United States Patent

[11] **3,570,391**

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[21] Appl. No. **772,889**
[22] Filed **Sept. 16, 1968**
[23] **Division of Ser. No. 649,323, June 27, 1967, Pat. No. 3,490,717**
[45] Patented **Mar. 16, 1971**

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[32] Priority **June 28, 1966, Apr. 14, 1967**
[33] **Sweden**
[31] **8798/66 and 5233/67**

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[54] **ELECTRONIC OR MICROWAVE FURNACE OR OVEN**
10 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **99/326,** 99/337, 99/352, 99/443
[51] **Int. Cl.** **A47j 37/04**
[50] **Field of Search** ..... 99/(GP170) (Inquired), 234 (T), 326, 331, 334, 352, 443; 107/57.3; 219/10.55; 126/(Inquired), 99/337

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ABSTRACT: An oven for heating packages (hermetically sealed food units) in which the packages are positioned in heat-absorbing relation to heating means. The packages are adapted to expand in response to excessive heat absorption. Sensing means are positioned to sense expansion of the package beyond a predetermined level. The sensing means activate cooling means which cool the package and counteract the effects of excessive heat absorption by the package.

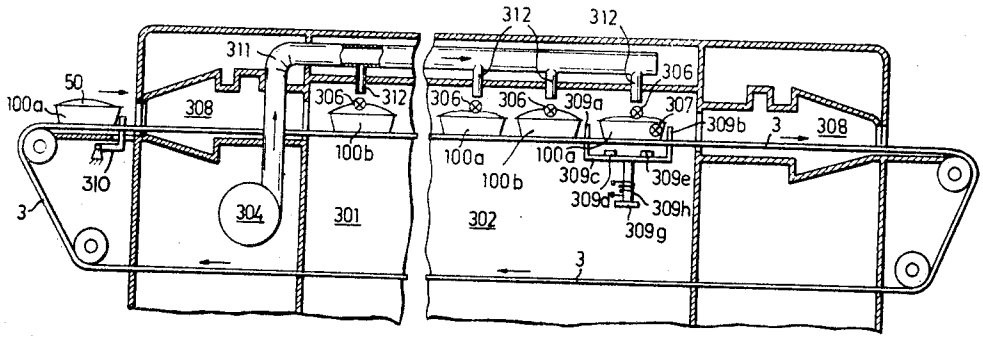


FIG. 1

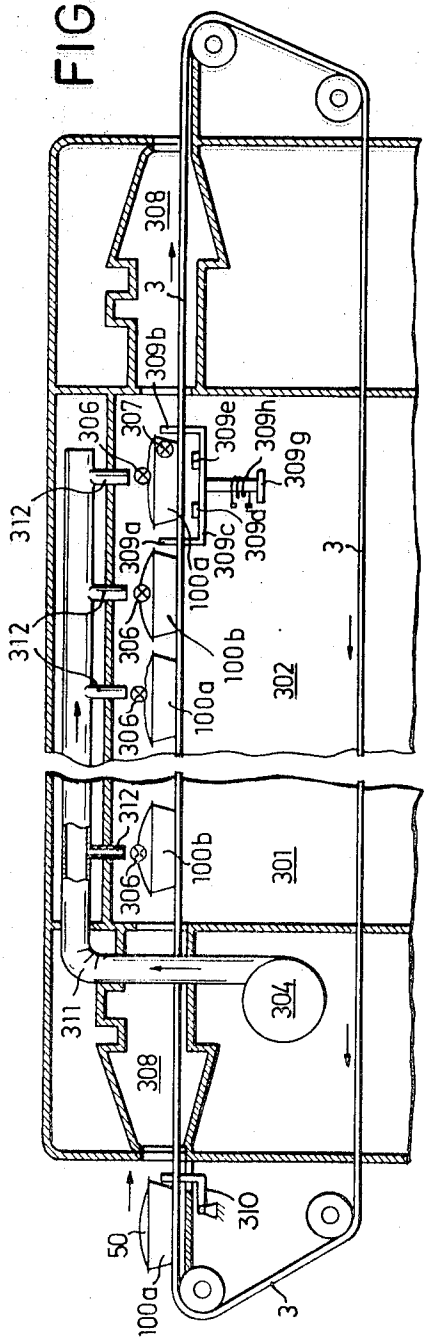
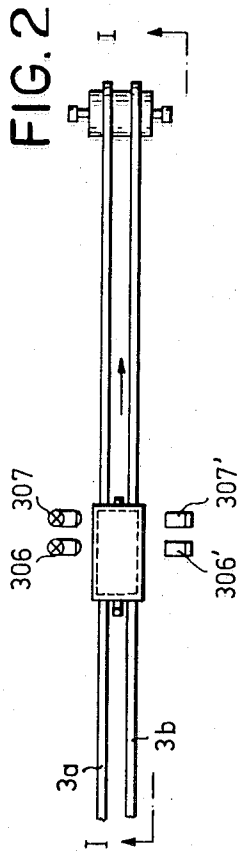


FIG. 2



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ELECTRONIC OR MICROWAVE FURNACE OR OVEN

This application is a division of copending application Ser. No. 649,323, filed Jun. 27, 1967, now Pat. No. 3,490,717 which was issued Jan. 20, 1970.

