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[33] **Germany**
[31] **1,608,325**

[54] **METHOD AND APPARATUS FOR HEAT-TREATING OF WORKPIECES**
7 Claims, 3 Drawing Figs.

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[50] **Field of Search** .... 263/6, 6B, 43, (Recirculation Digest)

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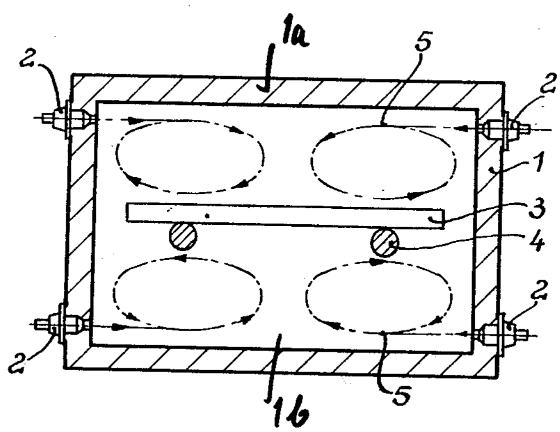
ABSTRACT: Workpieces are heat treated in an industrial furnace having a horizontally elongated heat-treating chamber. The workpieces to be treated are advanced through the chamber in a path intermediate the top and bottom walls bounding the same. Streams of substantially fully combusted combustion gases are introduced into the chamber from the lateral walls at speeds in excess of 50 m./sec. and with such orientation that they form above and below the workpiece two pairs of laterally adjacent gas spirals each of which rotates about its axis which extends in the direction of elongation of the treating chamber, the direction of rotation being always towards the associated other gas spiral of the pair.



