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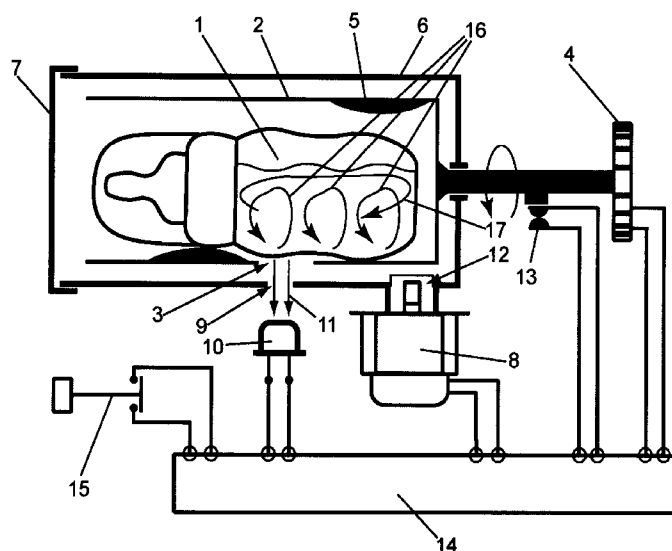


Fig. 1

throughout the entire bottle contents volume.

(57) Abstract: An object of the invention relates to ap-
paratus for managing temperature and sterilizing
products, and more particularly to baby food bottle warm-
ers and sterilizers for such bottles. Baby food bottle
warmer with temperature control comprises a power sup-
ply unit, a control unit, a microwave generator, at least
one infrared sensor, a heating chamber provided with a
lid at one end and closed at the other end, with means lo-
cated within the chamber to rotate a bottle equipped with
an electric motor, characterized in that the means for ro-
tating the bottle is a drum adapted to enable forced mix-
ing of the bottle contents during the heating process, the
heating chamber and the drum are further provided with
through holes, at least one in each, performed in such a
manner that while rotating the drum the through hole in
the drum periodically overlaps with the opening in the
heating chamber wall, whereas the infrared sensor is lo-
cated opposite to the opening in the chamber on the out-
side, so that upon rotation of the drum during heating in-
frared radiation from the bottle periodically falls onto the
sensitive area of the infrared sensor, with the drum rota-
tion axis directed horizontally or at an angle to the hori-
zontal plane. Technical result: increase in the heating rate
at the same time ensuring lack of local overheating and
increase in the accuracy of getting the target temperature

BABY FOOD BOTTLE WARMER WITH TEMPERATURE CONTROL

TECHNICAL FIELD

An object of the invention relates to apparatus for controlling temperature and sterilizing products, and more particularly to baby food bottle warmers and sterilizers for such bottles.

5 BACKGROUND OF THE INVENTION

Temperature measurement using infrared sensors (including pyroelectric sensors), is known for a long time - there are 20-year-old patents, for example. US5567941 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD, IPC G01J1 / 04, publ. 22.10.1996). Infrared sensors are widely manufactured by electronic industry.

10 There are also long-known technical solutions where an infrared sensor (pyroelectric sensor in particular) is used for controlling the temperature of objects heated in microwave ovens, for example US4347418 (MATSUSHITA ELECTRIC IND CO LTD, IPC H05B6 / 68, publ. 31.08.1982), MY116721 (SANYO ELECTRIC CO, IPC F24C7 / 00, publ. 31.03.2004). The known technical solution is quite trivial and so the number of patents in which it is applied
15 is quite large.

The main disadvantages of the previous analogs using a microwave oven with infrared radiation sensor to heat baby food bottles are as follows:

1) a need to manually set the desired temperature of the contents;

2) low temperature measurement accuracy because the sensor is distant from the object to
20 be heated (large heating chamber);

3) a rotating plate typically used in microwave ovens to provide a more uniform exposure of the object to be heated does not allow proper positioning of the heated object for accurately measuring the temperature with an infrared radiation sensor;

4) uneven heating of the bottle contents because of the lack of forced mixing - warming
25 outer layer is more intense, which may lead to degradation of health-giving nutrients, whereas the inner layer stays cold;

5) low accuracy in getting the target temperature. Hereafter the target temperature implies either default temperature, or the temperature preset by a customer, or the temperature

corresponding to the selected heating mode of the bottle contents on reaching that (as measured) heating is stopped.

On the open market there are models of baby food bottle warmer wherein heating is carried out using hot water or steam, such as Philips electronic heater
5 (http://www.philips.ru/c/avent-baby-preparing-for-feeding/avent-digital-bottle-warmer-scf260_37/prd/). In operating this model, a customer must preset the volume, type, and initial temperature of the contents, and, based on the preset values, the processor automatically calculates the heating time needed to reach the target temperature.

The main disadvantages of the known prototype are as follows:

10 1) a need to manually set the volume, type, and initial temperature of the contents, exact values of which are unknown in some cases which leads to incorrect calculation of the heating time;

2) a choice is possible between only three types of contents, for all the other types with dissimilar thermal conductivity and heat capacity the heating time may be calculated incorrectly;

15 3) besides some inconvenience for a customer in setting the above mentioned input data, there is an increased probability of customer's error while setting it (human factor), which leads to incorrect calculation of the heating time;

4) the device contains hot water, which can cause burns, to a baby as well;

5) Some crust is accumulated in the device which changes heating characteristics;

20 6) because of the lack of forced mixing the bottle contents is heated unevenly - warming outer layer is more intense, which may lead to degradation of health-giving nutrients, whereas the inner layer stays cold;

7) in calculating the heating time the heat capacity and thermal conductivity of the bottle itself are not taken into account, which can result in mistaken calculation of the heating time.

