A. G. E. HULTGREN.

METHOD OF HEAT TREATMENT AND FURNACE THEREFOR.

APPLICATION FILED MAR. 14, 1919.

1,401,983.

Patented Jan. 3, 1922.

3 SHEETS—SHEET 1.

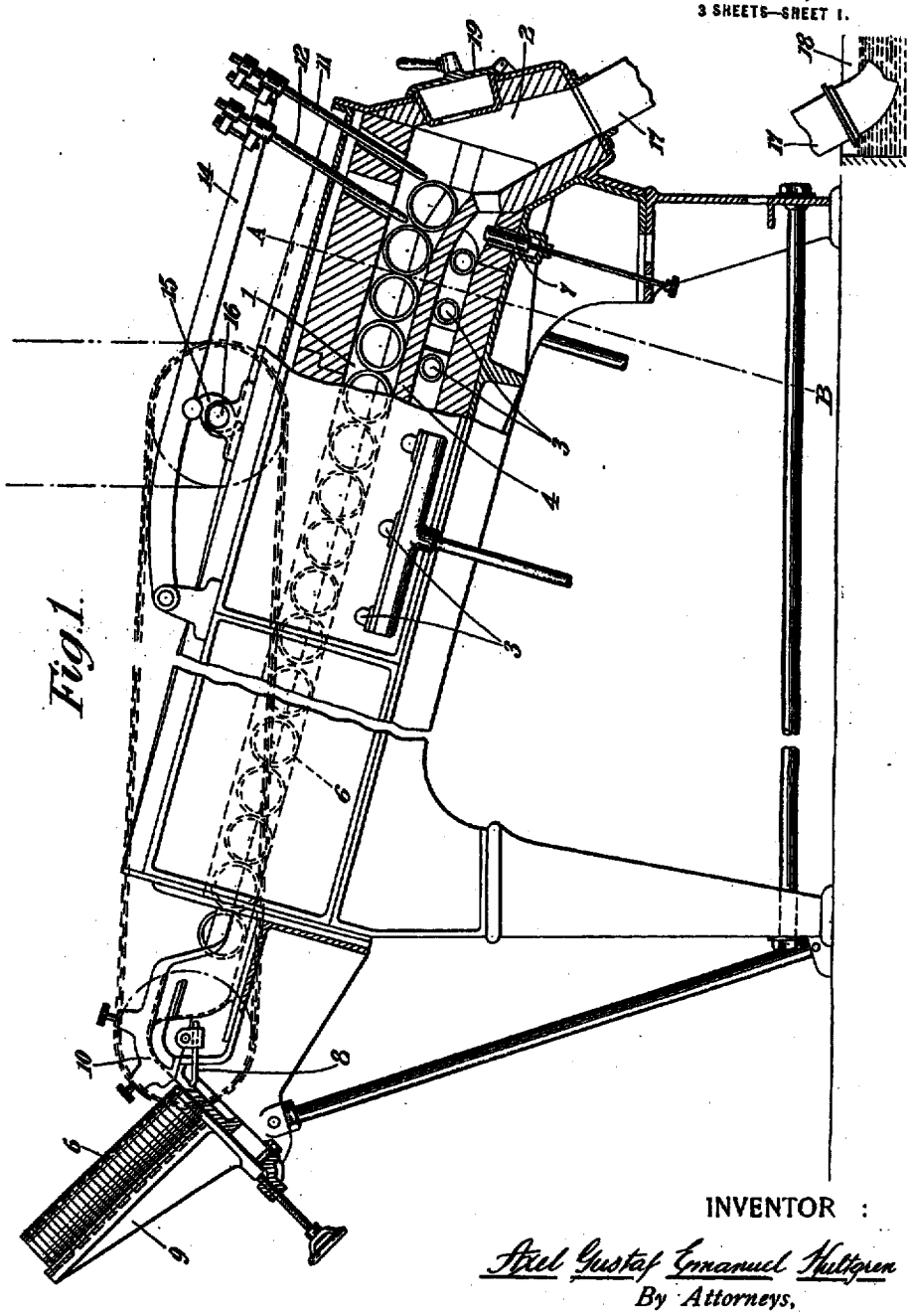


Fig. 1.

