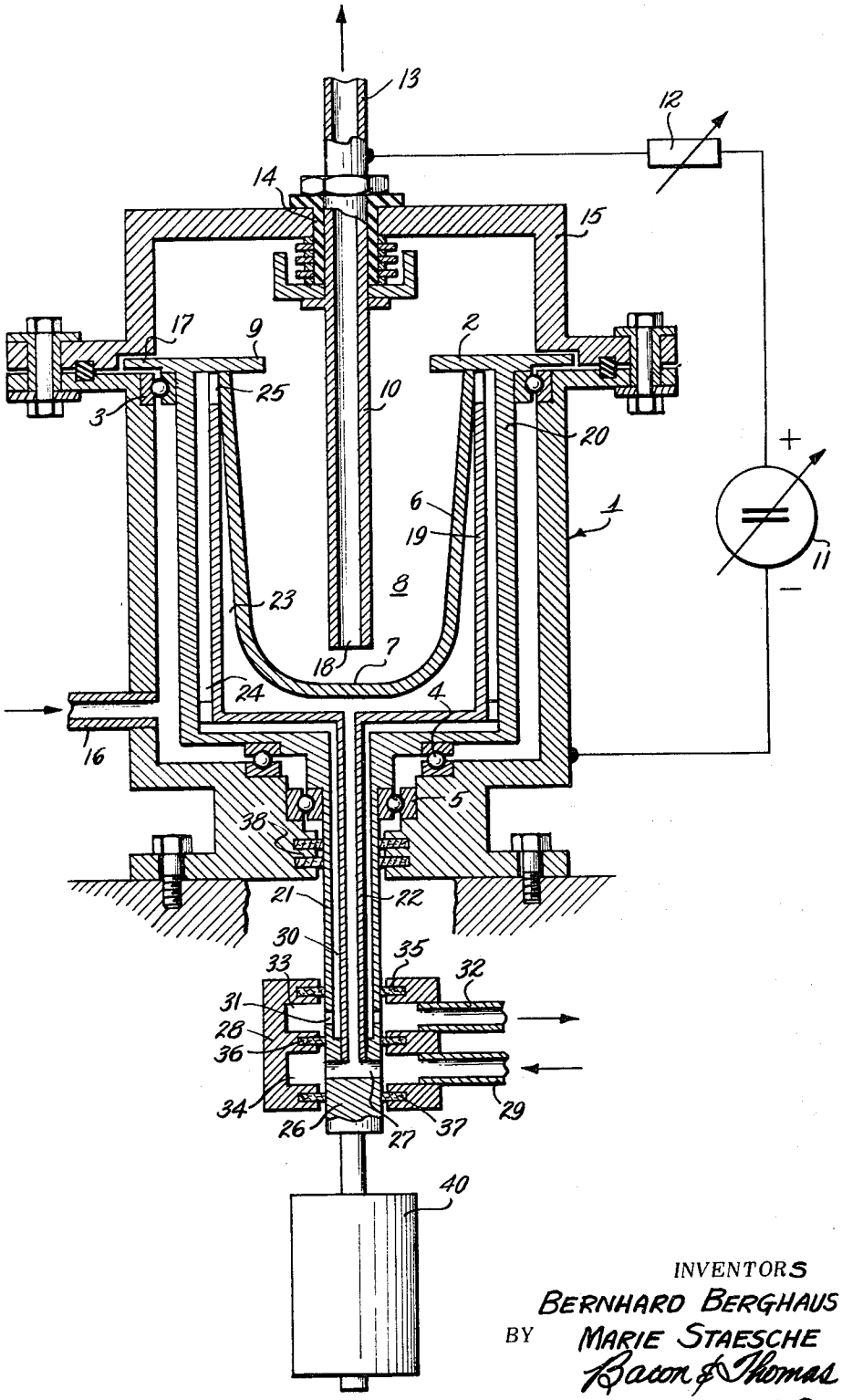
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METHOD AND MEANS FOR TREATING ARTICLES ON ALL SIDES

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METHOD AND MEANS FOR TREATING ARTICLES ON ALL SIDES

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ABSTRACT OF THE DISCLOSURE

An improved process is provided for treating small metal articles with a gaseous medium by glow discharge whereby all surface areas of the articles are exposed to the gaseous medium. The exposure of all metal surfaces to the gaseous medium results by subjecting the metal articles to both centrifugal and kinetic forces in a cylindrical drum.