The invention is related to a so-called electronic or microwave furnace or oven for dielectric heating of food and is particularly suitable for furnaces being made in the form of a transit furnace for straight passage of packages, etc., through the furnace (that is, without reversal of movement) of the objects to be heated. For reasons which will be obvious from the following description, hermetically sealed standard food packages of predetermined dimensions are highly preferred. As a result of the heating procedure, steam and gases may develop within the package causing interior pressure to build up, which may result in an increase to some extent of the volume of the package by its walls bulging out. If the seal of the package is not reliably sealed, this bulging effect will not take place. If part of the package walls is made of a material of considerably higher yielding strength than the remainder of the package, the bulging effect mentioned above will be more pronounced, so that a more accurate indication of the degree of volumetric increase of the interior of the package may be obtained. The expression used below "yielding wall portion" is, however, not limited to the last-mentioned case, but may also refer to packages having walls of uniform material and of uniform thickness.

THE FURNACE (FIGS. 1 AND 2)

In a system according to the invention, various different furnace types may be used. A so-called high frequency or microwave furnace for dielectric heating of food is preferred and, hence, the below description is substantially, though not exclusively, concerned with such a type of furnace being made in the form of a transit furnace for straight passage through the furnace, i.e. without reversal of movement, of the objects to be heated. For reasons which will be obvious from the following description hermetically sealed standard food packages of predetermined dimensions are highly preferred. As a result of the heating procedure, steam and gases may develop within the package causing interior pressure to build up, which may result in an increase to some extent of the volume of the package by its wrapping bulging out. If the seal of the package is not completely tight, this bulging effect will not take place. If part of the package wrapping is made of material of considerably higher yielding property than the rest of the wrapping, the bulging effect mentioned will be still more pronounced serving as a more accurate indication of the degree of volumetric increase. The expression used below, "yielding wall portion" is, however, not limited to the last mentioned case, but may also refer to packages wrapped in a uniform material and of uniform wall thickness.

When food is subjected to heating in a dielectric high frequency furnace, or to a relatively quick heating in other types of furnaces, the result of the heat application to the food may be quite an uneven distribution of said heat. By way of example, when heating frozen food, it often happens that some ice is still left in the package, while the balance already has melted and the corresponding water been evaporated, so that steam pressure is created within the package. This involves the risk of the package getting untight or that it even may burst and, moreover, makes an objective measurement of the temperature of the food practically impossible, in any case as long as the package must remain tightly sealed. In many cases it is utterly important that the package remains so tightly sealed that no gases can escape, for example in such instances where after the heating procedure the package is moved by means of a conveyor or conveyors, which must not become dirty, while on the other side impurities must not be able to penetrate into the package.

Up to the present date attempts carried out to control the heating of such food packages, so that a desired temperature will be reached on the basis of an objective temperature measurement, therefore have failed or proved unsatisfactory.

Similar difficulties have presented themselves, when attempts have been made to sort out untight packages by means of strictly objective methods.

These inconveniences can be eliminated by means of a furnace provided with a steam or gas guard, in the following simply denominated "gas guard," which is actuated in case the yielding wall portion of the package should bulge out due to the formation of a vapor or gas pressure inside the package when said package is in the heating zone within the furnace in a certain predetermined position relative to the gas guard.

A gas guard responds to a change of the shape of a package caused by a variation of the temperature of the contents of the package, is suitable for an objective control of said temperature under special conditions only and usually has to be combined with subjective measures such as visual inspection, measurement of a certain lapse of time based on an empirically determined average heating time or similar, or, when said method by reason exposed above is of little use or no use at all, by measuring the temperature without taking into consideration any control of said volumetric changes. Thus, the furnace should preferably be provided with means for combined supervision by a gas guard as well as by a temperature guard (temperature measuring device) of a type which does not require any object to be introduced into the food or even into the package. On the other hand the package wall itself may contain such an object consisting of a fusible medium or of surfaces the colors of which vary in dependence on temperature changes (detectable by photoelectric means) or other similar means.