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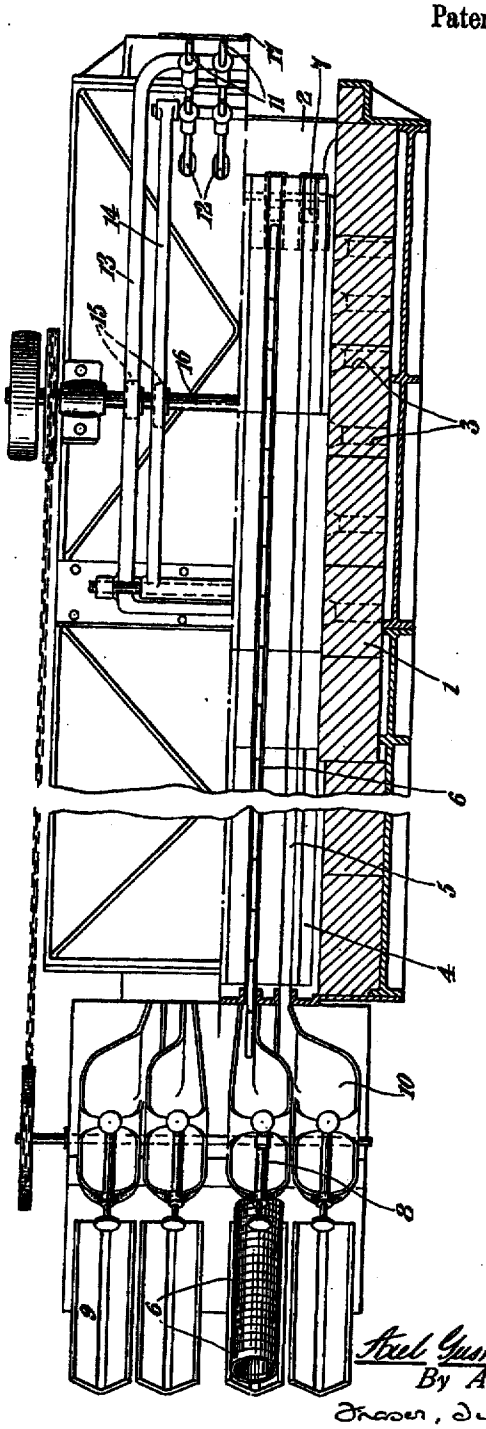
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3 SHEETS—SHEET 2.

Fig. 2.



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3 SHEETS—SHEET 3.

Fig. 3.

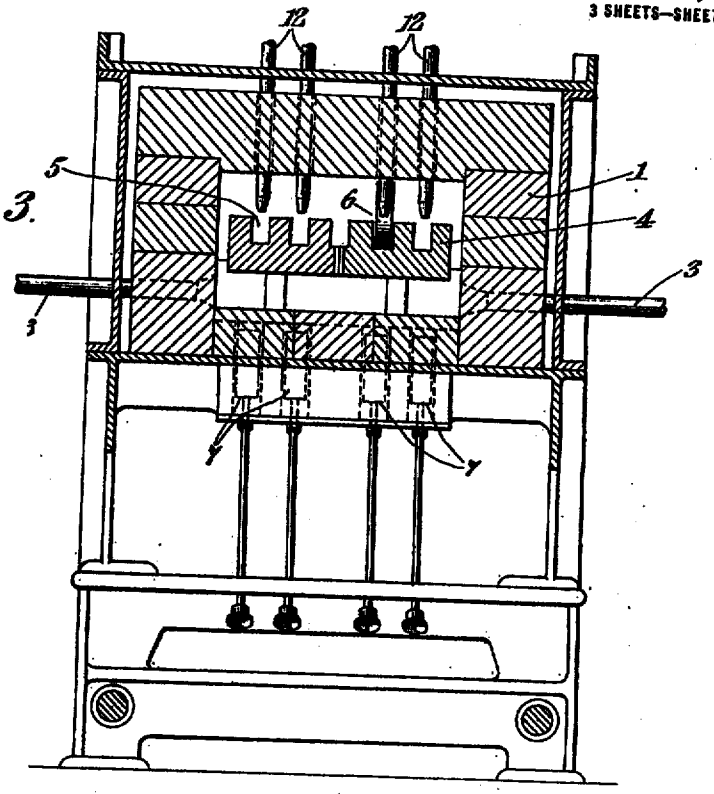
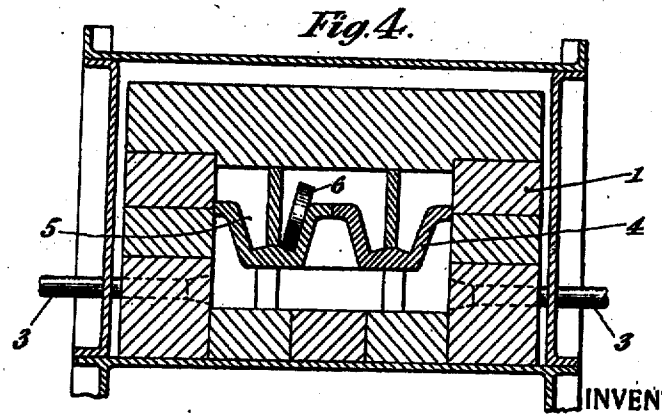