The invention relates to a method and means for treating the surface of parts, members and components, in particular of rolling bodies such as balls and rollers, on all sides.

In order to treat the surface of a rolling body on all sides, such as for the surface refinement of a ball in a gaseous medium, the refining elements have to act uniformly on all the surface parts. This, however, is difficult since the balls have to have a bearing face. The refining elements may be rendered easily accessible to all the other surface portions with the exception of the bearing face or contact surfaces with other balls, by letting pass the gas containing the refining element between the balls, but a uniform refinement (tempering) of these remaining surface portions cannot be attained therewith either, since the rate of flow and, therefore, the supply of refining (tempering) elements at different points of these remaining surface portions would be entirely different. For example, the flow velocity in the immediate vicinity of a bearing or contact surface would be substantially less than in the center between two adjacent bearing or contact surfaces.

The object underlying the invention is, therefore, to provide a method and a means for carrying out such method, for an all round uniform treatment of the surface of parts, in particular of rolling bodies such as balls and rollers, in a gaseous medium.

According to the present invention, such object is attained by producing centrifugal and kinematic forces acting on said parts, by means of which said parts on one hand are held on a carrier and, on the other hand, are kept in movement on said carrier continually or at least at times.

The method preferably is carried out so that the parts, for the purpose of producing said centrifugal and kinematic forces in a drum or trough are given a rotary motion about the axis of said drum or trough and to a motion relative to the inside wall of the drum or trough, which forms the carrier, said motions being produced by rotating said drum or trough.

The method disclosed by the present invention is suitable for surface refinement (tempering or heat treatment) in particular, in which the surfaces of said parts are nitrided, siliconized, boronized or phosphatized. The surfaces of said parts preferably are subjected to a reducing treatment prior to or during the introduction of refining elements, preferably in atomic hydrogen.

According to a further form of the method disclosed by the invention, the surfaces of said parts are degassed by vacuum treatment at increased temperature and then, or in the given case after introduction of refining elements, introduced into a liquid of which the surface tension is substantially less than that of water. Thereby—for the treatment of parts subjected to a high rate of wear, in particular of rolling bodies such as balls, rollers and the like—said parts after degasification or after introduction of refining elements are brought into a fatty alcohol sulfonate, preferably into Turkey red oil, or into a mixture containing at least one fatty alcohol sulfonate.

The method of the present invention may be carried out to special advantage in a gaseous atmosphere ionized preferably through a gas discharge. Said parts preferably are treated in a gaseous atmosphere ionized through glow discharge and connected via said carrier as one of the electrodes, preferably as cathode of the glow discharge.

The method according to the invention offers great advantages in particular in the treatment of ball-pen parts such as cages and/or balls. Preferably ball-pen balls treated are made of a steel alloy that in a refining or tempering operation, such as nitridation in particular, in an ionized atmosphere yields a hardness of more than 800 Vickers, preferably more than 1000. Particularly suited is the treatment of ball-point balls made of a steel alloy comprising from 5 to 20% chromium, preferably from 12 to 16%.

For carrying out the method according to the invention, preferably an apparatus is used in which is provided as carrier a container that is substantially symmetrical in a rotary respect, conveniently termed a drum or trough, and which further is provided with means to rotate the container. The container axis suitably is vertical, and the container conveniently is provided with a circular bottom. The apparatus advantageously is provided with means for cooling the container. Of special advantage are devices comprising a multi-wall trough forming the container, a cooling system disposed between the inside and outside walls of the trough, hollow shaft disposed on the trough bottom coaxial to the trough axis and trough which the coolant is supplied and drained and the energy is transmitted for rotating the trough, and means for feeding the coolant into the hollow shaft and for draining the coolant from the hollow shaft. In many cases it may prove suitable to provide means for heating the container from outside. Such means for heating from the outside suitably may comprise means for producing a gas discharge, preferably a glow discharge, on the outside wall of the container.