25 The patent application US20080121636A1 describes a household microwave oven equipped with an infrared sensor which measures the temperature of the food container (baby food bottle as well). It is measured just before heating the container (bottle). To enable correct temperature measurement the container (bottle) is placed in a special holder, which ensures wanted disposition with respect to the sensor. A customer is prompted to preset the food mass or

volume, as well as the target temperature. Based on these data, the time and power required to heat the contents to the target temperature are automatically calculated. The said holder can be equipped with a gadget to automatically measure the mass of the food-filled container.

The main disadvantages of the said prototype are as follows:

- 5 1) the need to manually set the volume (weight) of the contents (in some embodiments);
- 2) the need to manually set the target temperature of the contents;
- 3) in automatic weighing of filled bottle there is no correction for the mass of the bottle itself though it can be comparable with the mass of the contents. This leads to incorrect calculation of the heating time;
- 10 4) different types of bottle contents may have substantially different thermal conductivity and heat capacity, which is not taken into account in the heating time calculation and leads to a wrong result;
- 5) because of the lack of forced mixing heating of the bottle contents is uneven - warming outer layer is more intense, which may lead to degradation of health-giving nutrients, whereas
- 15 the inner layer stays cold.

The most similar analogue (prior art) is the microwave oven equipped with a processor (CN103844916, HARBIN SANHE JIAMEI TECHNOLOGY DEVELOPMENT CO., LTD, IPC A47J36 / 24, publ. 11.06.2014), comprised of a power plug (1), special purpose controller (2), rotating platform (3) with a baby food bottle, (4) a source of microwave radiation (5), infrared

20 temperature sensor (6), microwave oven housing (7) upper cover (8). The controller (2) is mounted on the bottom of the microwave oven case (7) and acts as control center of the microwave oven. The rotating platform (3) is mounted in the center of the oven case bottom (7) and can provide rotation at a constant rate during heating bottles with nutrient mixture. The source of microwave radiation (5) is mounted inside the housing (7) at the right hand side and is

25 devoted for heating the liquid contents of baby food bottle (4). Infrared temperature sensor (6) mounted on the left hand side of the microwave (7) measures the temperature of the liquid inside the bottle (4). The lid (8) closes the oven casing (7) during heating and can be removed to place on the platform (3). The controller (2) gives signals to the microwave radiation source to start heating and terminate heating when temperature reaches 37 °C and maintains the temperature to

30 get the needed product. One of the prior art drawbacks is the lack of forced mixing of the bottle

contents, because of which the device is not able to operate properly, namely, to heat the bottle contents up to 37°C within a reasonable time evenly and without overheating. Shutdown initiated by the temperature sensor happens before the volume-averaged temperature of the contents reaches the target one. For example, if one tries to heat up a glass of milk in microwave oven, the milk will be heated really unevenly, which is evident just by touch - the glass wall can burn, whereas the milk in the middle stays cold. Baby mixtures are even denser, so in that case the situation will be even worse. Frozen milk also cannot be warmed up qualitatively without mixing. Thus, the prior art drawbacks are as follows:

1) low heating rate since the device design does not enable mixing the bottle contents both in the surface layer and at a certain depth. Hence to avoid local overheating of the surface layer and equalize temperature over the whole bottle volume it is necessary to maintain mean heating power at rather low level which will increase the heating time;

2) presence of local overheating, again due to the fact that the device design does not provide mixing the contents throughout the bottle volume and thus heating leads to temperature gradient between the surface and inner deepened layers;

3) bad accuracy in achieving the target temperature as the infrared sensor is aimed at measuring the surface layer temperature which is higher than the temperature at a certain depth.

SUMMARY OF THE INVENTION

The problem to be solved using the present invention is to design a new device for heating baby food bottles which provides fast and uniform volume heating of the bottle contents, including both the surface and inner deep layers, without local overheating, in particular to temperatures that can cause degradation of health-giving nutrients in the contents.

The technical result achieved using the said invention is increase in the heating rate with prevention of local overheating, in particular to temperatures that can cause degradation of health-giving nutrients in the contents, and increase in the accuracy of getting the target temperature throughout the whole bottle volume, including surface and inner layers.

The problem put by and the required technical result are achieved due to the following improvements. The proposed baby food bottle warmer with temperature control, contains a power supply, control unit, microwave generator, at least one infrared sensor, heating chamber with a lid at one end with a machinery for rotating baby food bottle equipped with electric motor.

According to present invention, this machinery comprises a drum adapted to force mixing of the bottle contents during the heating process. Both heating chamber and the drum are provided with through holes, each with at least one, arranged so that during rotation the drum hole periodically overlaps with the through hole in the wall of the heating chamber. The infrared sensor is located
5 opposite the chamber hole at the outer side, so that upon rotation of the drum in the heating process the infrared radiation from the bottle periodically falls onto sensing area of the infrared sensor. The axis of rotation of the drum is directed horizontally or at some angle to the horizontal plane. The power supply output is connected to the input of the control unit whose outputs are connected to the microwave generator and electric motor. The inner side surface of the drum
10 hosts at least one element arranged to change the tilt angle of the bottle with respect to the rotation axis made in the form of, for example, ribs and/or spherical bulges, and/or dents, and at least one of the hole openings has a shape of, for example, slit or slot, the drum itself and the elements for changing the bottle tilt angle are made of dielectric material, and the drum rotation axis can be directed at an angle of no more than 60 degrees to the horizontal plane. The opening
15 in the heating chamber is provided with a dielectric cover transparent to infrared radiation within the range of the sensor sensitivity which prevents possible contamination of the sensitive area of the infrared sensor. The sensor can be provided with a temperature sensor, such as a thermocouple or another pyrometer probe measuring the temperature of the infrared sensor itself and/or its surrounding design elements. The device for rotating the bottles is further equipped
20 with a synchronizer connected to the control unit.