Fig. 4.



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METHOD OF HEAT TREATMENT AND FURNACE THEREFOR.

1,401,983. Specification of Letters Patent. Patented Jan. 3, 1922.

Application filed March 14, 1919. Serial No. 282,717.

To all whom it may concern:

Be it known that I, AXEL GUSTAF EMANUEL HULTGREN, a subject of the King of Sweden, residing at Gottenborg, in the Kingdom of Sweden, have invented new and useful Improvements in Methods of Heat Treatment and Furnaces Therefor, (for which I filed an application in Sweden on Mar. 4, 1918,) of which the following is a specification.

This invention relates to the heat treatment of rotatable bodies, and to furnaces therefor, particularly for heating bearing rings and washers for ball and roller bearings or blanks adapted to such rings and washers, or other symmetrical objects of circular outline, which are generically of the character of solids of revolution.

An object of the invention is to effect a uniform heating of such objects for hardening, forging, annealing, tempering, or other treatment with heat.

Another object is to bring about an automatic operation and an economical utilization of the heat supplied.

These objects are very desirable when treating bodies of the above kind with heat. Uniform heating is of great importance for the quality of the product and at the same time difficult to effect owing to the shape of said objects, which have a great extension in relation to the mass. Automatic work and rational utilization of the fuel are important factors, especially when such objects are manufactured on a great scale.

On examining critically the known types of furnaces for similar purposes, it will be found that the above desiderata are not realized simultaneously in one and the same type.

With reference thereto the non-automatic furnaces may immediately be left out of consideration, since in such furnaces no rational utilization of the escaping combustion gases for preheating the cold material takes place.

For effecting automatic operation various methods have been used, and the most important ones of such methods will be mentioned in the following.

In case of heating furnaces for small objects of round or square form, as rivets or the like, it has been suggested for said purpose to incline the bottom of the furnace, the objects thereby being caused to move through the furnace by their own weight. In this case it has not been aimed at to adjust the inclination of the bottom of the furnace in such manner that a rolling movement is effected, in order to obtain uniform heating of the objects, since no necessity therefor has been present, substantially on account of the small dimensions of the objects.

It has also been proposed by means of mechanisms operating in the furnace to cause the bodies to pass through the furnace, thus bringing about an automatic operation of the same. Such furnaces are, however, of no use in the present case, since mechanisms operating at high temperature will very soon be destroyed, and, besides, are rather complicated. Furthermore, uniform heating of all parts of the objects cannot be obtained in such furnaces, especially in those having an extended furnace chamber, it being practically impossible to effect an even distribution of heat, since the portion of the chamber near the roof of the furnace will be hotter than the portion near the bottom or vice versa.

The only way to give the objects uniform temperature during automatic feeding in a furnace the different parts of which have unequal temperature, is to effect the feeding movement, while causing the bodies to rotate at the same time.

Such a method proposed in connection with annealing furnaces consists in introducing the objects to be heated into cylindrical receptacles and causing the feed of the receptacles to take place on account of their own weight, while rolling down an inclined bottom of the furnace. This method is, however, connected with the serious inconvenience that the receptacles originally of cylindrical form will be deformed because of the influence of the heat and the load, the rolling movement thereby being prevented. In this connection it is to be noted that even small deformations are of great importance. Besides, this method is useless if the heated objects are to be subjected instantly to further treatment, as for instance hardening, forging or the like, because the emptying of the receptacles in heat is connected with waste of time, cooling of the material and other inconveniences.