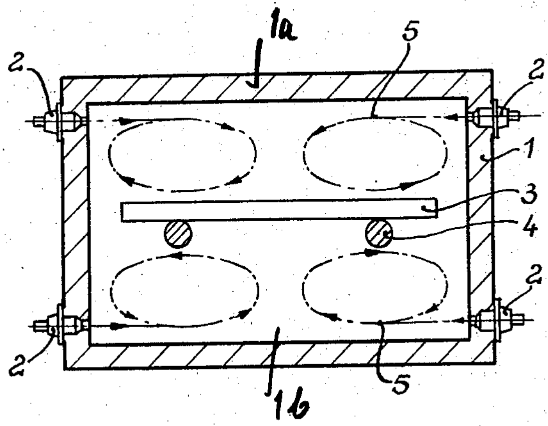


Fig.1

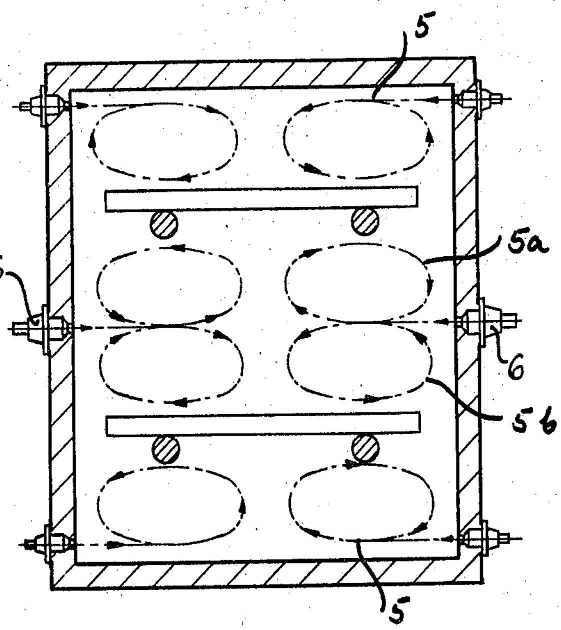


Fig.2

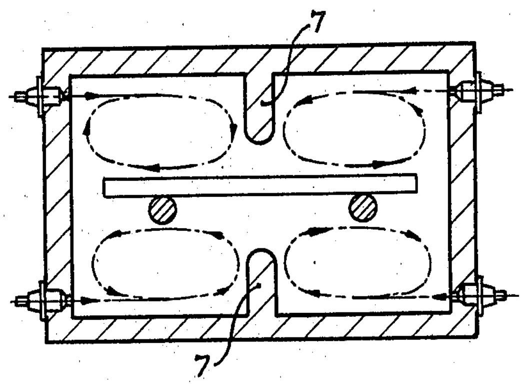


Fig.3

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METHOD AND APPARATUS FOR HEAT-TREATING OF WORKPIECES

BACKGROUND OF THE INVENTION

The present invention relates generally to the heat-treating of workpieces, and more particularly to a method of heat-treating workpieces in an industrial furnace. The method of the invention also relates to an apparatus for carrying out the method.

In the heat-treating of workpieces in continuously operating industrial furnaces, the workpieces generally require a very well defined specific volume of space within the heat-treating chamber. This is different from batch-type furnaces because there workpieces of different sizes and different quantities of workpieces are usually present in different batches, whereas in continuously operating furnaces, workpieces of a given series have identical dimensions and the quantity of workpieces in the heat-treating chamber at any given time is usually unvarying. Accordingly, in continuous furnaces of this type the available volume within the heat-treating chamber, that is the volume in which the hot gases may move, remains substantially unchanged at all times.

This is important because in the type of heat-treating furnace under discussion there is a relatively large volume of space above and, in some instances, also below the workpieces which are advanced through the treating chamber. The reason for this is to allow for high heat exchange values resulting from radiation of the combustion gases which are introduced into the heat-treating chamber. The manner in which heating of these volumes of space is effected may vary according to what is known in the art. It is known to arrange burners in the top wall bounding the heat-treating chamber as well as to arrange them in the lateral walls. A further known expedient is to provide so-called burner bridges which extend transversely of the direction of movement of the workpieces above or below, and operative for ejecting combustion gases substantially in the direction of movement of the workpieces. Both types of solutions suffer from some disadvantages. The so-called lateral burners which are arranged in the sidewalls bounding the chamber fail to provide for uniform heating of the workpieces across the width of the chamber, that is transversely of the direction of movement of the workpieces. The reason for this is that the conventional burners have relatively low issue speeds, that is speed at which combustion gases issue from the burner and enter into the heat-treating chamber, so that the rate of admixture of the combusted gases with the ambient atmosphere prevailing in the treating chamber is slow with the result that heat radiation onto the workpiece is uneven. A further disadvantage is the fact that combustion in large measure takes place only after the combustion gases have entered into the heat-treating chamber; this results in the development of flame jets which further intensify the unevenness of heating of the workpieces. In fact, these problems have been so pronounced that in the past two decades there has been a decided movement away from the use of lateral burner arrangements.

Ceiling burners, on the other hand, require special mounting arrangements and are usable only in the ceiling, that is the upper wall bounding the heat-treating chamber. Furthermore, the use of this type of burner necessitates the provision of a large number of relatively small burners which evidently increases the expenses involved quite drastically.

The other possibility, that is the arrangement of burners in form of bridges or banks, makes possible an even heating of the workpieces across the width of the chamber. However, the higher the capacity of the furnace is to be, the higher must be the number of such bridges or burner banks, as they will be called hereafter. This presents a problem because these banks require rather significant amounts of space to assure access and the possibility of removing and installing burners and auxiliary equipment. This, on the other hand, drastically decreases the volume of space between the respective burner bank and the facing surface of the workpiece advancing past the burner. Inasmuch as the intensity of heat radiation onto the surface of the workpiece is always dependent upon the thickness of the layer of combustion gas in the volume of space adjacent the respective surface, it will be clear that this decrease in space between the respective burner banks and the facing surfaces of the work pieces in disadvantageous because it necessitates a decrease in the layer of combustion gases which can be located in this space. This is contradictory to the deliberate attempt to provide in such heat-treating furnaces spaces above and/or below the workpieces to be heat treated which are as large as possible to accommodate the maximum thickness layer of combustion gases. A further disadvantage of the use of burner banks is the fact that the abrupt changes in the cross section of the free space above and/or below the advancing workpiece, which result from the presence of the burner banks, may result in sudden acceleration of the combustion gases sweeping through the interior of the chamber, and the impingement of the thus accelerated combustion gases upon the walls bounding the chamber, particularly wall projections which are necessitated in the region of the burner banks, may result in damage to the walls.