It is to be understood that a volumetric change of a package can take place even if no vapor or gas is formed within the same, viz if air or another gas (usually carbon dioxide used as protective gas) should undergo a terminal expansion. Thus, the gas guard may be employed to supervise a volumetric change, conditioned by said reason, and in such a case the gas guard may often be employed as sole temperature controlling device. However, it should be remembered that such a volumetric change is of much smaller proportions than a change in volume caused by the generation of vapor or gas, especially if part of the wrapping of the package consists of a readily yielding foil or similar material, which immediately bulges out as a response to gas development even if the pressure within the package is very low. For a combined control by means of a gas guard and a temperature guard, the gas guard is suitably arranged to be actuated only upon development of gas within the package (thus not upon the thermal expansion mentioned) or at least is actuated in some other way, so that it responds by emitting another type of signal, when it is influenced by said formation of gas or vapor.

Under practical conditions the gas guard, on account of among other things the reasons exposed above, should occupy a certain predetermined sensing position relative to the position of the package. The package therefore should rather not comprise a bag of plastic foil filled with food or similar, excepting the case that the bag is placed in some kind of temporarily used or provisional container, for example in a compartment, box (paper box, cardboard box) or similar container dimensioned to correspond to the dimensional shape and size of the package, said container possibly forming part of a conveyor system or constituting a support for such bags.

As a rule it is most convenient to give the whole of the package a sufficiently rigid structure and determined shape that the wall portion controlled by means of the gas guard remains in at a predetermined level in relation to the gas guard and to the support upon which the package is resting as long as it is supervised by the gas guard.

The gas guard should control the heating procedure of the package, whereby the whole control can be made simpler, i.e. comprising a reduced number of individual controlling operations, if the package during its dwelling time in the heating zone is subjected to a jet of air of comparatively weak cooling effect, which brings about a condensation of steam or gas created within the package. Said exposure to a jet stream of

air may go on continuously, but it may also be switched on by the gas guard, when the latter one responds to a volumetric change of the package. By such cooling procedure one can also avoid the risk of the package getting untight, i.e. ruptures in the wrapping occurring as a result of the increased pressure within the package reaching too high proportions before the control of the temperature will have brought the same down to a sufficiently lower value. In this connection it may be mentioned that a temperature of food of 70°—8° C. is usually desired, i.e. a temperature, which is more elevated than that at which the food is consumed.

FIG. 1 is a view of a vertical longitudinal section of part of a multiple stage electric high frequency furnace designed as a transit furnace.

FIG. 2 shows a detail of said furnace seen from above, whereby line I–I corresponds to FIG. 1.

FIG. 1 shows diagrammatically a transit furnace, suitably constructed as an ultra-high frequency furnace for dielectric heating of food. The furnace comprises several heating zones, by way of example three zones, of which only the first one, indicated by **301**, and the last one, indicated by **302**, are shown. An endless continuous conveyor belt 3 moves through the furnace. In the present case this belt consists of two narrow separate belt halves *3a*, *3b*, see FIG. 2, but it may also be made in another way, particularly in the form of two or four round cords, yet driven by a common driving device. Conveyor belt 3 suitably consists of synthetic fiber material and in continuous movement it does not need to have a very low dielectric loss factor, because every discrete portion of the belt is fairly quickly passing through the heating zone of the furnace, thus not dwelling in the same a sufficiently long time for acquiring an unsuitably high temperature, and then being subjected to quite a good cooling down by its subsequent movement in unheated atmosphere, and consequently again enters the furnace at practically room temperature. Cooling down of the conveyor belt by any special refrigeration device therefore is deemed unnecessary, but may easily be arranged, as the furnace according to FIGS. 1 and 2 is equipped with a cool air fan **304** raking in fresh air from the outside by suction, by way of example passing across or along conveyor belt **3**. Belt **3** is provided for the transportation of food packages **100***a*, **100** *b*.

Food packages **100***a*, **100***b* described more in detail below are in the present case substantially shaped like rectangular bowls made of plastic material of fairly rigid quality, provided with an horizontal flange and on top of said flange sealed tightly by means of a flexible thin plastic foil **50**. If the package is in position for use with the plastic foil **50** being on top of the package, said plastic foil is substantially horizontal or may be inclined, unless package **100***a* is not subjected to such heat that the steam or gas is formed inside the same inflating plastic foil **50** so that it forms a clearly visible swelling or bulge as is the case with the packages indicated by **100***b*.