According to the present invention which

relates only to heating of bearing rings and washers for ball and roller bearings or blanks adapted to such rings and washers, and similar circular objects the above-mentioned inconveniences are avoided by the objects themselves being fed through the furnace chamber by their own weight, while rolling continuously or intermittently along the bottom of the furnace which, for this purpose, possesses an exactly adjusted inclination.

The conditions to be fulfilled, in order that in such a furnace a rolling movement of all the work pieces shall really take place, will appear from the following explanation.

Supposing in the first instance that a single ring is standing on a plane inclined support having an angle of inclined α, it will be easily seen that, in case the support has an insufficient inclination, the ring, owing to the frictional contact therewith, assumes a position of equilibrium; no movement will take place. First at a certain angle of inclination the ring will commence to move, that is to say, to roll. This angle is termed the angle of rolling friction and is denoted in the following by V_{min}. The angle depends among other things on the following factors, viz. the material, the quality of the surface and the temperature of the support and of the ring as well as the weight and the size of the ring.

If $\alpha \geqq V_{min}$ the ring must be actuated by a counteracting force in order to be prevented from moving. If this force be removed, the ring begins to move down the plane, while rolling. Pure rolling will, however, take place only in case of α falling below a certain value: V_{max}. If $\alpha \geqq V_{max}$, the movement will take place in such manner that the ring is rolling and at the same time sliding on the support. This depends on the fact that the pressure against the support is so slight that the friction caused thereby is insufficient to prevent sliding. To this effect contributes also the circumstance that the component of the gravity acting in the direction of the movement is rather considerable. Summarizing the above, it will be seen that the condition of a single body having the shape of a solid of revolution and placed on an inclined plane beginning to move by itself, while rolling, is that $V_{min} \leqq \alpha < V_{max}$.

In the following the circumstances prevailing, if several rings placed in a row, one behind another, are to be fed forward, will be investigated. Here three different events are to be distinguished:

1. $\alpha < V_{min}$.

In this case a forward feed will take place only in case a power of sufficient magnitude pushing from behind be present. Otherwise, the bodies will be at rest. On investigating the conditions of each separate ring in a row, it will be seen that the foremost ring for moving has to be pressed from behind by the second ring, which is counteracted by an equal reaction pressure exerted by the first ring and, owing thereto, has to be actuated by a still greater pressure exerted by the third ring for beginning to move and so on. In other words, if any movement should be effected, the aftermost ring is to be actuated by a pressure equalling the sum of the resistances of all the rings to the movement. Between two adjacent rings there is acting a pressure which is the greater, the nearer the inlet end the ring is positioned and the less is the inclination.

In order that any ring, for instance the n:th ring in a row, counted from the forward end, shall roll during the forward movement, it has to maintain the engagement with the support, while sliding in relation to the adjacent rings, that is to say, the frictional power in the point touching the support has to be greater than the sum of the frictional powers in the points touching the two rings. The latter frictional powers are proportional to the pressures acting between the rings, and, owing thereto, are the greater, the more the ring is positioned at the back of the row, while the former frictional power caused by the component of the gravity forming right angles with the support of each ring of the row cannot exceed the value $f.P\cos\alpha$, f being the corresponding coefficient of friction and P the weight of the ring. It will therefore be evident that, concerning a certain ring of the row, as for instance the n:th ring from the forward end, the frictions against the support and the two adjacent rings may balance each other, and, consequently, no rolling movement can take place. As for all the preceding rings, the feed will take place by a rolling movement, while the succeeding rings will be fed by a sliding movement on the support. Obviously, this circumstance will be apparent, if α reaches its minimum, that is to say, if the support is horizontal. By experiments made with bearing rings of ball bearings in heat on a horizontal support n in this case was found to be = 3 to 4. If α increases, n will be greater.

2. $\alpha > V_{min}$.

