperature, the heat is absorbed quite rapidly and the temperature recording device 25 traces that part marked *b* in Fig. 3. The temperature drops until the device 21 is again effective to close the circuit through the heating means and the temperature is again caused to rise, whereupon the parts *c* of the curve is drawn. When the predetermined maximum temperature, for which the device 21 is set is again reached, the supply of energy to the heating means is interrupted and the temperature again drops, but not as rapidly as it did the first time, and as recorded in the part *d* of the curve.

The temperature continues to vary between the predetermined maximum and minimum limits, the time required for the temperature to drop from the maximum to the minimum becoming longer, and the time required for the temperature to be brought back from the minimum to the maximum temperature becoming shorter, until with an empty furnace structure, a substantially stable condition is reached. The curves of temperature and of temperature rise as recorded by the temperature device 25 will then be indefinitely repeated and are sub-

stantially indicated at the right hand end of the curve of Fig. 3. This means that the entire furnace structure has been heated to substantially uniform temperature and that whatever heat is lost, is lost by radiation from the outside surface of the furnace structure.

It is further evident that the slope of the curve of temperature recovery, that is, from the minimum to the maximum value, is dependent upon not only the outside surface of the furnace structure, but also upon the amount of energy translated into heat and upon the temperature of the heating means. However, with these factors maintained at any predetermined value, or under a predetermined set of conditions, a definite curve of heating and a definite curve of cooling is obtained and these two curves are substantially constant for a given furnace structure.

Fig. 4 of the drawing illustrates a similar temperature curve that is obtained with a charged furnace structure and it may be noted that the portion a' of the curve requires a much longer time to reach the same predetermined maximum value than was the case with an empty furnace structure.

A little consideration of the heating conditions in the charged furnace structure at the time when the thermal means 21 is effective to interrupt the energization of the heating means 16, shows that it is highly improbable that the mass of material 14 has been uniformly heated to predetermined temperature and that it will, therefore, absorb heat from the surrounding furnace structure.

The part b' of the curve is, therefore, much steeper, that is, the temperature drops more rapidly to the predetermined minimum at which the device 21 is effective to cause re-energization of the heating means. The recovery of the temperature is, moreover, much slower than was the case for the empty furnace structure, and therefore, the time required to trace the curve c' is much longer than that required to trace the curve c in Fig. 3.

The curve d' illustrates the decrease of temperature after the heating means has been de-energized and inasmuch as the charge 14 and the furnace structure have stored up more heat than at the first time, that is, at the end of the curve a' the slope of the curve d' is less and it requires a somewhat longer time to drop to the predetermined minimum temperature. The curve e' is shorter than was the curve e , that is, it requires a shorter time to bring the temperature back to the predetermined maximum point.

When the charge 14 has been uniformly heated to the predetermined temperature, it ceases to materially affect the slope of the

heating and of the cooling curves between the predetermined limits of temperature for which the device 21 has been set and these heating and cooling curves become substantially identical with those obtained for the empty furnace structure within the same temperature limits. The heating and cooling of the furnace structure and of the mass of metal contained therein are dependent substantially entirely upon the heat radiated from the outer surface of the furnace structure and, of course, upon the material comprising the furnace structure that is, its heat-absorbing, heating-transmitting and heat-radiating properties, which properties are independent of whether a charge is located within the furnace chamber. It is not overlooked that the charge has stored therein a certain amount of heat which will be effective to change the cooling curve of the structure if the cooling thereof is permitted to continue down to a relatively low temperature value, but this stored heat does not materially affect the cooling curves between the relatively narrow limits usually employed.

In Fig. 5, I have illustrated the final parts of the heating and cooling curve as obtained by a temperature recording device on an enlarged scale and have endeavored to show the variations in the length of time of the heating and of the cooling curves at about the time when the temperature conditions become substantially constant.

When a furnace has been installed to do heat-treating of any kind of material, it is, therefore, only necessary to take the heating and cooling curves of the furnace structure with the temperature controlling device 21 located in any predetermined position relatively to the furnace structure, more particularly within the furnace chamber, the temperature controlling device 21 being adjustable to maintain the temperature within given limits which may be determined in accordance with the type of heat treating to be done. For instance, if it is desired to heat a charge to a maximum temperature of say 1600° F., the minimum temperature limit may be 1550° or even 1575°. When a charge of any kind is placed within the furnace structure to be heat treated at a maximum temperature of 1600° F., the temperature recording device is again employed to record the temperature as was done with the empty furnace structure and with the device 21 in the same position.