At least in the last heating zone of the furnace, but suitably in all such zones, gas guards are arranged for all packages, which in operation may dwell in the corresponding zone, possibly only for the first package or the first and the second package (in the direction of the transportation movement of the conveyor belt **3**) in the zone. These gas guards in this particular case comprise a photoelectric cell **306** with an associated light source **306'** and the optic equipment, if any, located in such a position that the light beam governing the photoelectric cell is interrupted or weakened if or when the foils **50** of the packages **100** are inflated to a larger or lesser extent, but the gas guards are not all, or not in any appreciable degree, influenced by package **100***a*. Towards the end of at least the least the line zone **302** there is in addition a package position guard, also in execution of a photoelectric cell **307** with light source **307'**. This position guard is influenced by anyone of the packages **100***a*, and **100***b*.

In FIG. 1 the cells **306** and **307** are indicated quite symbolically by an encircled cross, irrespective of whether these cells are concealed or not by packages **100***a*, and **100***b*.

At least at the entrance and at the exit of the furnace, possibly also between the heating zones, there are high frequency filters **308**, in the present case quite diagrammatically indicated, or similar means preventing any leakage worth mentioning of high frequency energy out of the heating zone in question.

At the end of the last heating zone **302** there is a temperature guard **309**, which in this particular example at the same time serves as a stop or abutment for the moving food packages. The temperature guard **309** comprises for example a movable fork with two legs **309***a*, **309***b* spaced from one another such that the spacing corresponds to a somewhat larger dimension than the largest (longitudinal) dimension of a food package, disregarding the flange of the package mentioned above. The two legs **309***a*, **309***b* are rigidly connected to each other by means of a crosspiece **309***c* which is provided with an element **309***g* forming an electromagnetic armature operating by means of a solenoid **309***h*. The top of crosspiece **309***d*, **309***e* are in the form of rapidly responding thermocouples or temperature dependent electric resistors, which can be threads, laminates or heat sensitive semiconductor devices, for example so-called infrared transistors. The two legs **309***a*, **309***b* are positioned (located) between the two sections *3a*, *3b* of the conveyor belt, see in particular FIG. **2**.

FIG. 1 shows the temperature guard with energized solenoid **309***h* with the exception that the temperature sensing elements **309***d* **309***e* in the shown position actually contact the bottom of the food package **100***a* positioned immediately above, but for the sale of clearness is shown as at some distance in the FIG. mentioned. In this closed circuit position the sensing elements **309***d* **309***e* contact the underside of the package, and leg **309***b* occupies its upper position in which it prevents package **100***a* from being carried away by the conveyor, the result being that the package is kept motionless for heating and temperature control, while the other leg **309***a* prevents any following package **100***b* from pushing and displacing, for example by turning action, said package **100***a* out of its position for temperature control. When the solenoid **309***h* is disconnected, the legs **309***a*, **309***b* and the armature **309***g* occupy their lower position (not shown) and the sensing elements **309***d*, **309***e* occupy their illustrated lower position.

From the air delivery side of fan **304** a main air duct **311** leads to all heating zones of the furnace. From said duct **311**, nozzles **312** or similar means continuously or under control blow a weak stream of cooling air towards the plastic foil **50** of each package **100** to bring about a condensation of any steam, which to some slight extent could have been generated in the package. However, said cooling should not be so powerful or so longlasting that the heating time of the package will be prolonged too much and that the gas guards **306** would no longer serve any practical purpose. Normally, but not necessarily, said cooling will be governed by some control.

The furnace operates in the following manner:

Food packages **100**, one at a time, with the plastic foil cover **50** forming the top of any package, are permitted entrance into the furnace on the conveyor belt **3** by a solenoid stop **310**. The packages are fed into zone **301** of the furnace, where their longest dwelling time of, normally, approximately 1 minute is controlled by a time relay or another timer, which at the end of said time interval releases a stop (not shown), if still unreleased, so that the package can be moved to the next zone of the furnace. As long as the packages are kept motionless by some stop, the conveyor belt is sliding beneath them. Other possible arrangements can be imagined, however. A package, which has been fed into the furnace is stopped at the nozzle **312** in front of one of the already mentioned gas guards in zone **301**, and thereby the high frequency energy is switched on in zone **301** in question. If the cover foil **50** of the package is bulging up and rising to a certain given level, it will interrupt or weaken the light beam of the photocell of the gas guard. The output of the photocell then actuates the stop just mentioned so that it will be moved out of its blocking position so that the package is conveyed to the next zone, in this particu-

lar case supposed to be a second zone (not shown). If the cover foil 50 does not operate the gas guard during the maximum dwelling time determined by the time relay, the stop will anyway be released by said time relay, so that the food package continues onwards. By said alternative feeding out operation from zone 301, deep frozen food packages, in which the steam is generated later than in packages not deep frozen, will remain in zone 301 during the predetermined maximum time (approx. 1 to 1½minute) and, thus, will be thawed, while the other food packages continue earlier not becoming quite warmed up already in the first zone 301. If the subsequent zone proves to be already filled with packages, the heat is switched off in the first zone, for example by means of a photoelectric cell with delayed action, positioned at the entrance of the second zone. When packages, forwarded by normal conveyor belt speed, pass the photoelectric cell, this cell does not switch off the heat of the first zone 301, because of the delayed action just mentioned.