In this case the feed will take place automatically. If the feed is to be controlled, a power actuating the foremost ring and directed backwards must be exerted. The aftermost ring exerts, owing to its weight, a pressure against the preceding ring which in turn actuates the next ring by a pressure twice as large and so on. The result of this will be that the conditions of pressure and friction between the rings will vary throughout the row in reversed order relatively to

the event 1. Therefore, if the first ring be allowed to pass, all the rings will be fed forward, the n aftermost rings, while rolling, and the remaining foremost rings, while sliding. If α decreases, n will be increased.

3. $\alpha = V_{min}$.

From the above it may be evident that, in case $\alpha = V_{min}$, $n = \infty$, that is to say, for this inclination, V_{min}, an infinite number of rings may, theoretically taken, be fed forward, one after another, while rolling on account of a pushing power = 0. Since in reality little differences in the frictional circumstances are unavoidable in the different rings, said proposition may be changed to the following one valid in practice: if $\alpha = V_{min}$, a slight power pushing from behind will cause all the rings of the row to be fed forward while rolling.

If α increases or decreases from V_{min}, there will be a risk of part of the rings in the row sliding; in the former case the foremost rings will slide, and in the latter case the aftermost rings. This risk is the greater, the greater is the number of rings.

Consequently, the condition of all the solids of revolution arranged in the manner described rolling, while fed forward, through a furnace of the type mentioned above is as follows:

The support carrying the work pieces should have an inclination equal or approximately equal to the angle of rolling friction under the prevailing circumstances. The lesser is the number of work pieces in one and the same row, the greater may be said angle to the horizontal, but said angle may not exceed a certain value at which, concerning a ring in the row where the pressures exerted by adjacent rings are the greatest (said pressures being caused either by the weight of the rings or by the feeding pressure), the sum of the torques of the frictional powers caused by said pressures is equal to the torques of the friction against the support.

This invention provides a method of heat treatment and a furnace therefor wherein the bottom or hearth of the elongated and nearly horizontal furnace chamber through which the rings or other objects roll in series, has a slope which accords with the conditions hereinbefore stated, with controllable means for heating the chamber to the required temperature, and means for determining or controlling the rate of progression of the rolling objects through the furnace. The invention further comprises other features of method and apparatus, as will be defined in the claims. The heating devices are placed in correspondence to the use of the furnace. They are generally located along a part only of the chamber, counted from the outlet end. In annealing furnaces they may be placed along the middle portion of the chamber, no heating devices being provided at the outlet end. In all cases the inlet end is heated by the escaping gases of combustion only. The inclination of the bottom is equal or approximately equal to the angle of rolling friction under the circumstances prevailing. By this it is attained that the rings or washers introduced at the higher end of the chamber pass through it owing to their own weight, while rolling intermittently or continuously, thus being heated uniformly. The speed is so controlled that the rings, when passing through the furnace, receive in a suitable place such maximum temperature or are subjected to such heating or cooling as is intended by the heating process in question.

The control of the progress of the rings or objects through the furnace chamber is best accomplished by introducing checking or retarding means at or near the discharge end, such means being adapted to passively or actively stop or retard the rings at such end, with provision for discharging the rings one by one at suitably timed intervals. Preferably intermittently-acting releasing or discharging means are provided at the outlet end, and intermittently-acting infeeding means at the inlet end, these respective means being driven from the same source and at the same effective rate of speed, so that for each ring discharged at the outlet, a new ring is introduced at the inlet, thereby keeping the furnace chamber always filled with rings undergoing treatment.

A preferred embodiment of a hardening furnace constructed according to the invention is illustrated in the accompanying drawings in which—

Fig. 1 is a side view and partially a longitudinal section of the furnace. Fig. 2 is a plan view and partially a horizontal section thereof. Fig. 3 is a cross-section on line A—B in Fig. 1. Fig. 4 is a section corresponding to that shown in Fig. 3 and illustrating a somewhat modified form of the bottom of the furnace.