Suitably in apparatus for carrying into effect the method disclosed by the invention, said container itself may be formed and constructed as discharge vessel. In such case it also is possible to make the container rotate within a coolant, for example in a cooling-water reservoir. Preferably the container outside wall is provided with baffles of such shape that the coolant in rotation of the container is moved so as to ensure a good heat convection. For example, such baffles may be given the form of a spiral coil surrounding the container, whereby in rotation of the container a coolant flow is obtained in direction of the container axis.

Preferably apparatus for carrying out the method according to the invention is provided, however, with a container that is rotatable in a stationary discharge vessel. In such case the container in the form of a multi-wall trough, as indicated above, is of special advantage. Such a device suitably comprises drive means disposed outside the discharge vessel to produce the container rotation, a shaft passing through the wall of the discharge vessel for connecting the drive means to the container, and packing means for passing the shaft through the wall of the discharge vessel in a vacuum-tight manner.

Inside the container and conveniently coaxially to the container axis, there suitably is provided an electrode. Said electrode suitably is connected to a pole of a voltage source, and the container to the other pole thereof.

The electrode and/or the container suitably are connected to the voltage source through the discharge-vessel wall by isolated bushings provided with a protection-slit system. In such case, preferably a tube is provided which protrudes into the container and passes through the discharge-vessel wall and additionally serves as gas pipe, preferably for the gas discharge, the tube mouth suitably being covered with a fine mesh net of electrically conducting material.

The present invention will be explained in more detail with the aid of a means—shown in the drawing—for carrying out the method disclosed by the invention and as applied to a method of nitridation of ball-pen balls.

In the drawing, a trough **2** in a discharge vessel **1** is rotatably mounted with the aid of ball bearings **3** to **5**. The latter are so arranged that the trough can rotate in said vessel up to relatively high speeds without risking disturbances in the run of the trough. A carrier for the ball-pen balls to be nitrided is provided by the inside wall **6** of trough **2**. In order to distribute the ball-pen balls over said inside wall, the balls at the start of the operation and while the trough is still at rest, are poured on the floor **7** which extends to the inside wall **6** and defines therewith a chamber **8**, whereupon the trough is rotated by motor or the like **40**.

Thereby first the balls on the floor **7** are made to rotate so as to produce centrifugal forces that act on the balls to spread same over the inside wall **6**. When further increasing the speed of the trough, the balls rise higher and higher on the conically widening inside wall **6** until at a certain speed said wall and the floor **6** are covered with one layer of balls only. When raising the speed, the centrifugal forces acting on the balls are increased more and more too, so that the balls are fastly held on the inside wall that forms the carrier element and only can move along the plane of the latter. To prevent the balls from running upwardly beyond the top edge of the trough, the inside wall **6** at its upper end is provided with an overhang **9**.

It will be noted that the start of the trough and the increase in the speed thereof, in particular within the range of speeds that are relatively low in comparison with the average operational speeds, have to be as low and as steady as possible so as to maintain the adhesive friction of the balls on the carrier during the entire increase in the speed. For, in order to bring the balls into the desired rotation, forces of acceleration have to be transmitted on to same, and these forces shall not exceed the maximum permissible forces of the adhesive friction. As soon as the average speed of the trough has been reached and the balls have been distributed in one layer over the inside wall **6**, nitridation of the balls may set in.

In the present case, the balls are nitrided under the action of an electric glow discharge. To such end an electric glow discharge is produced between the electrode **10** and the inside wall **6** on reaching the average operational speed. Nitridation then is effected as in the case of known glow nitridation processes. The inside wall **6** for this purpose has to be under a negative voltage at least at times, i.e., it has to be connected as cathode. The operating voltage for producing the glow discharge is supplied by the regulable continuous-voltage source **11**. In place of one such regulable direct-voltage source may be used a similar source having a constant voltage and a regulable series resistor **12**. It is of course also possible as in the case of known glow nitridation processes, to use an alternating-current voltage source in place of a direct-voltage source. Use of an alternating-current voltage source for the current supply is of advantage in particular when during nitridation material is removed from electrode **10** in the form of dust and deposited on or applied to the balls to be treated. It also is possible to supply the electric energy in the form of pulses and to provide for such purpose a pulse generator in place of the direct-voltage source **11**.