The furnace zone (not shown) following subsequent to zone 301 provides additional heating and constitutes a collecting intermediate storage zone, that is a kind of "waiting room," where each package is supervised by a gas guard 306 in the same way as in the first zone. Said gas guard either interrupts the heating process or causes the package to continue to next zone, depending on the type of furnace and the chosen mode of operation of the furnace.

When the packages enter the last zone 302 and supposing that said zone can house several packages in a row on belt 3, then the foremost package 100*a* continues to travel on belt 3 until it interrupts the light beam of the position guard device 307. Thereby the circuit of the solenoid 309*h* is closed, so that the movable elements 309*g* of temperature guard 309 are lifted up until the temperature sensing elements 309*d*, 309*e* contact the bottom surface of package 100*a* and the package just enough to be disengaged from the conveyor belt and to rest, with the whole of its weight, on the temperature sensing elements 309*d*, 309*e* with the result that the package is no longer actuated by the conveyor belt. Simultaneously, also the fork legs 309*a*, 309*b* will thus be raised. The leg 309*b* has no true function as blockage device for the forward feed of the package, but it provides a more reliable suspension of the package in raised position and eliminates the possibility of lateral displacement. Leg 309*a*, lifted at the same time, prevents next package 100*b* from pressing on and, as the case may be, pushes it slightly backwards on the conveyor belt. In this connection it may be pointed out that the general construction principle described in the foregoing makes it easy to locate the high frequency energy radiating aperture of a high frequency furnace directly below the packages, and consequently to obtain optimal efficiency.

When a food package 100*a* arrives at fork 309*a*—309*c* and contacts the temperature sensing elements devices 309*d*, 309*e*, then the following happens. The preheated food in the package is subjected to additional heating. As such heating usually cannot be uniform in space if filling of the package is in homogenous or unevenly distributed, the package must not be fed out before each of the two sensing elements indicates the desired temperature, for example 70°—80° C., or slightly more. However, local steam generation at discrete points in the food occurs much earlier, before all of the food within one package has been heated approximately to the desired temperature, so that the cover foil 50 will rise and actuate the gas guard 306 which, then, interrupts or greatly reduces the heating intensity by interrupting or reducing the high frequency generation and/or by increasing the cooling air supply from nozzle 312 positioned above the package in question, for example by electromagnetic actuation completely opening an already partly open throttle valve. When subsequently the foil 50 is lowering down again owing to total condensation of the steam in the package, the high frequency energy is switched on again after a predetermined time interval, controlled by delay means such as a retarded relay, time relay, thermic relay (bimetallic), condenser resistance network or similar means. As long as the two sensing elements 309*c*, 309*d* do not indicate the desired temperature in both of the two contact points, the cycle described above will be repeated, i.e. repeated bulging and sagging of foil 50. As soon as the two sensing elements indicate the desired temperature, they cause the electromagnetic circuit 309*g*, 309*h* to be interrupted, so that the package will be released and lowered down on conveyor belt 3 to be fed out of the furnace by means of the belt.

However, there may be additional packages 100 behind the first package thus supervised in zone 302. Because said additional packages usually arrive later, it is highly improbable that they require to be fed out earlier than the first package. However, one can for example design and connect the gas guards 306 controlling these additional packages in such a way that they induce a reduction of the heating effect for these packages, for example by controlling a device shielding, deflecting and/or absorpting said effect, or else by increasing the cooling air supply as already mentioned.

Referring to the temperature guard 309 described above, it is essential to check the temperature at least at two different points on the outside of the package. Thus, the two sensing elements 309*c*, 309*d* control individual switches (not shown) connected in series, such as relays, gates etc., which will be switched on (rendered conductive), when the desired temperature has been reached. When the circuit of the two switches is closed the high frequency generator is made inoperative. A switch controlled by the last gas guard 306 located above 309 can be connected in parallel with the switches such as to interrupt the high frequency energy as long as the light beam of the photocell means of the gas guard is shielded and also during a certain subsequent delay period as already mentioned.

However, one can determine the average external temperature of the package by way of one (or more) temperature sensing elements of elongated shape. Supposing such a device being designed as a long resistance tape or layer, being sensitive to variations of the temperature and extending in the longitudinal direction of the conveyor belt 3, substantially in touch with the whole length of the food package, then the temperature guard may be arranged to interrupt the heating energy as soon as the resistance has reached an average value corresponding to the desired temperature of the food.

