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(54) **BIODEGRADABLE POLYMER PROJECTILE FOR NON-LETHAL FIREARMS, USABLE BY RECREATIONAL-SPORTING SHOOTERS**

(57) A biodegradable polymer projectile, in particular for non-lethal firearms, usable for recreational-sporting purposes and equipped with a barrel and inert gas for the expulsion of the projectile itself, has a spherical or ogival shape and a surface working and a distribution of the internal masses configured to be stable to the penetration of the air.

A process for the production of a biodegradable polymer projectile, in particular for non-lethal firearms, us-

able for recreational-sporting purposes, characterized in that it is provided with the following steps: mixing a biodegradable polymer to be used for producing the projectile; pressure injection of the same polymer inside multiple imprints molds from which the raw projectile will exit, after having been shelled out from the casting container; in which the desired reference weight can be obtained by calibrating the density of the polymer mixture; said projectiles being spherical or ogival.

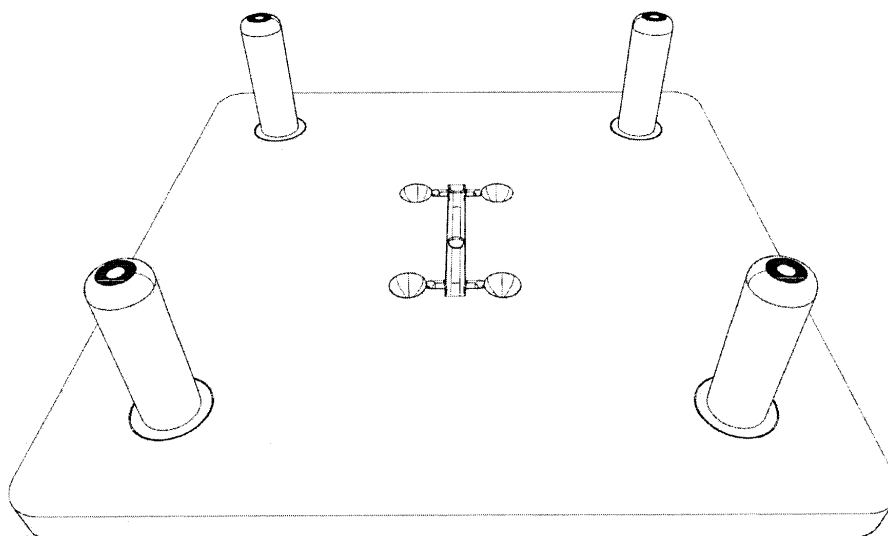


FIG. 2A

Description

[0001] The present invention substantially relates to the field of ammunition for freely sold firearms, i.e. non-lethal firearms, usable by recreational-sporting shooters.

[0002] More specifically, the invention is a spherical 0.43 gauge (10.80 ± 0.01 mm) projectile made of a biodegradable polymer.

[0003] To this end, it is worth noting that the term "projectile" in ballistics and military terminology means the body which is expelled from a firing mouth, while "bullet" means that body which may be launched: this is an etymological subtlety which however is not perceived in common use.

[0004] According to the present invention, such a projectile has the feature of being stable to the penetration of the air due to the particular surface working and distribution of the internal masses.

[0005] The object of the invention is to be usable with firearms catalogued as free sale firearms, with muzzle power expressed less than 7.5 Joules, with 0.43 inch gauge, in order to recreate the ballistic features of the trajectory of firearms within the limit usable by recreational-sporting shooters, i.e. from 5 m to 15 m, while maintaining the specific non-lethal features of the aforesaid type of firearms.

[0006] A better comprehension of the invention is obtained with the following detailed description and with reference to the accompanying drawings which show a preferred embodiment of the invention by way of non-limiting example.

[0007] In the drawings:

figure 1 is a photograph showing the distribution of the micro bubbles in the projectile;

figures 2A, 2B and 3 show a multiple imprints mold, preferably made of steel, for the production of projectiles;

figure 4 is a photograph of the raw balls produced by molding;

figures 5 and 6 show the rotatable plate and the finishing grinding wheel used for grinding the raw balls;

figure 7 is a photograph showing how the recovered projectiles look after they have been fired;

figures 8 and 9 are photographs showing the detected speeds of the projectiles in m/s with short firearm and long firearm, respectively;

figure 10 is a photograph showing the plastic deformations of a wooden birch target hit by a projectile;

figure 11 shows projectiles which are broken after hitting a galvanized steel target;

figure 12 is a photograph showing the plastic deformations of a plasticine target hit by a projectile which is partially penetrating the target itself;

figure 13 shows an example of a box for selling the invention, the dimensions of which are the results of the volumetric calculation able to contain 220 projectiles.

