April 2, 1957 L. H. WASHBURN 2,787,685

APPARATUS RESPONSIVE TO TEMPERATURE CONDITIONS

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Fig. 1.

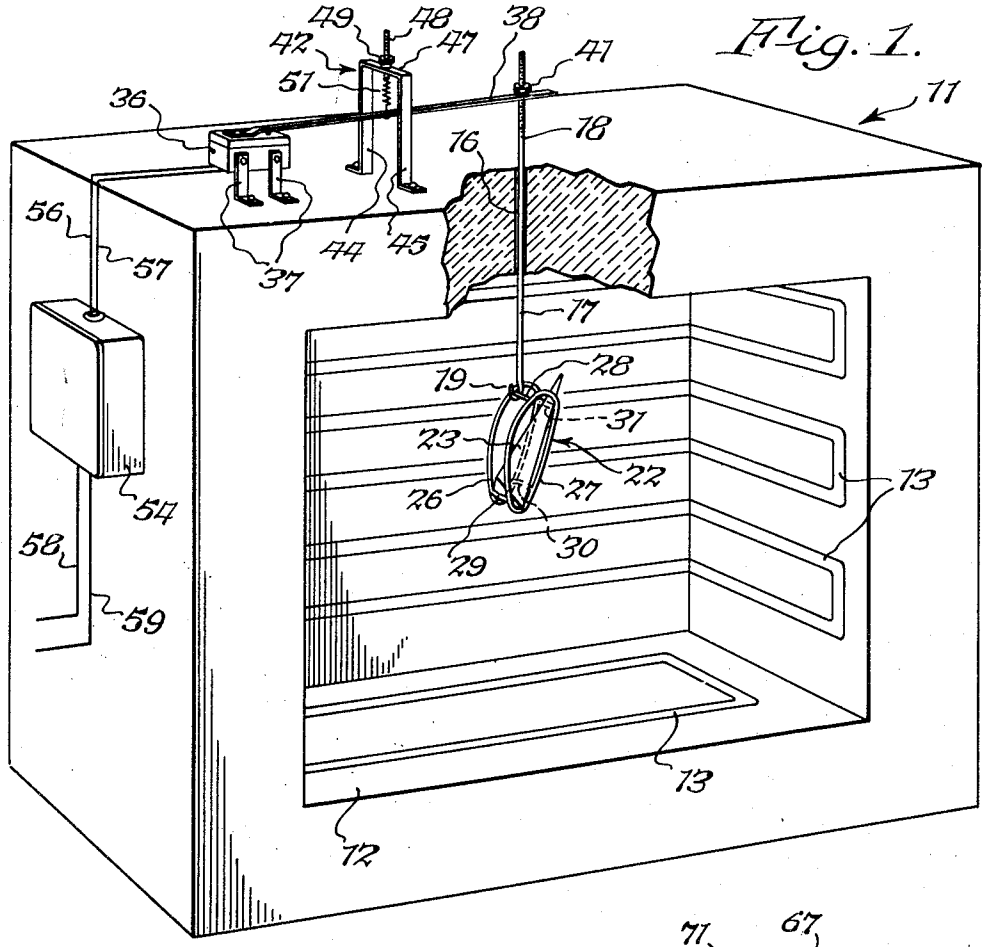
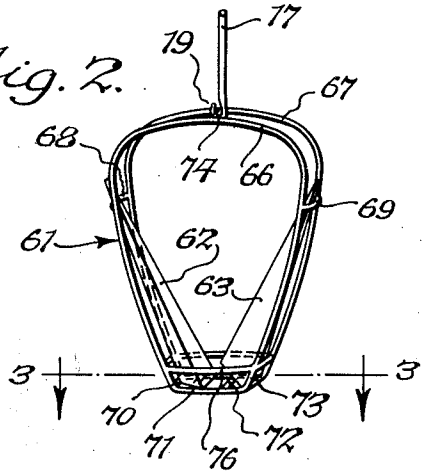


Fig. 2.



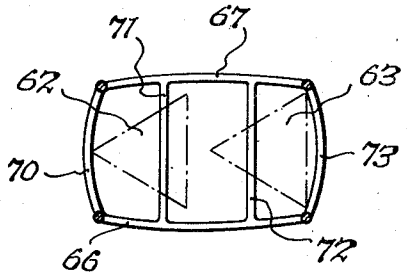


Fig. 3.

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APPARATUS RESPONSIVE TO TEMPERATURE CONDITIONS

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9 Claims. (Cl. 200—142)

This invention relates to apparatus which is responsive to temperature conditions. It is particularly concerned with apparatus adapted to be used with a kiln or furnace to indicate the temperature conditions therein or to modify such conditions.