In another embodiment of the present invention, the heater is further provided with a device for cooling heating chamber connected to the control unit.

In another embodiment, the heater is further provided with a water tray and is capable of sterilizing the contents of the heating chamber by the steam produced during heating.

25 In another embodiment, the heater is further provided with a fan for cooling a magnetron of the microwave generator.

In another embodiment, the heating chamber is further provided with additional vent holes to pass air from the fan.

In another embodiment, the heater is further provided with additional outer casing.

In another embodiment, the heater is further provided with an indicator of the preset target and/or the current temperature of the bottle contents connected to the control unit. A LED panel, liquid crystal display or LED display can be used as indicator.

5 In another embodiment, the heater is further provided with at least one control means (a touch panel, a button, a joystick or a handle) for changing the target temperature.

In another embodiment, the heater is further provided with a sound emitter indicating events in the course of heater operation.

A significant innovation in the present invention is regular mixing of the baby bottle contents while heating in a microwave field (with the bottle positioned optimally relative to the
10 infrared radiation sensor for accurate temperature measurement), combined with multiple measurements of the bottle surface temperature. Microwave field heats not only the surface layer, but also the contents at a certain depth, but regular mixing ensures negligible temperature difference throughout the volume contents which allows one to increase a mean heating power without danger of overheating some regions of the content, in particular to temperatures that can
15 lead to degradation of health-giving nutrients. In turn, the increase in the mean heating power, allows one to proportionally reduce the heating time. Thus, mixing the bottle contents together with temperature measurements of the bottle surface performed according to the above described technique enable better (than in the prior art without mixing) accuracy in determination of the volume-averaged temperature of the bottle content, more accurate finding of the moment to stop
20 heating and, thereby, improve the accuracy in getting the target temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood from the description of non-limiting nature and with reference to supplementary drawing (Fig. 1) which shows general schematic of the device.

INVENTION EMBODIMENT

25 Bottle 1 with contents is placed horizontally (Fig. 1) or at certain angle (not shown in the drawing) in the dielectric drum 2 with one or more holes 3, made, for example, in the form of slots or slits on its side surface. The drum 2 may be of a cylindrical (Fig. 1), polyhedron (not shown in Fig. 1) or any other suitable shape. Said drum 2 is connected with a shaft to motor 4, which may be equipped with a reduction gear (not shown in the drawing), for example, any
30 motor used in household microwave ovens for rotating a plate. The motor 4 rotates the drum 2

with a period ranging from 0.3 to 30 seconds. At higher rotation rate the contents suffers agitation and foaming, whereas at lower rotation rate mixing is not sufficiently efficient. There are elements (at least one) on the inner side surface of the drum configured to change the angle of bottle tilt with respect to the rotation axis which are dents (not shown in the drawings) and/or bulges made in the form of, for example, ribs (not shown in the drawing) and/or spherical bulges 5 (Fig. 1). These elements cause more intense mixing of the bottle contents 1 in the direction along bottle longitudinal axis. The drum itself and the elements for changing the bottle tilt angle are made of dielectric material. The drum rotation axis can be directed at some angle with respect to the horizontal plane (not shown in the drawing) which is no more than 60 degrees 10 because at larger angle there is no adequate mixing of the bottle contents.

The drum 2 is placed inside a cylindrical metal housing 6 disposed horizontally (Fig. 1) or inclined at some angle (not shown in the drawing), closed at one end and with metallic lid (door) 7 at the other end which can be secured on hinges to chamber body 6 so that a customer can open it and load inward the bottle 1. The chamber 6 may be of any possible form provided 15 that the device operates properly, for example, a rectangular prism shape (not shown in the drawing). In the said chamber 6 is injected microwave radiation from the microwave generator 8, for example, one of the standard magnetrons used in household microwave ovens, and there is at least one through-hole 9 in its lateral surface. The infrared sensor 10 is located beyond the heating chamber 6 near the through-hole 9 so that from time to time while rotating the hole 3 20 (slit, gap) in the drum 2 becomes right opposite to the hole 9 in the heating chamber wall 6, and the thermal infrared radiation 11 from the heated bottle 1 occasionally falls onto the sensitive area of infrared sensor 10. Such a design of the chamber 6 and the drum 2, as well as the location of the through holes 3 and 9 allows optimal positioning of the bottle with respect to the infrared sensor and ensures an accurate temperature measurement and control under continuous mixing 25 the contents in the heating process, which allows to enhance the rate of heating at the same time avoiding temperature gradient between the surface and inner layers of the bottle contents and preventing local overheating. Thus the surface and inner layers of the bottle contents always have the same temperature and hence the infrared sensor 10, measuring the temperature of the surface layer of the bottle contents, in fact, indicates the actual temperature of the contents as a 30 whole increasing the accuracy of getting the target temperature.