[0008] The material used for producing the projectile being described preferably is a mixture of Polystyrene (PS) and Barium Sulfate (BaSO_4), which is used as an additive in order to make the plastic biodegradable once it contacts the bacteria present in the soil. The Barium Sulfate is an inert and harmless mineral matter used as contrast medium in magnetic resonance imaging. With regards to the percentages of PS/ BaSO_4 , it is apparent from the experiments carried out that the mixture that behaved itself best in sustaining the working processes consists of $70\% \pm 10\%$ of PS (with 3% of biodegradable additive therein) + $30\% \pm 10\%$ of BaSO_4 .

[0009] The biodegradability of such a mixture was ascertained and certified during the experimental tests.

[0010] It is worth noting that the projectile could be made of other plastic materials. For example, ABS and NYLON could be used, or also PLA.

[0011] According to the present invention, the production cycle starts with mixing the biodegradable polymer to be used, and then with the pressure injection of the same inside multiple imprints molds from which the raw balls will exit after having been shelled out from the casting container. The selected reference weight is obtained by calibrating the mixture.

[0012] The choice to proceed with making the raw balls through the pressure injection allows optimizing the mass distribution and minimizing the formation of bubbles, as well as obtaining micro bubbles which are more homogeneously distributed in the balls (fig. 1).

[0013] Advantageously, such a uniform distribution of the micro bubbles effectively contributes to the stability of the projectile along its trajectory.

[0014] The raw balls thus obtained (fig. 4) are inserted into a machine built for the purpose of carrying out an automatic polishing and grinding process. Such a working is obtained by means of the assistance of a system of plates (fig. 5) acting on the grinding wheels (fig. 6) specifically designed to eliminate imperfections in the molding and to reach the desired gauge.

[0015] This grinding process allows achieving a sphericity with an approximation degree of 0.01 mm (a hundredth of millimeter).

[0016] Figures 5 and 6 show an embodiment of grinding wheels and plates between which the raw balls are worked, the passage of which in the working grooves allows carrying out the grinding thereof, which ensures all the peculiar features of the finished product:

1. almost perfect sphericity
2. working precision
3. surface with micrometric roughness

[0017] Once the grinding step is terminated, the balls are washed and dried and finally passed through a mechanical calibration control system in order to eliminate all the balls not meeting the required features.

[0018] The ballistic tests performed to test the projectile prototypes were carried out both indoor, i.e. in the

absence of wind, and under such conditions as to be exposed to the weathering agents. Such tests have resulted in the following assessments.

INTERNAL BALLISTICS

[0019] The elastic features of the polymer used for the construction of the projectile, its perfect sphericity, the micrometer-level working of the gauge, allow the same to be deformed when subjected to the inert gas launch pressure and to adhere to the inner surface of the barrel in such a way to obtain an optimal exploitation of the working pressure in the barrel of the firearm. These features are quite apparent in the traces left on the projectiles which were recuperated after they were fired (fig. 7).

[0020] Advantageously, these properties allow the projectile to reach a higher muzzle speed in percentage terms with respect to the projectiles made with other plastic materials, in any case remaining within the legal limits, i.e. 7.5 joules of power, corresponding to 173 m/sec of speed with the minimum gramage allowed (figures 8 and 9).

[0021] The projectiles hereto described have a calibrated weight at the end of working of 1 ± 0.01 g.

EXTERNAL BALLISTICS

[0022] The particular surface working obtained by means of the above-described grinding system is one of the peculiar features of the projectile according to the present invention; indeed the surface roughness allows the projectile to create a "golf ball" effect during its flight trajectory, where the roughness acts as generating element of aerodynamic lift. The sliding of the projectile in the barrel and the outlet turbulence generated cause unpredictable rotations thereof which are stabilized and made ineffective by the aerodynamic feature obtained with the peculiar working of the surface through the grinding process. Thereby, a stretched and stable external trajectory is caused, both in terms of accuracy of the shot and of concentration of the rose, as well as capable of limiting the falling effects of the ball when close to the distance of the useful shot. The tests carried out were repeatable events detected in all prototype lots produced.