Temperature measurement by direct contact between sensing elements and the package may, however, be substituted by another type of temperature measurement, for example by a radiation pyrometer sensitive to infrared light, or a semiconductor diode or transistor sensitive to heat, provided that the temperature is measured at least at two different points, in the present case suitably at many points, which together form an elongated line or surface, the temperature sensing device being spaced from the food package and directed or focused onto a large surface of same, suitably towards a large portion of the surface of the plastic cover foil 50, the heat conductivity of which is superior to, i.e. the insulation being interior, to that of the other walls of the package.

Alternatively the temperature guard need not be located entirely outside of the package. At a convenient point of the package it can be provided with one or several defined marks or with an elongated mark of some material sensitive to temperature, for example with so called thermocolor, which definitely or temporarily changes color and/or degree of brightness, when a predetermined desired temperature has been reached. Such change of color can be readily detected by means of photoelectric cells, which in addition may perform the same operations as the elements 309*d*, 309*e* described above. Also other types of marks sensitive to temperature may be used, for example materials mechanically sensitive to temperature as a wall portion, which softens at a desired temperature, marks of waxy substances with softening behavior etc. the action of which easily is detected by mechanical, optical or electrical (galvanic, inductive or capacitive) means.

The solenoid device 309*g*, 309*h* can be substituted by a motor or a mechanism capable of lifting the sensing elements

309c, 309d which mechanism can be mechanically connected with, and driven by, the conveyor belt 3 or the driving device of the belt. Such mechanical connection may be effectuated by electrical means, for example by electromagnetically operated mechanical engagement of some kind like a solenoid-operated pawl which by magnetical actuation will drop into a gear or ratchet wheel belonging to the driving means of the conveyor belt 3, or a so-called one-revolution clutch.

The gas guard 306 has been described above as comprising a photoelectric cell. However, it may be a mechanical, pneumatical or capacitive device. In the present example, mechanical operation by the cover foil 50 would require a high mechanical sensitivity. Pneumatical operation, would not require auxiliary electrical means as a throttle, a shield reducing the high frequency etc. may very well be controlled entirely by mechanical and pneumatical means, respectively. By way of example, the gas guard (not shown) may comprise a suction nozzle connected to an air duct with comparatively weak vacuum, whereby said vacuum rises and, by means of a device sensitive to pressure changes (electrical contact, purely pneumatically operated slide for governing a jet of compressed air, for example the one in nozzle 12 etc.) will increase the cooling of the food package and/or will reduce the intensity of the heating energy. A bolometer may also be used as gas guard, either acting independently, whereby cover foil 50 shields the heat radiation or an air jet of the bolometer (depending upon if the bolometer resistance in its inactive stage is warmed by heat radiation or cooled by an air jet), or acting in connection with a pneumatical or mechanical sensing device actuating the so-called flag (movable element shielding heat and air respectively) of the bolometer.

Mechanical sensing, suitably by means of a mechanically operated electric contact, is a convenient means especially for packages not having windows of plastic foil or similar, for example when the wrapping of the package entirely consists of cardboard or relatively rigid plastic material.

Supervision of the temperature exclusively by means of a gas guard may be sufficient or necessary in such cases, where the heat conductivity (or heat insulation) of the package wrapping and the heat resistance have such characteristics that temperature measurement by means of some kind of temperature guard will be unreliable, unduly delayed or even impossible.

At a combined supervision by gas guard and temperature guard one and the same wall portion may be used, for example the cover foil 50 mentioned above or a thin but tight-fitting window in the package for sensing both the bulging action (gas guard) and the increase of the temperature (temperature guard).

In the arrangement of the furnace and package with cover foil 50 as described and shown in FIGS. 1 and 2 the temperature sensing device may alternatively contact one or more of the lateral surfaces of the package. If both end surfaces of the package are used, the sensing device may simultaneously serve the purpose of firmly holding the package in a determined position below the gas guard and the associated nozzle 312 without being raised from the conveyor belt 3. Individual stops are, then, not required. Also when the contact is arranged to engage one lateral surface of the package only (a counter support being applied against the opposite lateral surface) or to engage the two lateral surfaces of the package, the package may be kept in firm stationary position by means of the sensing device.