SUMMARY OF THE INVENTION

It is, accordingly, an object of the present invention to overcome the aforementioned disadvantages.

A more particular object of the present invention is to provide a method of heat-treating workpieces in continuously operating industrial furnaces.

A further object of the invention is to provide such a method which will result in more even and quicker treating of the workpieces.

Yet a further object of the invention is to provide an apparatus for carrying out the method.

In accordance with the above objects, and others which will become apparent hereafter, one feature of our invention resides in the provision of a method of heat-treating workpieces in an industrial furnace provided with a horizontally elongated treating chamber having an upper and a lower wall. According to our method a workpiece to be treated is advanced through the chamber in a path intermediate the walls, and streams of substantially fully combusted combustion gases are introduced into the chamber at speeds in excess of 50 m./sec. Furthermore, the streams of combustion gases are so oriented as to form intermediate the workpiece and at least one of the top and bottom walls a pair of laterally adjacent gas spirals each of which has an axis coincident with the direction of elongation of the treating chamber and a rotary component of movement about its respective axis in direction towards the associated gas spiral.

By resorting to our novel method and utilizing high-speed burners having ejection nozzles of relatively small cross section but ejecting the combustion gases at high speeds, the ejected streams of combustion gases are admixed with the ambient atmosphere prevailing in the heat-treating chamber much more rapidly than has been possible heretofore. This evidently provides for temperature equalization in the direction of the heating chamber transversely of the advancement of the workpieces, thus eliminating the disadvantages of heretofore-known lateral burner constructions. By furthermore assuring that the combustion gases entering the treating chamber from the burners are at least substantially fully combusted before they so enter, the disadvantageous effects of flame jets are either eliminated or significantly reduced.

It is, however, the main concept of the invention to so orient the incoming streams of combustion gases that the combustion gases are forced into a spiral movement about an axis or axes coincident with the direction of advancement of the workpieces, that is the direction of elongation of the heat-treating chamber. In other words, the kinetic energy of the streams of combustion gases is not allowed to become dissipated, but rather is retained to a significant extent with the result that the constant spiral movement of the streams of combustion gases effects constant circulation and turnover of the entire ambient atmosphere and eliminates the accumulation of stagnant gas in so-called dead corners, a phenomenon which evidently results in inadequate heat radiation from such areas and therefore inadequate heat-treating of workpiece portions which are exposed to gases in such areas.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatic vertical transverse section illustrating a furnace for carrying out our invention, according to one embodiment;

FIG. 2 is a view similar to FIG. 1 but illustrating a further embodiment of the invention; and

FIG. 3 is a view similar to FIG. 1 but illustrating yet an additional embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Discussing firstly FIG. 1 it will be seen that reference numeral 1 identifies the lateral walls, and reference numeral 1*a* identifies the top and bottom walls which together bound the heat-treating chamber 1*b* of a continuously operating industrial furnace. It is not believed necessary to discuss further details concerning the general construction of such a furnace because this is conventional and forms no part of the invention.

In the illustrated embodiment guide means 4 are provided located substantially midway between the top and bottom walls 1*a* and extending in what is the direction of elongation of the heat-treating chamber, that is intermediate the (nonillustrated) inlet and outlet thereof. In conventional manner the guide means 4 may be constructed as water-cooled tubular guides. The workpiece or workpieces 3 are advanced resting on the guide means 4. Thus, in the illustrated embodiment of FIG. 1 there is a space between the upper side of the workpiece 3 and the top wall 1*a* and a further space between the lower side of the workpiece 3 and the bottom wall 1*a*.