Hole 9 through which the infrared radiation 11 from heating chamber 6 hits the infrared sensor 10 can be closed by a thin dielectric cover (not shown in the drawing) transmitting

infrared radiation within the spectral range corresponding to the sensitivity range of the infrared sensor 10 and thus preventing possible contamination of the sensitive area of the infrared sensor 10. The opening 12 (Fig. 1) through which electromagnetic radiation from microwave generator 8 enters the heating chamber 6 can also be closed with a lid or cap of a dielectric material, which prevents influx of foreign objects and substances to the magnetron stub antenna.

A rotatable drum 2 combines functions of mixing the bottle contents 1, positioning the bottle relative to the infrared sensor 10, and shutter for the thermal infrared radiation from the bottle 1.

The drum 2 can further be equipped with a synchronizer 13 connected to the control unit 14 and producing electrical signal – a sync pulse when the holes 3 and 9 overlap. Such a sync pulse allows one as well to imply a well-known technique of synchronous detection in the measurements of the thermal radiation from heated object with infrared sensor. The technique is implemented in the control unit 14 which, as soon as the sync pulse arrives, turns off power supply to the microwave generator 8 for a time interval when the thermal radiation from the heated object is measured by the infrared sensor 10. This enables minimization of the of microwave field effect directly upon the infrared sensor 10 during the measurement, which influence sometimes results in a measurement error, and thus further increases the accuracy of temperature measurement by sensor 10. Synchronizer 13 can be either mechanical or magnetic switch, activated by cams or magnets at the motor shaft. It is also possible to use an optocoupler (not shown in the drawing), in which case a shutter is fixed on the motor shaft.

The signals from infrared sensor 10 and synchronizer 13 are directed to the control unit 14.

The power supply unit (not shown in the drawing) can be manually disconnected from the control unit 14 with a switch 15, by which a customer can turn on or turn off the heater. Besides delivering signals and power supply to the microwave generator 8 and the electric motor 4, the control unit 14 can, in some embodiments, comprise additional elements, such as units for specific power supply, and others (not shown in the drawing).

By applying standard techniques known in microwave technology, a heating chamber 6 with a lid (door) are designed so that to minimize escape of microwave radiation into the surrounding space.

A well-known technique of synchronous detection has been implemented in the control unit 14 with a use of the sync pulse in detecting signal from the infrared sensor 10. Such approach increases significantly the measurement accuracy of the friendly signal even in the presence of intense noise. To minimize the influence of microwave field directly upon the infrared sensor 10, the control unit 14 can turn off power supply to the microwave generator 8 upon arrival of the sync pulse for a time interval when the thermal radiation from the heated object is measured by the infrared sensor. When the signal amplitude from the infrared sensor 10 becomes that corresponding to the target temperature of the bottle contents (usually that is close to the normal human body temperature of 36-37°C), the control unit 14 stops heating.

Thus, the new design of the proposed heater with continuous mixing of the bottle contents, optimal positioning of the bottle throughout the mixing process with respect to the sensor 10 and controlling the temperature ensures more rapid and uniform heating as compared with the prior art, and therefore more accurate heating to the target temperature (36-37°C), irrespective of the initial temperature, volume, type, thermal conductivity, heat capacity of the bottle contents and the bottle itself. Heating of 100 ml takes approximately 50 s, which is 2.5 times faster than with fastest competitor device (heater for baby bottles), moreover, without danger of local overheating the contents.

The heater is easy to use, as it operates in fully automatic mode, owing to which it can have only one button, namely on/off (in the preferred embodiment). The heater is also safe to use, since it does not contain hot water and hot construction elements. Overheating of the contents, for example because of customer's error, is impossible. The preset target temperature is safe for a baby. The heater ensures healthy heating. Not only the surface but the entire volume is heated with forced mixing. The local temperature does not rise above the temperature that can lead to degradation of the health-giving nutrients so those are conserved. It is possible to work with frozen contents (for example, frozen donor breast milk): there is still no risk of local overheating since temperature of the contents cannot rise above its melting point close to 0°C. As a result of heating and melting inside the bottle, a liquid phase appears which begins to mix being always in touch with a solid phase at a melting point, so local overheating at this stage is also eliminated.

Additionally, heater may be equipped with limit switches (not shown in the drawing) which break the power circuit of the microwave generator 8 when the lid (door) 7 gets opened. Also, the heater may be provided with a temperature sensor (thermorelay) breaking power circuit

of the microwave generator 8 when overheated. These elements are not shown in the drawing; they do not crucially affect the heater operation but are necessary because of safety requirements for household microwave ovens.

5 Additionally, the heater may be provided with a fan (not shown in the drawing) cooling the magnetron. This fan is operated by the control unit 14. In the wall of the heating chamber 6 can be made vent holes (not shown in the drawing) through which the air flow from the fan enters and exits the chamber 6. This air flow cools down the chamber wall 6 and the rotary drum 2 to room temperature, thus reducing their thermal radiation and further improving the accuracy of the temperature measurement of bottle contents 1.

10 Additionally, the heater can be provided with outer casing (housing), e.g., metal (not shown in the drawing). Based on standard techniques known in microwave technology, the housing is configured so that to minimize escape of microwave radiation into the surrounding space.

15 Additionally to the infrared sensor 10 recording the radiation from heated object, a temperature sensor (e.g., thermocouple or another pyrometer sensor) measuring the temperature of the infrared sensor itself and/or its surrounding design elements (not shown in the drawing). Based on this measured temperature, a correction can be made increasing the accuracy in measurement of the bottle 1 temperature.