Referring to the drawings, the furnace consists of an extended channel 1 made of brick-work, the foremost portion of which situated next to the outlet opening 2 is provided with gas burners 3 for heating the channel to the temperature desired. Disposed in the channel is an inner bottom 4 provided with longitudinal recesses or grooves 5 guiding the rings 6 to be heated and having an inclination so adjusted in the manner mentioned above that the rings placed in said grooves are caused to roll through the furnace by their own weight. Preferably, the said bottom 4 is freely accessible in the interior of the channel so as

to be capable of being enwrapped by the flames of the gas burners at the sides as well as at the foremost end. The supply of heat at the said end is controlled by means of valves or dampers 7, adjustable up or down by screws, one for each groove 5 in the bottom 4, and positioned at the lower, foremost portion of the channel. The introduction of the rings 6 taking place at the back of the furnace is preferably effected automatically by means of rotating arms 8 catching the rings 6 which are placed in a suitably inclined magazine 9, said arms causing them to mount a sloping track 10 from which they drop in such a manner as to remain standing on the edge in the grooves leading to the furnace. This feeding apparatus is set forth in detail in my application filed August 10, 1918, Serial No. 249,366. The present invention is not limited to this or to any specific feeding-in mechanism. By the use of a feeding device of this kind it is attained, in conjunction with a reliable and continuous supply of rings to the furnace, that the rings dropping from the sloping track push, when entering the furnace, the aftermost ring in each row, said action being propagated through all the rings in the row, thus preventing interruptions or disturbances of the accurate feed of the rings in the furnace caused for instance by small particles entering the furnace or disengaged from its walls. The rate of feed is controlled by means provided at the foremost or discharge end of the furnace and, preferably, acting to advance the rings intermittently, that shown consisting of stop rods or slides 11, 12 supported by arms 13, 14 which are actuated by means of cam disks 15 secured to a rotating shaft 16 so as to raise the stops 11 and 12 alternatingly. As the stop 11 is raised, the foremost ring in the row will be released so as to be capable of dropping through the chute 17 into the hardening bath 18, while the stop 12 blocks the remaining rings. The stop 11 is then dropped and the stop 12 raised, which releases the end ring and allows it to roll freely down until stopped by the stop 11, this movement being propagated successively through all the rings behind, so that the frictional traction between them is successively released, and all the rings in the row roll forward one step or space. The rate of feed is so controlled that the rings are heated to the temperature desired, before being let out of the furnace.

Owing to the rings rolling through the furnace, that is to say, directing always varying parts of the periphery toward the surrounding parts of the furnace having different temperatures, a quite uniform heating of the rings and accordingly also a uniform hardening of the same are secured. The combustion gases formed in the foremost part of the furnace and passing through the same in opposite direction to the rings, transfer successively the heat to the latter. By this a rational utilization of the heat supplied is obtained.

The described mechanism contributes in an important sense to this result by insuring that the rings shall roll forward at each movement a distance equal to their diameter, whereby each ring turns a scant third of a revolution (3.1416÷3) at each movement, so that in each stopping position a new portion of the ring rests against the heated hearth and the ring is newly positioned to the hot gases circulating above; and so that after each third feed the ring has performed less than one complete revolution, with the result that the successive points of contact with the hearth are never the same, but instead progress circumferentially around the individual rings, thus insuring in a most perfect manner the uniform and symmetrical heating or heat treatment of the rings, so that each ring may receive the same treatment around its entire circumference as the result of its passage through the furnace.

The chute 17, being preferably in close conjunction with the outlet end 2 of the furnace and so inclined and shaped that in this chute also the rings 6 are caused to roll, is closed at all sides and extends below the surface of the hardening bath 18 thus forming a liquid seal which prevents cold air from entering the furnace at the outlet end. Furthermore, at said end an inspection opening having a door 19 is provided, through which, if desired or required, the foremost rings in each row are accessible from the outside also.

In Fig. 4 a somewhat modified form of the bottom 4′ of the furnace as illustrated. This form differs from that shown in Fig. 1 chiefly in that one side wall and the bottom of each groove 5′ are inclined in lateral direction thereby causing the rings 6 to assume an oblique position in which they are guided by the inclined side wall and the bottom. This embodiment affords the advantage that rings having different widths may be placed in the groove 5′, without changing the width of the groove. Furthermore, in such grooves rings or washers may be guided the periphery of which is formed according to any other surface of revolution than the cylindrical surface shown, as for instance a conical exterior, or an exterior which is non-equatorial spherical zone, as is the case with the supporting rings of certain self-adjusting axial ball-bearings.