It is an object of the invention to provide an inexpensive apparatus for indicating the temperature conditions within a kiln or furnace.

Another object of the invention is to provide apparatus of the character described which is simple and of inexpensive construction.

A further object of the invention is to provide apparatus of the character described which is adapted for use in furnaces or kilns of different types.

Another object of the present invention is to provide apparatus of the character described which may be adapted either for calling attention to temperature conditions within a kiln or furnace or for modifying such temperature conditions.

Another object of the invention is to provide apparatus of the character described which is dependable in operation and utilizes readily obtainable and inexpensive replaceable elements.

Other objects and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a perspective view of a kiln embodying apparatus according to the present invention;

Figure 2 is an enlarged perspective view of a modified form of cradle or cage for the replaceable heat-responsive elements; and

Figure 3 is a transverse sectional view taken on the line 3—3 of Figure 2.

In the manufacture of ceramic products the firing of the products is one of the most expensive and difficult steps. Proper firing is not merely a matter of raising the temperature of a kiln in which the products have been placed. Rather, it is necessary to maintain definite time-temperature relationships throughout the firing period and also to take into account the chemical composition of the ceramic bodies in the kiln and the shapes, thicknesses and masses of those bodies. The maturing temperature of a ceramic body, i. e. the temperature at which the body has the desired density and degree of vitrification, varies with the rate of heating. Consequently, a device which measures only the kiln temperature will not necessarily show whether the ware in the kiln has been properly matured. If the proper temperature is not reached the ware in the kiln will be weak and porous. On the other hand, if the maturing temperature is exceeded the ware may be excessively dense and hard and may be warped.

Although temperature indicating devices such as recording pyrometers are used to a considerable extent in the firing of ceramic products, such apparatus is expensive and is not feasible for many users of kilns. As a means of determining whether proper firing conditions are being maintained in a kiln and when the maturing temperature of ceramic ware therein has been reached,

pyrometric cones have come into general use. These cones are slender trihedral pyramids formed from mixtures of ceramic materials. Since such cones have compositions similar to those of ceramic ware, their reactions in kilns at elevated temperatures may be correlated to that of the ware in the kilns with considerable accuracy.

Pyrometric cones are obtainable which soften and progressively deform by bending under advancing heat at fairly regular temperature intervals over a long temperature range. In use, such cones are placed on refractory bases or supports at one or more points within a kiln where they may be observed through a peephole provided in the kiln door or wall. Normally, a series of cones is used in each of the locations chosen. Each such series usually contains one or more cones which soften and bend over at a temperature below the maturing temperature of the ware in the kiln, a cone which softens and bends when the maturing point is reached, and one or more cones which soften at higher temperatures and will not bend unless the kiln is overfired. By observation of such a series of cones it may then be ascertained (1) when the maturing point of the ware is approaching, (2) when firing should be discontinued, and (3) to what extent, if any, overfiring has occurred.

It will be realized that to keep watch on pyrometric cones through a peephole requires a considerable amount of attention and expenditure of time. By the present invention pyrometric cones may be used to indicate temperature conditions within a kiln in such a way that it is unnecessary to continually or periodically observe the cones since the deformation of a cone or cones will result in the sounding of an alarm or the taking of other desired and predetermined action. An embodiment of apparatus for using a pyrometric cone in this way is shown in the accompanying drawings and described hereinafter in connection with an electrically heated kiln.

As shown in Figure 1, the kiln **11**, which is formed of refractory material of any suitable type, has had its front removed to better show the heating chamber **12** therein. Arranged around the interior of the heating chamber are electrical heating elements, designated by the reference numeral **13**, which may be of any desired and suitable type. Such elements are connected to a suitable source of electric power, preferably through means (not shown) by which the power supplied to the kiln may be regulated.

As made clear in Figure 1, a small hole or orifice **16** is provided through the top wall of the kiln **11**. Extending through the hole **16** and freely movable therein is a supporting rod **17**. The rod **17** is provided with a threaded portion **18** on the upper end thereof and has its lower end formed as a hook **19**. Supported by the hook **19** is a cage or cradle, generally designated by the reference numeral **22**, within which a pyrometric cone **23** is held in an upright, but inclined position. The cage **22**, which preferably is formed of heat-resistant wire such, for example, as wire made of nickel or nickel-chromium-iron alloys like "Inconel" comprises a pair of generally oval, side-frame members **26** and **27** that are joined and held in spaced, parallel relation by a plurality of ribs or cross bars **28**, **29**, **30** and **31**. When the cradle **22** is suspended from the hook **19** by the top rib **28**, the lower ribs **29** and **30** are so disposed with respect to the intermediate rib **31** that the pyrometric cone **23** when resting with its base on the lower ribs is supported adjacent its tip by the intermediate rib **31**.