The gas guard or guards can be used to sort out untight packages, for example when at least one of the two temperature sensing elements indicates the desired temperature value, or rather another higher temperature, though the cover foil has not previously exhibited any bulging or inflation the package can be considered untight, and its separation could be effectuated by means of the criteria just mentioned. Alternatively one can sort out such packages, which during the whole of their passage through the furnace have not been exhibiting any bulging of their cover foil 50. Such packages can be identified and sorted out in different ways, for example by inflated portion resulting in the application of a sorting-out mark on the package to be sensed for example by photoelectric means, whereby the mark is applied by spray in case any bulging has failed to appear, said spraying being effectuated by means of a conventional electrically operated marking device, normally inactive, but entering into action, when the package is passing past a sensing point without previously having been prepared, for example by having been made inactive, by a bulging signal from the gas guard. In its simplest execution the furnace may be designed to the effect that a cover foil of a package when getting inflated will touch a color pad or similar, or by means of the gas guard will trigger a color gun when bulging, said gun applying an "approved-mark" onto the package, so that all packages not provided with said "approved-mark" will be sorted out, conveniently after having left the furnace. This operation may be effected by the mark being sensed (suitably by photoelectric means) at the same time as said package actuates a guard (photoelectric cell device, mechanically governed contact or similar). This guard operates a package ejector if the guard is actuated without an "approved-mark" having been sensed on the package simultaneously with, or previous to, the actuation of the guard.

There are also other possibilities to sort out and/or mark untight packages by means of controls actuated by the bulging action. Packages, the contents of which, for some reason or other, cannot at all, or in any case cannot within a predetermined maximum period, be warmed up to the desired temperature, are to be classified in the same category as untight packages. The risk of such packages appearing exists especially in connection with high frequency furnaces, if such a furnace is improperly set, in which case numerous packages, or all of them, will be sorted out, thus signalling a deficient furnace functioning, or if packages being unsuitable for such furnaces are employed, or if the contents of the package has been subjected to certain undesired chemical or physical influences.

The furnace may also very well be used also for untight packages, food placed on plates and dishes, etc. Gas guards 306 should then preferably be rendered inoperative, either manually or automatically. Automatic inactivity of the gas guards may be obtained by means of a similar guard sensing the vertical level of any package being about to enter the furnace. If food servings or other objects, which cannot and shall not be tested with respect to bulging of the type mentioned above, should be introduced into the furnace, and their height would be such as to affect anyone of the other gas guards, then the height or vertical level guard arranged at the furnace entrance will be actuated and will render all of the other gas guards temporarily inoperative. If the objects introduced do not influence the height guard, then the gas guards should not, or need not, be inactivated, provided that such objects of other types than those to be tested by the gas guards are not permitted to remain in the furnace during an unlimited time or too long a time. This can be prevented by time and/or temperature control or by subjective (not automatic) observation and manual operation.

In many cases it may suffice to provide the furnace with automatic supervision of temperature at one point only on a food package. In addition the furnace may in practice very well have one single heating zone only, but the quality of the heating process is much superior if more than one zone is provided.

A furnace of the present type is especially useful and advantageous for heating vacuum-type packages. Also vacuum-type packages may well have a very yielding wall portion as cover foil 50, which wall normally is in touch with the contents of the package, as long as the package is not heated. The practical possibility has been proved by tests and is also known from foodstuffs wrapped in plastic vacuum bags, for example roasted peanuts in plastic vacuum bags, which since many years have been on the market.

EXAMPLE OF EMPIRICAL OPERATIONAL DATA

On testing a furnace in accordance with FIGS. 1 and 2 having three heating zones, fed with filled food packages according to FIGS. 12 and 13 of said U.S. Pat. No. 3,490,717 the following values were obtained or established. A package fed into the furnace remains during maximum approximately one minute in zone 301 before it continues its travel to the second zone (not shown in the drawings). If the second zone is already filled with packages, the heating process in zone 301 is interrupted or reduced until the feeding in operation into the next zone can take place. In said second zone (not shown) the usually intermittent heating time, controlled by means of the gas guards, varies and depends upon when the third (last) zone 302 will be able to receive further packages from the preceding zone, the main purpose of which is to provide such intense preheating that the dwelling time in the third zone 302, where the temperature control takes place, will last for approximately one minute or less. The packages can and may be permitted to acquire their final temperature already in the second zone (not shown). The total dwelling time in all of the zones of the furnace amounts to approximately 1.5 minutes, to 4 minutes, and varies somewhat for subzero frozen food, normally refrigerated food and not refrigerated food.

Three furnace sizes for having a connection power of 2.5 kva., 7.5 kva. and 15 kva., respectively have been tested. In the two larger types 80 respectively 160 deepfrozen food packages (each containing approximately 200 grams of food) could be prepared during one hour. As to food from refrigerators the hourly output was 80, 240 and 480 packages respectively. Said furnaces, as well as other similar furnaces were, or may be, equipped with stops of different design and in larger numbers than described above, to stop and to release food packages, and further with elements for control of the passage of food packages through the furnace. The above values have been obtained when the food temperature was 70°80° C. when leaving furnace exit. The temperature of packages according to FIGS. 12 and 13 of said U.S. Pat. No. 3,490,717 decreases by 3° C. only during a period of 15 minutes and, hence, are sufficiently heat insulating for all normal purposes in spite of the big thin cover foil 50 and the small wall thickness of bowl 51. The above values of temperature and dwelling period in the furnace have been measured for all kinds of ready cooked dishes like soup, complete servings of potatoes and meat or fish, hot dessert and similar, so that a substantially total sterilization of the contents could be obtained.