20 Additionally, the heater can be provided with an indicator of the preset target and/or the current temperature of the bottle 1 (not shown in the drawing), e.g., with a LED panel, liquid crystal display, LED display or some other display for further convenience.

Additionally, the heater can be provided with control means (not shown in the drawing) for changing (e.g. in line with doctor's recommendation) the preset target temperature using a touch panel, a button, a joystick or a handle.

25 Additionally, the heater can be provided with a sound emitter (not shown in the drawing) which beeps sound signals about events in the course of heater operation, e.g., about heating start and/or stop.

30 Additionally, the heater can be provided with a refrigerator (e.g., a Peltier element with a fan for cooling its hot fraction), which provides cooling for the heating chamber and its contents to a temperature, for example, from 0 to 10°C (not shown in the drawings). Power is supplied to

the refrigerator by the control unit 14. This allows one to prepare baby food bottle 1, place it in the chamber 6, and to keep it there at low temperature for a long time, and if necessary, switch on heating and warm it.

There can be used an additional thermosensor (thermorelay) which prevents cooling the chamber 6 below 0°C (not shown in the drawing). This heater is then equipped with control means such as a touch panel, button, joystick, handle, etc., to start cooling. The control unit 14 is provided with a special program code which, when cooling is switched on, turns off heating and drum rotation and supplies power to the refrigerator. When heating is switched on, the control unit 14 turns off the refrigerator and returns to normal operation. For more efficient cooling of the heating chamber 6 it can be covered by heat insulating material such as a porous polymer (not shown in the drawing). The cooling mode allows one to pre-prepare baby food in the bottle 1 and store it in the heating chamber 6 at a low temperature, for example, overnight. This prevents development of microorganisms therein, including pathogenic ones. If required, just a press of one button puts the heater into operation and within a short time (for example, 0.5-2 minutes, depending on the contents amount) a customer gets the bottle 1 at comfort temperature (e.g., 36-37°C).

Additionally, the heater can have a sterilizer mode. For this purpose, a special removable water tray (not shown in the drawing) is placed at the bottom of the heating chamber 6, whereas some holes are made in its upper part (not shown in the drawing) for the steam escape. In this case, the heater is provided with a control means such as a touch panel, button, joystick, handle, and so on, to activate the sterilizer mode. Before switching on sterilizer mode, a customer is required to place into the drum 2 items to be sterilized (a bottle, a dummy, and the like) and pour into the tray from 20 to 100 ml of water. Less water boils-off too fast and will not provide high-quality sterilization, whereas more water boils-off longer than high-quality sterilization happens. The control unit 14 is provided with a special program code which, upon switching on sterilizer mode, supply power to the microwave generator 8 for a certain time sufficient for high-quality sterilization (from 2 to 4 minutes, which is a conventional time for baby bottle sterilizers). The microwave radiation heats the water and it begins to boil, the heating chamber 6 becomes filled with steam at about 100°C sterilizing items placed in the drum 2. Excessive steam escapes through holes in the top of the heating chamber 6. After completion of the sterilization process the tray with remaining water is removed from the heating chamber 6. In order to avoid heating

of the heater outer surface, the heating chamber 6 can be covered with a heat insulating material, for example, porous polymer.

The heater operates as follows.

A customer is to put the electric plug of the heater to the power outlet, open the lid (door)
5 7, place a filled bottle 1 inside of the drum 2 and close the lid 7. The contents should have sufficient fluidity so that to flow to the bottom when the bottle is tilted. A contents can be frozen, but when defrosted it is expected to acquire a specified fluidity. Microwave radiation from the microwave generator is injected into the chamber 6 and heats the bottle contents. The drum 2 is rotated in the heating process by means of the electric motor 4.

10 When the drum rotates, due to the fact that the axis of rotation is located horizontally or at an angle to the horizontal plane, the bottle rolls in the drum and rotates around its own axis which enable mixing of its contents. When rolling and rotating the bottle 1 in the drum 2, there arise convection currents 16 in the bottle liquid contents which transfer heat mostly in the
15 direction perpendicular to the rotation axis, as shown schematically in Fig.1 with horizontal arrangement of the drum rotation axis. Thus, the mixing process involves almost entire volume of the liquid contents of bottle 1, ensuring rapid and uniform heating of the volume contents including surface and inner layers, without local overheating, as well to temperatures that can lead to degradation of health-giving nutrients. Microwave field heats not the bottle wall but its contents, not only the surface layer, but also the contents at a depth of up to several centimeters
20 (depending on the contents properties). This ensures uniform heating of the entire volume of the contents and the temperature of the bottle outer surface has enough time to equalize with the temperature of the contents.

In an alternative invention embodiment, the drum 2 can be provided with at least one element configured to change the tilt angle of the bottle 1 longitudinal axis upon rotation, for
25 example, bulges 5 (Fig. 1) and/or dents (not shown in the drawing). As the drum 2 (Fig. 2) rotates, bottle 1 periodically rolls over bulge 5 of the drum 2, which provides a more intensive mixing of its contents. While rolling over the bulge during rotation the bottle axis tilts relative to the horizontal plane, which leads to arise, in addition to mentioned flows 16, of convection currents 17 transferring heat predominantly along the bottle axis. Such a combination of
30 concurrently occurring convection currents 16, 17 involves the entire volume of the bottle liquid contents in the mixing process, which, coupled with forced mixing enabled by directing the rotation axis of the drum 2 horizontally or at some angle to the horizontal plane, provides

uniform heating of the entire volume of the contents and enables still quicker equalization of the temperatures of the bottle outer surface and bottle contents.