A switch **36** is mounted on the top of the kiln **11** by suitable means, such as mounting brackets **37**, and is provided with an elongated, operating arm or lever **38**. The latter extends substantially horizontally and parallel with the top of the kilns. Adjacent its outer end the lever **38** is provided with a hole through which the threaded end portion **18** of the vertical rod **17** projects,

the rod being held within said hole by a threaded nut 41. Secured to the top 13 of the kiln 11 intermediate the switch 36 and the rod 17 is a yoke or inverted U-shaped bracket 42. The loke 42 projects upwardly from the kiln and comprises vertical legs 44 and 45 which are joined at their upper ends by a horizontal portion 47. A hole is provided in the latter in which there is slidably arranged a vertical stud 48 having a nut 49 threaded thereon.

A coil spring 51 is attached to the lower end of the stud 48 and to the adjacent portion of the switch operating arm 38. The tension of the spring may be adjusted by turning the nut 49 to thereby raise or lower the stud 48 in the horizontal portion 47 of the yoke. Attached to the switch 36 and extending to a junction box 54 are a pair of leads 56 and 57. Other desired or necessary electrical connections such as the wires 58 and 59 may also be led to the junction box 54 to permit establishing the desired electrical circuits.

The operation of apparatus according to the present invention depends upon the characteristic softening and deformation of pyrometric cones in response to the achievement of certain temperature conditions within a kiln. With apparatus as shown in Figure 1, the kiln is closed and firing is started. When predetermined temperature conditions have been obtained in the kiln the pyrometric cone 23 will soften and deform sufficiently to drop out of the cradle or cage 22 solely by its own weight. The weight suspended on the outer end of the arm 38 by the rod 17 will thereby be diminished and the spring 51 will move the arm 38 upwardly thereby to actuate the switch 36. It will be understood that actuation of the switch 36 may produce any one or several of a number of predetermined results depending upon the electrical circuits provided and the type and arrangement of the switch. Thus, for example, movement of the lever 38 to actuate the switch 36 may produce, directly or by use of suitable relays, either the giving of a signal, either visual, audible, or both, or the cutting off or reduction of power supplied to the kiln, or, if desired, any combination of such actions.

As pointed out above, the usual practice in operation of a kiln is to employ a series of pyrometric cones for determining the point at which firing should be discontinued. When using the apparatus illustrated in Figure 1, the pyrometric cone 23 used may be so chosen that the proper time for shutting off the kiln 11 is indicated by the softening of the cone and its dropping out of the cradle 22. In such case the switch 36 may be so connected to a suitable circuit that the power supply to the kiln is interrupted when the switch is actuated by the spring 51. If desired, however, actuation of the switch 36 may cause an audible or visible signal to be given. An attendant or operator, whose attention is attracted by such signal, may then shut off the kiln manually. Alternatively, if desired, the cone 23 may be so chosen that it softens and deforms before the maturing temperature is reached. In that case when the cone drops from the cage or cradle 22 the resultant operation of the switch 36 may give a suitable signal indicating that the time for shutting off the kiln is approaching. An operator may then observe a series of pyrometric cones within the kiln through the peep hole provided and determine therefrom when firing should be discontinued.

In Figures 2 and 3 there is illustrated a modified cage or cradle 61 which is adapted to hold two pyrometric cones. Like the cradle 22, the cradle 61 is formed of heat resistant wire and comprises a pair of side frame members 66 and 67 which are maintained in spaced, parallel position by a plurality of cross-bars or ribs 68, 69, 70, 71, 72, 73 and 74. The last-mentioned rib is engaged by the hook 19 of the vertical rod 17 to support the cage within a kiln 11. The cones 62 and 63 are placed within the cradle 61 so that their bases rest against the lower cross-bars 70, 71 and 72, 73, respectively, while the cones are supported adjacent their tips by the intermediate ribs 68 and 69, respectively. Adjacent the lower portion of the cage 61 there is also provided a peripheral rail 76 that prevents the cones from falling out of the cage before they are deformed by heat.