In the embodiment shown in the drawing, the whole trough **2** and the discharge vessel **1** is under a negative, i.e., cathodic potential. To supply this negative potential, the negative pole of direct-voltage source **11** is connected to discharge vessel **1**. The positive pole of source **11** via series resistor **12**, that preferably is regulable, is connected to the current conductor **13** which by means of an insulated bushing **14** provided with a system of protection slits, is passed through the cover **15** of the discharge vessel. In the discharge vessel, the current conductor **13** protrudes into the trough **2** and forms the anode **10**.

For carrying out the nitridation process, a glow discharge is produced along inside wall **6** which covers the latter completely. The discharge power density of this glow discharge on the inside wall **6** that is under cathodic potential, and on the balls electrically connected to said wall and therefore also cathodically connected, is proportioned in equivalent manner as in the known glow nitridation processes. It will be noted, however, that overheating of the relatively small ball-pen balls has to be avoided.

Nitridation is carried out in flowing gas, preferably in ammonia or in a mixture of nitrogen and hydrogen. In the example shown in the drawing, gas is supplied to the discharge vessel through the pipe **16**. The gas flows via a slit defined by the bottom portion and the cover of the discharge vessel as well as an edge **17** provided particularly on the trough **2**, into the discharge space proper. This narrow slit and the edge **17** are provided to prevent the ingress of particles into the ball bearings as dusted off through cathode sputtering. The effect of the edge **17** and the slit confined thereby, i.e., the prevention of the penetration of particles into the ball bearings, is assisted by the gas flow, since the gas flowing through the supply line **16** has to flow in the direction opposite to that of any movement of particles through the slit towards the bearings. Thus the penetration of particles into the ball bearings is totally prevented. To drain the gas from the discharge vessel, conductor **13** is made tubular. As the mouth of this gas draining pipe that is formed by the current conductor, is positioned at the lower end of the trough, the gas is forced to flow along the cathode or, respectively, along the balls to be nitrided, whereby is ensured a continual supply of fresh gas to the gas atmosphere enveloping the balls, a thorough scavenging of the discharge vessel and a quick removal of any possibly appearing undesired gases. The tube opening of the conductor **13** that forms the gas discharge line, is covered by one or more fine-mesh net **18** to prevent the formation of a discharge within the tube.

A special problem is the avoidance of overheating the small ball-pen balls. Such overheating is counteracted by cooling the cathodic inside wall **6**. Such cooling, however, is difficult as it has to be maintained during operation and thus during rotation of trough **2**. To such end, trough **2** is formed as multi-wall trough provided with an intermediate trough-like wall **19** surrounding inside wall **6** and an outside wall **20** also of trough-like configuration and surrounding said intermediate wall, and with a hollow shaft **21** disposed coaxial to the trough axis on the bottom of said outside wall **20**. Within shaft **21** is provided a tube **22** that opens in the bottom of the trough-like intermediate wall **19**. The latter and the trough-like outside wall **20** are so formed and disposed as to give origin to two trough-like hollow spaces **23**, **24** between the inside wall **6** and the intermediate wall **19** as well as between the latter and the outside wall **20**, which hollow spaces only intercommunicate through connecting ducts **25** disposed at the upper end of intermediate wall **19**. Hollow space **23** via pipe **22** and ducts **27** provided in the extension **26** of hollow shaft **21** as well as via the transmission **28** com-