Both in the first and second embodiments of the invention described in the preceding two paragraphs, it allows heating with a much higher power than in the prior art without forced
5 mixing avoiding danger of local overheating of the contents over temperature that can lead to degradation of many valuable milk proteins and other health-giving substances.

The control unit 14 supplies power to the microwave generator 8 from which a microwave radiation is injected into the heating chamber 6. Microwave field heats not the bottle wall but its contents, not only the surface layer, but also the contents at a depth of up to several
10 centimeters (depending on the contents properties).

When the drum 2 is rotating, the hole 3 (slit, gap) in the drum regularly becomes opposite to the hole 9 in the heating chamber wall 6, and the thermal infrared radiation from the heated bottle 1 falls onto the sensitive area of infrared sensor 10. At these moments, the control unit 14 triggered by the signal from the device 13 turns off the power supply to the microwave generator
15 8 to eliminate influence of the electromagnetic microwave radiation upon the infrared sensor 10, which influence can sometimes lead to an error in the temperature measurement. The signal from the infrared sensor 10 enters the control unit 14, which, based on embedded algorithm decides to continue, terminate or correct the heating power. If the temperature has not yet reached the target one at current measurement, the control unit 14 performs another heating cycle. Owing to
20 continuous mixing, the average temperature of the contents of bottle 1 will differ by no more than 2°C from the bottle wall temperature, whereas in the prior art (without mixing) the temperature gradients in the volume contents can be as high as tens of Celsius degrees. When the current measurement shows that the temperature has reached a predetermined (target) value, the control unit 14 stops heating and gives a notice to a customer about operation completion by
25 proper sound and/or light and/or other indication. The customer has then to open the lid 7 and remove the bottle 1 with heated contents. In total the heating proceeds much faster (up to a factor of 2) compared with the prior art, which is of importance for bottle warmers. One can as well talk about a substantial increase in the accuracy of getting the target temperature since due to continuous mixing and lack of temperature gradients in the volume contents the measured bottle
30 wall temperature with an accuracy of 2°C will be equal to the average temperature of its contents. Note that the above accuracy can be further increased to a value less than 2°C by using certain techniques, for example, increasing the number of measurement cycles, varying the

heating power, and so on. In particular, this accuracy is determined by the time the measurement takes. The larger the number and variety of measurements (for example, measurement of "parasitic" heating with additional thermal sensor), the more accurate the temperature measurement is.

5 Note that contents should have sufficient fluidity to flow into the bottle lower part upon rotation. The contents can be frozen (e.g., frozen donor breast milk), but it must restore needed fluidity when defrosted.

 In another invention embodiment, preferred target temperature can be changed by customer using appropriate controls (not shown in the drawing). If a customer does not do this,
10 the default value is actual.

 Next, a customer has to press the button "heating on/off" and the control unit 14 starts to execute the work program. If the lid 7 is opened and its limit switches give a signal about it, no action is undertaken; otherwise, the control unit 14 supplies power to the electric motor 4, the rotating drum 2 and the cooling fan (not shown in the drawing).

15 Upon rotation of the drum 2, sync pulses from unit 13 start to arrive to the control unit 14. In one of the heater embodiments, the sync pulses are used as a reference signal and the control unit 14 performs synchronous detection of the signal from infrared sensor 10. A DC or pulsed power is supplied to the microwave generator 8. In another embodiment, power to the microwave generator 8 is supplied only during the time periods when the infrared radiation from
20 the bottle 1 does not fall onto the infrared sensor 10, which allows one to eliminate the effect of the microwave field on the sensor.

 In an alternative embodiment, an additional temperature sensor (not shown in the drawing) is used, a signal from which is recorded by the control unit 14 and appropriate correction is made.

25 If a customer repeatedly presses the on/off button (not shown in the drawing), or opens the lid 7 of the chamber 6, or the temperature of the microwave generator 8 exceeds the limit, the control unit 14 immediately cuts off power to the microwave generator 8, motor 4, drum 2 and the fan.

 If the signal from the infrared sensor 10 (after correction and/or synchronous detection)
30 reaches a level corresponding to the preset target temperature, the process is terminated and the

power to microwave generator 8, motor 4 of the drum 2, and the fan gets turned off. If the heater is equipped with a sound generator, it alerts about the end of heating.

If the heater has a function of sterilizer, its operation requires that one puts objects to be sterilized into the drum 2, pours into a special tray (not shown in the drawing) in the heating chamber 6 from 20 to 100 ml water, locks the lid 7 and presses the power button to put into run the mode of sterilization. The control unit 14 supplies power to the microwave generator 8 and the fan for a certain time, for example 2-4 minutes, which is common time to sterilize baby bottles. If while sterilizing a customer will press the sterilization on/off button or open the lid 7 of the chamber 6, or the temperature of the microwave generator 8 will exceed the limit, the control unit 14 immediately turns off the power from the microwave generator 8 and the fan. When the preset time for sterilizing elapses, the process is stopped and power supply to the microwave generator 8 and the fan is switched off. If the heater is equipped with a sound generator, it alerts about the end of sterilizing. After completion of the sterilization process the tray with remaining water is to be removed from the heating chamber 6.