As shown in FIG. 1, the sidewalls 1 are provided with lateral burners 2 which are so arranged as to reject streams of combustion gases into the interior of the heat-treating chamber 1*b* in the direction of the respectively indicated arrows. The burners 2 are of the high-speed type which ejects the combustion gases, when in full operation, with an outlet speed of more than 50 m./sec.; the burners 2 are further so constructed that the combustion gases are at least substantially fully combusted before they enter into the heat-treating chamber 1*b*. Burners such as the ones identified with reference numeral 2 in FIG. 1 are well known to those skilled in the art and are therefore not described in detail. Their construction does not, in itself, constitute a part of the present invention.

As evident from FIG. 1, the burners 2 are arranged in pairs with the burners of each pair being transversely aligned in the opposite lateral walls 1, and with the combustion gases issuing from the respective burners having such an orientation that they form spirals or coils 5 of which in the illustrated embodiment of one pair is located in the space above and one pair is located in the space below the workpiece 3. We wish it to be understood, however, that the construction of the furnace may be such that only a space exists above the workpiece, or that a space exists only below the workpiece. In this case there would then of course be only one pair of the spirals 5. In any case, the spirals are shown to have longitudinal axes which extend in the direction of elongation of the chamber 1*b*, that is in the direction of advancement of the workpiece 3. As indicated by the arrows associated with the respective spirals 5, the combustion gases rotate in such a manner that the gases in each spiral rotate towards the other spiral of the pair, that is after the combustion gases issue from the respective burners they rotate towards the middle of the chamber and then reverse direction to rotate back towards the sidewall 1 from which they have just issued. Of course, there is a component not only of rotary movement, as illustrated by the arrows, but also a component of longitudinal movement which is not shown but which is largest where the component of rotary movement is smallest, that is at the core or center of the spirals 5 and in the space below the workpiece 3 in the area between the guide members 4.

The embodiment of FIG. 2, which is basically similar to that of FIG. 1 and wherein like elements are identified with like reference numerals, we have shown a construction wherein workpieces may be advanced through the heat-treating chamber on two or more vertically spaced and superimposed levels. The manner in which this is accomplished is the same as in FIG. 1, that is the workpieces 3 advance on guide members 4. Of course, as in the case of FIG. 1 it is immaterial what means are utilized for advancing the workpieces 3 because such means are entirely conventional and form no part of the invention.

As evident in FIG. 2, there is a space between the upper and lower guide means, that is between the upper and lower workpieces, because the guide means are vertically spaced from one another. In such a construction the heat requirements, the space requirements and the economic expenditures for construction of the furnace are reduced over what would be necessary for constructing a requisite number of separate furnaces capable of the same output.

In accordance with the embodiment illustrated in FIG. 2 we provide additional high-speed burners 6 associated with the respective lateral walls 1 and transversely aligned, as before. They are arranged approximately midway between the upper and lower limits of the space existing between the upper and lower workpieces and, when in operation, produce two further superimposed pairs of combustion gas spirals, of which the spirals of the upper pair are identified with reference numeral 5*a* and those of the lower pair with reference numeral 5*b*. It should be noted, however, that their rotational component is reversed with respect to the rotational component of the spirals 5. The advantages of this construction are the same as discussed above with respect to FIG. 1 except that in the embodiment of FIG. 2, two workpieces, or two layers of workpieces, may be treated simultaneously. Of course, it is possible to further expand the construction of FIG. 2 by providing additional layers of workpieces and additional ones of the burners 6.

The type of furnace with which our present invention is utilized may differ. Thus, it is possible to use pusher-type furnaces, walking-beam-type furnaces, roller-hearth-type furnaces or rotary-hearth furnaces. The arrangement of the burners 2—as opposed to the burners 6 of FIG. 2—is advantageously such that they eject their streams of combustion gas into the upper third of the volume of space above the workpieces and into the lower third of the volume of space below the workpieces, as illustrated in FIG. 1.