A visual inspection of the heating and cooling curves will quickly disclose to the operator when they are substantially the same as those which were obtained for the empty furnace structure and the operator is then sure that the charge has been uniformly heated throughout its mass. If it is desired to leave the charge at that tem-

perature for a predetermined length of time, this is easily done by watching the record traced on the record sheet which is usually provided with markings to indicate the length of time and the charge can be removed after the predetermined length of time has elapsed.

It may be noted that the method embodying my invention makes use of devices that are now available in the operation of heat-treating furnaces. However, if desired, the curve drawing means 25 may be slightly altered to draw a curve that is magnified so that the portions *b c d* and *b' c' d'* and *e'* will be drawn to a larger scale in order that comparison may be made easier.

Various changes in detail and arrangement may be made without departing from the spirit and scope of the invention, and such modifications are intended to be covered by the appended claims.

I claim as my invention:

1. The method of determining when a mass of material has been heated to uniform predetermined temperature throughout when subjected to heat in a furnace structure which comprises the determination of the heating and cooling curves of the charged furnace between predetermined temperature limits and noting when these curves become substantially identical with those of the same furnace structure when empty.

2. The method of determining when a mass of material has been heated to a uniform predetermined temperature throughout when subjected to the heating effect of a heating means that is thermostatically regulated within predetermined temperature limits which comprises the determination of the heating and cooling curves of the charged furnace structure occurring when the heating means is so regulated and noting when these curves become substantially identical with those of the same furnace when not charged and when subjected to the same regulated heat effects.

3. The method of determining when a mass of material has been heated to a uniform and predetermined temperature throughout when subjected to a predetermined heat input within a predetermined range of temperature in a furnace structure which comprises the determination of the heating and cooling curves of the furnace structure within said range of temperature, the determination of the heating and cooling curves of the furnace structure with the mass of material located therein at the same heat input and within the said predetermined range of temperature and noting when the two sets of curves are substantially identical.

4. The method of determining when a mass of material has been heated to a uniform and predetermined temperature

throughout when subjected to heat in a furnace structure which comprises the determination of the heating and cooling curves of the furnace structure at said predetermined temperature, the determination of the heating and cooling curves of the furnace structure with the mass of material located therein, at said predetermined temperature and noting when the two set of curves are substantially identical.

5. The method of determining when a mass of material has been heated to a uniform and predetermined temperature throughout when subjected to a predetermined and substantially uniform heat in a furnace structure which comprises the determination of the heating and cooling curves of the furnace structure at said predetermined temperature and substantially uniform heat, the determination of the heating and cooling curves of the furnace structure at said predetermined temperature and heat with the mass of material located therein, and noting when the two sets of curves are substantially identical.

6. The method of heat treating a mass of material in a furnace structure which comprises heating the same to a predetermined temperature, maintaining the temperature of the furnace structure within predetermined temperature limits, determining the time when said mass of material ceases to affect the heating and cooling curves of said furnace structure, and maintaining said mass of material at a temperature within said limits for a predetermined length of time.

7. The method of heat treating a mass of material in a furnace structure which comprises heating the same to a predetermined temperature, maintaining the temperature of the furnace structure within predetermined temperature limits, determining the time when said mass of material ceases to affect the heating and cooling curves of said furnace structure, maintaining said mass of material at a temperature within said limits for a predetermined length of time and then cooling it.

8. The method of heat treating a mass of material in a furnace structure that comprises subjecting the same to the heating effect of a heating means that is thermostatically regulated within predetermined temperature limits, determining the heating and cooling curves of said furnace with the mass of material therein, noting when these curves become substantially identical with the corresponding curves of the same furnace when not charged and when subjected to the same regulated heat effects.

9. The method of heat treating a mass of material in a furnace structure that comprises subjecting the same to the heating effect of a heating means that is thermostati-

cally regulated within predetermined temperature limits, determining the heating and cooling curves of said furnace with the mass of material therein, noting when these curves
5 become substantially identical with the corresponding curves of the same furnace when not charged and when subjected to the same regulated heat effects and maintaining said

mass of material and said furnace structure within said temperature limits for a pre- 10
determined length of time.

In testimony whereof, I have hereunto subscribed my name this 8th day of August 1923.

WIRT S. SCOTT.