If the heater has a function of refrigerator, its operation requires one to put baby bottle with prepared food into the drum 2, lock the lid 7 and press the power button to put into run the refrigerator mode. The control unit 14 supplies power to refrigerator (e.g., a Peltier element) (not shown in the drawing) and the fan that cools down hot fraction of the refrigerator. When customer needs to start heating, the control unit 14 turns off power to the refrigerator and reinstate ordinary heating mode described above.

One can put in the heater any bottle with any amount of any contents type (it is necessary that it has sufficient fluidity in non-frozen state), with any initial temperature (including initially frozen).

Generally customer is not prompted to enter any data which eliminates possibility of error caused by human factor (in some embodiments, a customer can set preferred target temperature).

Due to forced mixing of the contents it is heated uniformly, while heating by the microwave field is performed slowly enough so there is enough time for the bottle surface temperature to equalize with the contents temperature, and the temperature control is performed with the infrared sensor giving a signal to stop heating. It enables accurate reaching of target temperature throughout the contents volume and excludes local overheating.

Even though the present invention has been described in detail by the example of preferred embodiments, it should be noted that these exemplary embodiments are described only for purpose of illustrating the invention. The description should not be construed as limiting full scope of the invention since the steps and tools of the described methods can be modified by those skilled in the field of physics, electronics, signal processing and others. Changes may be made aimed at to adapt it to particular devices or circumstances that not go beyond the scope of the appended claim. One skilled in the art understands that within the scope of the invention as defined by the appended claims, various changes and modifications, including equivalent solutions, are possible.

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CLAIMS

1. Baby food bottle warmer with temperature control comprising a power supply unit, a control unit, a microwave generator, at least one infrared sensor, a heating chamber provided with a lid at one end and closed at the other end, with means located within the chamber to rotate a bottle
5 equipped with an electric motor, characterized in that the means for rotating the bottle is a drum adapted to enable forced mixing of the bottle contents during the heating process, the heating chamber and the drum are further provided with through holes, at least one in each, performed in such a manner that while rotating the drum the through hole in the drum periodically overlaps with the opening in the heating chamber wall, whereas the infrared sensor is located opposite to
10 the opening in the chamber on the outside, so that upon rotation of the drum during heating infrared radiation from the bottle periodically falls onto the sensitive area of the infrared sensor, with the drum rotation axis directed horizontally or at an angle to the horizontal plane.
2. Bottle warmer according to Claim 1, characterized in that the power supply output is connected to input of the control unit whose outputs are connected to the microwave generator
15 and the electric motor.
3. Bottle warmer according to Claim 1, characterized in that the lateral surface of the drum is provided with at least one element configured to tilt the bottle axis during rotation.
4. Bottle warmer according to Claim 3, characterized in that the elements for changing the tilt angle of the bottle axis are bulges and/or dents.
- 20 5. Bottle warmer according to Claim 4, characterized in that the bulges are made in the form, for example, of ribs and/or spherical humps.
6. Bottle warmer according to Claim 1, characterized in that at least one opening is made in the form, for example, of slot or slit.
7. Bottle warmer according to Claim 1 and 3, characterized in that the drum and the elements for
25 changing the tilt angle of the bottle axis are made of a dielectric material.
8. Bottle warmer according to Claim 1, characterized in that the drum rotation axis is tilted at an angle of no more than 60 degrees to the horizontal plane.
9. Bottle warmer according to Claim 1, characterized in that the hole in the heating chamber is covered with a dielectric lid transparent for infrared radiation within the sensitivity range of the

infrared sensor, which lid prevents possible contamination of sensitive area of the infrared sensor.

10. Bottle warmer according to Claim 1, characterized in that the infrared sensor detecting the radiation from the heated object can be further provided with a temperature sensor such as thermocouple or any other pyrometer sensor that measures the temperature of the infrared sensor itself and/or constructive elements surrounding it.

11. Bottle warmer according to Claim 1, characterized in that the means for rotating the bottle is further provided with synchronizing means whose output is connected to the control unit input.

12. Bottle warmer according to Claim 1, characterized in that the device is additionally provided with means for cooling the contents of the heating chamber and an input of the means is connected to the control unit output.

13. Bottle warmer according to Claim 1, characterized in that the device is additionally equipped with a water tray adapted to ensure sterilization of the heating chamber contents by water steam produced in heating process.

14. Bottle warmer according to Claim 1, characterized in that it is further provided with a fan for cooling a magnetron of the microwave generator.

15. Bottle warmer according to Claim 1 and 14, characterized in that the heating chamber is provided with vent openings for the passage of air from the fan therethrough.

16. Bottle warmer according to Claim 1, characterized in that it is provided with an additional housing.

17. Bottle warmer according to Claim 1, characterized in that an indicator is further provided with preset target and/or the current temperature of the bottle contents, whose input is connected to the control unit output.

18. Bottle warmer according to Claim 17, characterized in that, for example, a LED panel, liquid crystal display, or LED display is used as indicator.

19. Bottle warmer according to Claim 1, characterized in that it is additionally provided with at least one control means for changing the target temperature.

20. Bottle warmer according to Claim 19, characterized in that the control means is, for example, a touch panel, a button, a joystick or a handle.

21. Bottle warmer according to Claim 1, characterized in that it is further provided with a sound emitter which beeps on events in the heater operation.