I claim:

1. A food transporting and heating means for heating at least one package which is adapted to expand in response to excessive heat absorption comprising a conveyor defining a feed path, heating means arranged along said feed path, plural cooling air dispensing means arranged in a dependent position above and/or along said feed path at selected locations therealong, plural photocell circuit means including light sources directed across said feed path at said selected locations therealong operatively effective to selectively operate said cooling air dispensing means at each said location when the light beam of said light source is interrupted, said conveyor being adapted to convey at least one said package in heat-absorbing relation to said heating means whereby expansion of said package in response to excessive heat absorption causes interruption of one said light source, whereby cool air is dispensed to counteract the effects of said excessive heat absorption.

2. A food transporting and heating means for heating hermetically sealed food units comprising at least two endless conveyor belts arranged in side-by-side clearance positions from each other so as to define a feed path in the direction of movement of said conveyor belts, heating means arranged beneath and along said feed path, plural cooling air dispensing means arranged in a dependent position above and along said feed path at selected locations therealong in facing relation to said heating means, plural photocell circuit means including light sources directed across said feed path at said selected locations therealong operatively effective to selectively operate said cooling air dispensing means at each said location when the light beam of said light source is interrupted, said conveyors being adapted to convey at least one said food unit in heat-absorbing relation to said heating means whereby expansion of said food unit in response to excessive heat absorption causes interruption of one said light sources, whereby cool air is dispensed to counteract the effects of said excessive heat absorption.

3. A food transporting and heating means as defined in claim 2 wherein said heating means is a high frequency heating means; and including stop means movable from a clearance position beneath said conveyor belts into a blocking position extending into the clearance between said conveyor belts and being adapted to selectively hold a food unit against movement with said conveyor belts, said stop means being located at one or more of said selected locations of said cooling air dispensing means and adapted to confine said food unit against movement during the dispensing of said cooling air.

4. A food transporting and heating means as defined in claim 3 wherein said stop means includes a spaced-apart pair of front and rear upright arms, said front arm being adapted to confine said food unit against continued movement with said conveyor belts and said rear arm being adapted to hold successive food units from contact with said stationary food unit.

5. A food transporting and heating means as defined in claim 4 wherein the lateral dimension of said conveyor belts is of a minimal extent being adapted to permit unimpeded slipping movement of said belts beneath a food unit held stationary by one of said stop means.

6. A food transporting and heating means as defined in claim 3 in the form of a multiple zone transit furnace.

7. An oven comprising heating means for heating at least one hermetically sealed unit of food positioned in heat-absorbing relation to said heating means, said food unit being adapted to expand in response to excessive heat absorption, cooling means for cooling said food unit when heated, and sensing means positioned to sense expansion of said food unit beyond a predetermined level, said sensing means activating said cooling means in response to expansion of said food unit beyond said predetermined level whereby the effects of excessive heat absorption by said food unit is counteracted.

8. An oven as claimed in claim 7, wherein said heating means are dielectrically heating microwave means, and said cooling means comprising at least one air dispensing means arranged to direct cool air on said food unit, said sensing means comprising at least one photocell circuit including a light source associated with the photocell and emitting a beam of light which clears said food unit unless the unit expands beyond said predetermined level and when said food unit expands beyond said predetermined level interrupts said beam whereby said cooling means is activated.

9. An oven comprising plural heating means for heating one or more hermetically sealed units of food, said food units being adapted to expand in response to localized excessive heat absorption, conveyor means defining a feed path for said units of food through said oven and positioned so that said food units carried on said conveyor are in heat-absorbing relation to said heating means, plural cooling means arranged along said feed path for cooling said food units, plural sensing means, each of said sensing means being positioned to sense expansion of one of said food units beyond a predetermined level and to activate one of said cooling means positioned adjacent said food unit to cool said food unit and counteract the effect of said excessive heat absorption.

10. An oven as claimed in claim 9, wherein said plural heating means are dielectrically heating microwave means, said conveyor means is a belt conveyor passing through the oven, said plural cooling means are air dispensing means arranged along said feed path, and said plural sensing means are a series of photocells, each having an associated light source to emit

beams of light at said locations, every beam being clear of the belt conveyor and of said food units unless any of said units expands beyond said predetermined level and interrupts the associated beam whereby said associated cooling means is activated.