municates with the coolant supply line **29**. Hollow space **24** via a hollow space **30** formed between hollow shaft **21** and pipe **22** and via ducts **31** provided in the hollow shaft, as well as via transmission **28** communicates with the coolant draining line **32**. The stationary transmission **28** for feeding the coolant into the rotating shaft and for draining same from the latter, is indicated only in principle and essentially comprises an assembly forming two hollow spaces **33, 34** annularly surrounding the shaft. The hollow spaces **33, 34** are sealed relatively to each other and relatively to the shaft by means of the packings **35** to **37**, and one of said hollow spaces communicates with the coolant supply line **29** and the other with the coolant draining line **32**. By means of said transmission **28** and the formation described of trough **2** and shaft **21** it is possible to properly cool the inside wall **6** (that is operated as cathode) and thereby also the ball-pen balls present on said inside wall, during rotation of the drum. To such end a coolant is supplied via coolant supply line **29** which flows across hollow space **34** and the ducts **27** first into pipe **22** and thence through hollow space **23** and along the outside of interior wall **6**, thus cooling the latter. The heated coolant then flows off again through the connecting ducts **25** and hollow space **24** into hollow shaft **21** and hollow space **30**, and reaches the coolant draining pipe **32** via the ducts **31** and hollow space **33**. It will be noted that the intermediate wall **19** as well as the pipe **22** preferably should be made of a material of which the thermal conductivity is as low as possible in order to transmit as little heat as possible from the coolant (already heated) flowing out from the hollow spaces **24** and **30** on to the coolant in hollow space **23** as well as on to the coolant supplied through pipe **22**.

It has to be noted yet that the packing **38** for passing shaft **21** in a vacuum-tight manner through the wall of discharge vessel **1**, is indicated in principle only. Vacuum-tight bushings for rotating shafts have already become known in various executions and need not be described here in detail.

For the purpose of attaining a treatment of the parts that is uniform on all sides, in the present case therefore a nitridation of the ball-pen balls uniform on all sides, forces acting on the parts have to be set up which give these parts a motion relatively to the carrier, i.e., to inside wall **6**. These kinematic forces may be produced, for example, by alternatingly raising and lowering the speed of trough **2** with respect to the mean operational speed. It is also possible, however, to continually and slowly raise the speed during the first half of the treatment time, and to lower same continually again during the second half of the treatment period. Other possibilities reside in the stepwise increase of the speed or in the generation of discontinuities in an otherwise constant speed. The kinematic forces also may be produced through a special configuration of the trough.

In any case, however, the parts to be dusted or powdered have to be kept in motion as continually as possible on the carrier surface, at least however from time to time. For through this continual motion, other surface portions of the parts to be treated are brought again and again under the immediate influence of the glow discharge so that in the average a uniform treatment of all the surface portions is attained.

The present method has proved excellent, in particular for the refining treatment of ball-pen balls. The main requirement for the latter is the assurance of a uniform ink flow. The ink or dye material is transferred from the ball-pen ball into the writing paper by rotation of the ball. The ink flow thereby is effected by the gravitational action of the ink and the capillarity of the gap between ball and cage. It is obvious that the forces maintaining the ink flow are very small and that even slight deviations from the true spherical shape and slight impurities on the ball surface are troublesome and inconvenient. Such impurities, contaminations and irregularities of the ball surface arise mainly on the basis of corrosion, for example on the basis of surface oxidation or corrosion between the ball and a protective layer surrounding same. Fats too prevent a uniform flow of ink.

The initially used steel balls which after short use gave rise to contaminations and corrosion of the surface and thus to irregular ink flow and smearing, soon were replaced by balls made of stainless steel, but the writing properties of the ball pens were not substantially improved thereby. Balls of corundum, anodically treated aluminium and, of late, also of tungsten-carbide and even diamond balls have been used. Such balls raise the price of the ball pen substantially, but the irregular ink flow is not satisfactorily eliminated thereby. Moreover, tungsten-carbide balls or diamond balls are unsuited for soft glueless paper grades in particular, owing to their extraordinary hardness.

Exact investigations have shown that the difficulties with ball-pen balls have their origin in the impurities which remain on the ball surface even after the cleansing operation which terminates the manufacturing process. It has been found that the conventional surface-cleansing processes of mechanical and chemical types are not capable, neither singly nor in combination, of effecting sufficient cleansing of the surface of ball-pen balls. This, after all, is the source of all the difficulties with which even the best ball pens are still affected today.