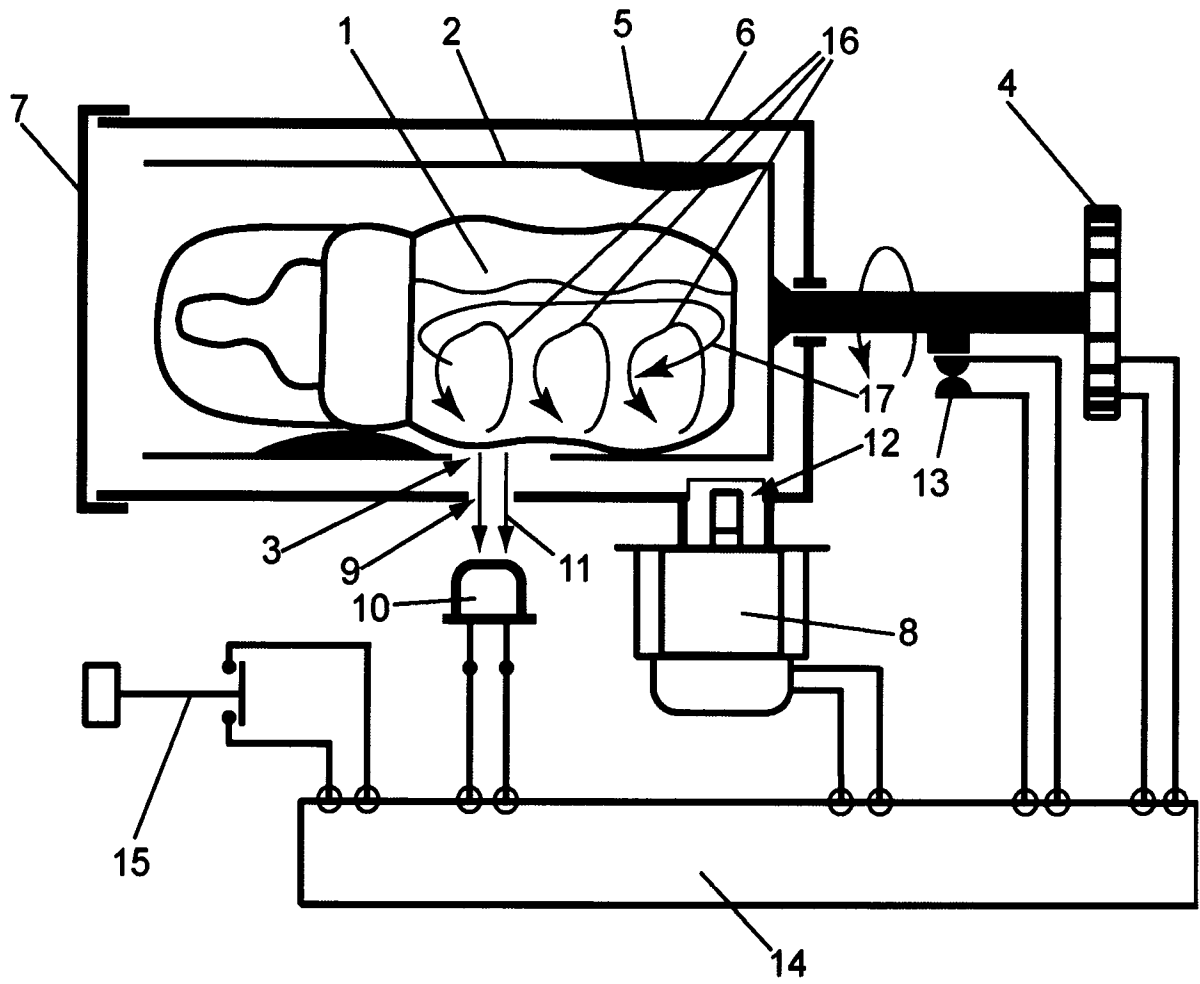


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU 2015/000497

A. CLASSIFICATION OF SUBJECT MATTER <p style="text-align: center;"><i>A47J 36/26 (2006.01)</i></p> <p>According to International Patent Classification (IPC) or to both national classification and IPC</p>		
B. FIELDS SEARCHED <p>Minimum documentation searched (classification system followed by classification symbols)</p> <p style="text-align: center;">A47J 36/00, 36/24, 36/26, H05B 6/64-6/80</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)</p> <p style="text-align: center;">Espacenet, USPTO, RUPAT, PatSearch (RUPTO internal)</p>		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
D, A	CN 103844916 A (HARBIN SANHE JIAMEI TECHNOLOGY DEVELOPMENT CO., LTD) 11.06.2014	1-21
A	US 6703590 B1 (INSTA-MIX, INC.) 09.03.2004	1-21
A	WO 2009/128015 A2 (KONIN-KLIJKE PHILIPS ELECTRONICS) 22.10.2009	1-21
A	RU 2010150959 A (KONIN-KLIJKE PHILIPS ELECTRONICS) 20.06.2012	1-21
A	RU 2226248 C1 (ISAKOV VLADIMIR ALEKSEEVICH) 27.03.2004	1-21
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
<p>* Special categories of cited documents:</p> <p>“A” document defining the general state of the art which is not considered to be of particular relevance</p> <p>“E” earlier document but published on or after the international filing date</p> <p>“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>“O” document referring to an oral disclosure, use, exhibition or other means</p> <p>“P” document published prior to the international filing date but later than the priority date claimed</p> <p>“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>“&” document member of the same patent family</p>		
Date of the actual completion of the international search <p style="text-align: center;">10 October 2015 (10.10.2015)</p>		Date of mailing of the international search report <p style="text-align: center;">19 November 2015 (19.11.2015)</p>
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37		Authorized officer <p style="text-align: center;">S. Zhuravlev</p> Telephone No. (495)531-64-81