Coming, finally, to the embodiment illustrated in FIG. 3, it will be seen that this is largely the same as the one of FIG. 1 from which it differs only in the provision of partition walls 7 which extend from the respective top and bottom walls 1*a* into the chamber 1*b* towards but short of the guide means 4 so as to subdivide the upper space above the workpieces 3 and the lower space below the workpieces 3 in the manner illustrated in FIG. 3. The purpose of these partition walls 7, which extend in the direction of elongation of the heat-treating chamber 1*b* and therefore in the direction of movement of the workpieces 3, is to enhance, particularly in furnaces having relatively small distance between the lateral walls 1 thereof, the direction reversal of the incoming streams of combustion gases to thereby facilitate their guidance in a sense forming the gas spirals 5.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in the heat treatment of workpieces. It is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention. The gas streams issuing from the burners (in FIGS. 1 and 2) are caused to be deflected so as to form the rotating spirals by the fact that the burners are located opposite each other in pairs, with the oppositely directed gas streams mutually deflecting one another.

We claim:

1. A method of heat-treating workpieces in an industrial furnace provided with a horizontally elongated treating chamber having an upper and a lower wall, comprising the steps of advancing a workpiece to be treated through said chamber in a path intermediate said walls; and introducing streams of substantially fully combusted combustion gases into said chamber at spaced locations at speeds in excess of 50 m./sec. and with orientation that said gas streams impinge upon one another and form intermediate said workpiece and at least one of said top and bottom walls a pair of laterally adjacent gas spirals each of which has an axis coincident with the direction of elongation of said treating chamber and a rotary component of movement about its respective axis in direction towards the associated gas spiral.

2. A method as defined in claim 1; further comprising the step of introducing further streams of said combustion gases into said chamber at said speeds and with such orientation as to form intermediate said workpiece and the other of said top and bottom walls a further pair of laterally adjacent gas spirals similar to the first-mentioned pair.

3. A method as defined in claim 2; further comprising the step of advancing an additional workpiece through said chamber in an additional path vertically spaced from the first-mentioned path; and introducing into said chamber additional streams of said gases at speeds in excess of 50 m./sec. and with such orientation as to form in the space between said paths two additional superposed pairs of laterally adjacent gas spirals similar to the first-mentioned pairs of gas spirals.

4. An industrial furnace for heat-treating workpieces, comprising wall means defining a horizontally elongated treating chamber having transversely spaced sidewalls and vertically spaced top and bottom walls; guide means extending longitudinally of said chamber in a plane intermediate said top and bottom walls for guiding a workpiece for advancement through said chamber; and burner means including pairs of burners provided in said sidewalls transversely aligned for ejecting streams of substantially fully combusted combustion gases into said chamber at speeds in excess of 50 m./sec. transversely of the direction of advancement of said workpiece and into the space between said workpiece and at least one of said top and bottom walls with such orientation that said gas streams impinge upon one another in a sense causing their conversion into respective rotating gas spirals, whereby to obtain between said workpiece and said one wall a pair of laterally adjacent gas spirals each of which has an axis coincident with the direction of elongation of said chamber and a rotary component of movement about its respective axis in direction towards the associated gas spiral.

5. A furnace as defined in claim 4, said burner means comprising further pairs of burners provided in said sidewalls transversely aligned and operative for ejecting further streams of said combustion gases at said speeds into a further space between said workpiece and the other of said top and bottom walls whereby to provide in said further space a further pair of laterally adjacent gas spirals similar to the first-mentioned pair.

6. A furnace as defined in claim 5, said guide means comprising first and second guide instrumentalities for guiding the first-mentioned workpiece and an additional workpiece in two vertically superposed spaced planes; and said burner means including additional pairs of burners provided in said sidewalls transversely aligned and operative for ejecting into the space between said workpieces two additional superposed pairs of laterally adjacent gas spirals similar to the first-mentioned pairs of gas spirals.

7. A furnace as defined in claim 5; and further comprising divider means provided on said top and bottom wall, respectively, projecting into said chamber and extending longitudinally of said chamber intermediate the respective gas spirals of each pair of gas spirals.