The furnace is not limited to heating with gas but may, of course, be heated by any other kind of fuel, as for instance oil or

solid fuel. Nor is the freely disposed bottom of the furnace shown in the drawings indispensable, since the furnace chamber may consist of a single channel.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. The method of heat treatment of symmetrical circular objects constituting solids of revolution, which consists in passing them in a continuous succession through a long chamber in which they are directly exposed, the bottom of which chamber has such inclination that the objects advance with a rolling traction on the bottom while sliding against one another at their points of tangential contact, simultaneously heating such chamber, and controlling the progress of the objects through the chamber at such rate with reference to their mass and to the temperature and length of the chamber as to subject each of the successive objects during its rolling progression to the prescribed heat treatment.

2. The method of claim 1, the control of the progress of the objects being accomplished intermittently at the discharge end of the chamber by the successive release of the terminal objects and, whereby as each object is released it is free to roll forward independently of those behind it, which follow in succession, so that as each object is freed from restraint by the one ahead, it tends by starting forward to reduce the restraining engagement with those behind.

3. A furnace for heat treatment of rings or analogous symmetrical circular objects constituting solids of revolution, comprising an elongated furnace chamber adapted to hold a considerable series of such objects in serial contact and exposed directly within said chamber having means for laterally engaging and guiding the objects during their rolling progress to hold them substantially upright, and, said chamber having a sloping bottom of such inclination that the circular objects advance by gravity with a rolling traction on the bottom while sliding against one another at their points of tangential contact, with means for admitting said objects at the higher end, an outlet at the lower end, means for controlling the rate of progress of such objects through said chamber, and means for heating said chamber and for controlling the temperature thereof, whereby to determine the duration and extent of the heat treatment of the objects therein.

4. A furnace according to claim 3, having intermittent means for controlling the progress of the objects, acting upon the objects at the outlet end of the chamber, said means adapted to release and arrest the terminal object and afterward to release the next following object, whereby to feed forward the entire series one space.

5. A furnace having an elongated heating chamber with a sloping bottom and longitudinal lateral guiding means, adapted to hold a series of rings or analogous objects and cause them to progress through it by rolling in an upright position by force of gravity, and intermittent feeding mechanism at the outlet end including two alternately acting stops, the one adapted to hold and release the terminal ring, and the other to hold and release the next ring in series whereby the remaining rings of the series are held by engagement each with the preceding one.

6. A furnace according to claim 5, the stops movable out of and into the path of the rings, and rotative means for so moving them alternately.

7. A furnace according to claim 5, the stops consisting of rods entering the furnace chamber, levers carrying the rods, and a rotary cam moving said levers alternately.

8. A furnace according to claim 3, having means for successively discharging the objects from the outlet of the chamber, means for successively feeding in the objects at the inlet end, and driving means impelling both said means at equal effective speeds.

9. A furnace according to claim 3, the guiding means being a channel in the furnace bottom adapted to laterally engage the objects as they progressively roll through the chamber.

10. A furnace according to claim 3, having a bottom or hearth over which the objects roll, with a combustion chamber beneath such bottom, with means for affording communication for combustion gases at the sides of said bottom, whereby hot gases may flow from beneath the furnace bottom to the chamber above.

11. A furnace according to claim 3, having a bottom or hearth over which the objects under treatment roll, with a combustion chamber beneath said bottom, said hearth having multiple channels for guiding the objects as they roll through the chamber in a plurality of series, burners introducing combustible to said lower chamber, and dampers for controlling communication with such chamber near the discharge end of the furnace.

12. A furnace for heating bearing rings and washers of ball and roller bearings and blanks of such rings and washers, comprising an extended channel, means for introducing said work-pieces into the furnace, two bottoms in said furnace one of which being positioned above the other and supporting said work-pieces, means for heating the work-pieces to the necessary temperature and placed between the bottoms, apertures in the upper bottom admitting the

heat to the work pieces, and grooves in said upper bottom adapted to guide the work-pieces, each of said grooves having side-walls and bottom inclined in lateral direction, the upper bottom having an inclination about corresponding to the angle of rolling friction under the circumstances prevailing and adapted to cause the work-pieces to roll through the furnace by their own weight and to be heated to the temperature desired.

In testimony whereof I have signed my name.

AXEL GUSTAF EMANUEL HULTGREN.