It will be evident that in some cases the use of the modified form of cage 61 with a pair of pyrometric cones permits even more convenient and efficient operation of a kiln than is possible with the single cone arrangement illustrated in Figure 1. Thus, for example, one of the cones placed in the cage 61, such as the cone 62, may deform and consequently drop from the cage at a temperature somewhat below the maturing temperature, while the other cone, 63, may be so chosen as to deform and drop when the maturing temperature is reached. Raising of the arm or lever 38 and actuation of the switch 36 under the influence of the spring 51 when the cone 62 drops from the cradle may cause the sounding of an alarm, as by a bell or light, indicating this fact to the attendant or operator. Thereupon, if desired, spring tension may be readjusted by rotating the nut 49 on the stud 48 so that the switch 36 may again be actuated to shut off the current to the kiln and prevent overfiring of the ware therein when the second cone, 63, deforms at the maturing temperature.

In the foregoing description it will be apparent that the apparatus of the present invention may be conveniently and effectively used in the firing of ceramic products to prevent overfiring thereof and to avoid the need for constant attention to a kiln during firing. The apparatus which is simple and easily assembled on or removed from a kiln utilizes to maximum advantage pyrometric cones which are commercially manufactured and easily available. Moreover, the only parts which will require frequent replacement are the pyrometric cones employed and these are quite inexpensive. In use, in the apparatus, a cone is supported only at its base and adjacent its tip and has no load or pressure applied thereto. Consequently, there is no interference with the normal functioning of the cone and it will deform in response to heating in substantially the same way as it would if placed on a refractory plaque. It will be understood that while a single temperature condition indicator according to the invention will be sufficient for small kilns, in larger kilns a plurality of such indicators placed at different locations in the kiln may be desired. In such case certain of the indicators may be so arranged as to warn of uneven temperature conditions while one or more others may be arranged to shut off the kiln when the maturing temperature is attained.

It will also be understood that many modifications and variations in the structure described and in the use of the apparatus may be made without departing from the spirit of the invention. For example, the shape or construction of the cages 22 and 61 may be varied as desired or convenient and the latter, if desired may be enlarged to hold more than two cones. Further, for example, the coil spring 51 may be replaced by a tension spring of another type or by an adjustable compression spring supporting the arm or lever 38. As previously pointed out, actuation of the switch 36 by change of weight depending from the arm 38 may be caused to establish electrical circuits for performing any desired function. Consequently, the switch may be either normally closed or normally open, as desired, and any suitable electrical circuits may be attached or connected thereto. In this connection, it may be noted that temperature responsive apparatus of the type herein described is not limited to use with electrically heated furnaces but may be used to advantage with furnaces heated in other ways. In view of the foregoing, it is desired that the invention shall not be considered as limited to the structure of the apparatus herein described and shown but that it shall be interpreted as broadly as permitted by the terms of the appended claims.

I claim:

1. Apparatus for indicating temperature conditions within a kiln comprising a movable cradle within said kiln, means outside of said kiln responsive to movement of said cradle, and ceramic means carried by said cradle and adapted to fall therefrom solely by its own weight in response to predetermined temperature conditions within said kiln.

2. Apparatus for indicating temperature conditions within a kiln comprising a movable cradle within said kiln, means outside said kiln resiliently supporting said cradle, ceramic means carried by said cradle and adapted to fall therefrom solely by its own weight in response to predetermined temperature conditions within said kiln, and means operatively connected to said supporting means responsive to movement of said cradle.

3. Apparatus for indicating temperature conditions within a kiln comprising a movable cradle within said kiln, means outside said kiln supporting said cradle, ceramic means carried by said cradle and adapted to fall therefrom solely by its own weight in response to predetermined temperature conditions within said kiln, means connected to said supporting means resiliently opposing the weight of said cradle, and means operatively connected to said supporting means responsive to changes in weight of said cradle.

4. Apparatus as set forth in claim 3 in which said resilient means is adjustable.

5. Apparatus for indicating temperature conditions within a kiln comprising a movable cradle within said kiln, means outside said kiln resiliently supporting said cradle, and control means connected to said supporting means and operable thereby, said cradle being adapted to hold a pyrometric cone in such manner that under predetermined temperature conditions within said kiln said cone will deform and fall from said cradle solely by its own weight, thereby causing movement of said supporting means and operation of said control means.

6. Apparatus as set forth in claim 5 in which said control means is a switch.

7. Apparatus for indicating temperature conditions within a kiln comprising a movable cradle within said kiln, a pyrometric cone resting within said cradle and adapted under predetermined temperature conditions to deform and fall from said cradle solely by its own weight, an arm outside of said kiln, said cradle being suspended from said arm, means connected to said arm and resiliently opposing the weight of said cradle, and control means operable by movement of said arm in response to change of weight of said cradle.

8. Apparatus as set forth in claim 7 in which said cone is supported solely at its base and adjacent the tip thereof.

9. Apparatus as set forth in claim 8 in which said control means is a switch.

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