With the aid of the present method, however, we succeed in obtaining an entirely clean ball surface by treatment in an atmosphere that preferably is ionized by glow discharge, which can be permanently maintained when the ball-pen balls are subjected to a surface improvement (refinement or thermal treatment) immediately subsequent to the conventional cleansing operation or simultaneously therewith.

Maintenance of a completely clean ball surface may be facilitated yet by immersing the balls into a liquid which acts in a conserving way and of which the surface tension is substantially less than that of water, for example in a fatty alcohol sulfonate such as Turkey red oil. The pores still remaining on the surface absorb such liquid, and further the balls are coated with a thin layer of liquid which due to the anchorage in the pores adheres very firmly to the surface and yields a perfectly smooth, corrosion-protected and wettable ball surface.

When ball-pen balls are treated in accordance with the present method, the balls do not have to be made of a particularly high-grade material; on the contrary any steel is suited as material for the ball-pen balls. In spite of the use of cheap steel, ball-pen balls treated according to the present method show and possess better properties and characteristics than conventional and known ball-pen balls.

It is very suitable and satisfactory also to subject the cages of ball-pen balls to a treatment according to the present method too. In particular is recommended a vacuum cleansing treatment with subsequent saturation in a fatty alcohol sulfonate such as Turkey red oil, or in mixture comprising at least a fatty alcohol sulfonate. By such treatment of the cages, the properties of the ball pens comprising same will be further improved.

Although the results of the treatment are generally better when operating in an ionized atmosphere, the present method is not limited to such a mode of operation. For example, the ball-pen balls may be subjected to a gas nitridation according to the present method in lieu of the glow nitridation described in the example. In such a case also is obtained a perfectly uniform surface refinement or improvement owing to the continual movement of the balls. The same holds true, of course, for cleansing methods and other refining methods which take place without any action of an ionized atmosphere.

It has to be noted further that the method disclosed herein is not limited at all to parts of ball pens but is very well suited also for the uniform treatment of other

parts and components such as rolling bodies in the form of balls and rollers, in particular balls and rollers for antifriction bearings. Such parts may be subjected, for example, to a nitriding, carburizing, boronizing or siliconizing process, or also to a reducing treatment with the aid of hydrogen. Further, the parts to be treated also may be subjected to a surface-cleansing operation, for example in a hydrogen atmosphere, and to annealing processes such as in an atmosphere of inert gases. In many cases it is recommended to produce the requisite treatment temperatures directly on the surface of the treated articles through cathodic heating in a glow discharge effected in the abnormal cathode fall of potential. The surface treatment according to the method disclosed by the present invention has practically proved very satisfactory in particular for the surface improvement or refinement, mainly for the nitridation and carburization of bell-pen balls and ball-bearing balls as well as of rollers for roller bearings. The balls were nitrided perfectly uniform in an atmosphere of ammonia and hydrogen for example, as shown by pertinent investigations with the aid of polished microsections. Microscopic examinations also showed the perfect egality and regularity of the surface treatment.

Further, operations were successful in which through cathode sputtering of the carrier surface, material is removed from this surface in the form of dust and is immediately transferred on to the balls moving on the carrier surface, so that the balls after execution of the method were coated with a uniform surface layer of the carrier material.

In order to carry out a successful impregnation of the articles it is desirable to get a dispersation of at least 1 g. per cm.^{2}, to which if need be a gas with high atomic weight is conducted into the process.

We claim:

1. In a method of nitriding the surfaces of metallic balls by treatment in a rotating drum within a nitrogen-containing gas atmosphere, the steps of: rotating a drum about an axis generally parallel to an inner surface thereof defining a ball confining surface; spreading a multitude of balls in a single layer on said surface whereby centrifugal force will hold said layer thereon; and cyclically changing the speed of rotation of said drum whereby to change the positions of all said balls on said surface.

2. The method defined in claim 1 including the further step of: providing an electrode within said drum and spaced from said surface; and producing a glow discharge between said surface with the balls thereon and said electrode whereby to nitride the entire surface of each of said balls.

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