TERMINAL BALLISTICS

[0023] During the experimental tests, the elastic feature of the polymer completely met the specifications required, adapted to ensure the inability of the projectile to discharge its kinetic energy so as to penetrate the material or fabric impacted.

[0024] From the tests carried out, it has been noted that the projectile rebounds by impacting on materials with hardness coefficient of medium hard wood type (marine plywood $651 \div 1000$ Kg/cm²), causing elastic deformations thereto.

[0025] The projectile rebounds on materials with soft

hardness coefficient (birch wood $351 \div 650$ Kg/cm²), causing plastic deformations thereto (fig. 10).

[0026] The projectile rebounds on materials with hardness coefficient greater than 69 HRB (aluminum), causing plastic deformations thereto.

[0027] The projectile rebounds on materials with hardness coefficient greater than 75 HRB (galvanized steel), without causing plastic or elastic deformations thereto (fig. 11).

[0028] The projectile partially penetrates materials with very soft hardness coefficient (plasticine, pressure less than 50 Kg/cm²), causing plastic deformations thereto (fig. 12).

[0029] The photographic proof shown in the drawings mentioned above were repeatable events detected in all prototype lots produced, which thus ensure meeting the legal requirements specified above.

[0030] The construction features of the projectile the object of the present invention cause the innovative peculiarities in the field of recreational-sporting shooting. By using the present invention, it indeed advantageously is possible to obtain:

- a reduction of the operating costs, ballistic features being the same,
- a substantial reduction of the dangerousness of the projectiles, with subsequent lowering of the cases of collateral damage,
- the complete zeroing of the environmental impact and therefore the possibility of restoring the integrity of the area without the need for costly reclaiming operations,
- the possibility of using such peculiarities in order to produce multiple gauges, having both spherical and ogival shape.

[0031] Finally, it is worth noting that in order to sell the invention, a box was developed the dimensions of which are the results of the volumetric calculation able to contain on average a sufficient quantity required to carry out the recreational-sporting activity of target and dynamic shooting.

[0032] Such a quantity is 220 projectiles.

[0033] The dimensions of the box were calibrated also so as to facilitate the transport of the projectiles by the shooter in the firing area while being insertable in a belt pouches or webbing set.

[0034] The closing system serves the function of facilitating the insertion of one's hand to take the desired quantity of projectiles (fig. 13).

CONCLUSIONS

[0035] The projectile according to the invention described hereto is a technical innovation in the field of recreational-sporting and operational shooting, allowing all individuals over the age of 18 to approach the shooting discipline without necessarily having a shooting license;

it allows a very low operating cost, lower than the cost of firearm ammunition, despite having a ballistic response which certainly is similar in the shot up to 15 to 20 m.

[0036] It is an evolution for any training program concerning the use of firearms, both institutional or safety-related programs.

[0037] Finally, it is worth noting that projectiles may be made according to the present invention, having gauge different from 0.43 inches, which have been described hereto only by way of non-limiting example.

[0038] For that disclosed hereto, the process for producing a biodegradable polymer projectile according to the present invention comprises the following steps:

- mixing a biodegradable polymer to be used for producing the projectile,
- pressure injection of the same polymer inside multiple imprints molds from which the raw projectile will exit, after having been shelled out from the casting container,

in which the desired reference weight can be obtained by calibrating the density of the polymer mixture; said projectiles being spherical or ogival.

[0039] With regards to the aforesaid steps, it is worth making the following considerations.

[0040] The mixture of the biodegradable additive (which preferably is of the type that can be acquired from American company Willow Ridge Plastic, i.e. products such as OXO Biodegradable or Polylactic Acid [PLA]) preferably is calibrated at 3% with the plastic material formed by a mixture of Barium Sulfate and Polystyrene integrated with other elements which characterize the mineral component thereof, such as for example, Titanium Dioxide, talc, Calcium Carbonate. Such a biodegradable mixture becomes 1.5 in the finished product, where about half the original 3% is compensated for by the mineral origin filler. This is the solution which, according to experimental tests, ensured the best results in terms of working and of the biodegradable feature proven by our natural destruction tests by the enzymes in the soil, resulting in a finished product formed by 70%+/-10% of Polystyrene and 30%+/-10% of Barium Sulfate, with the percentage of biodegradable additive and the mineral origin filler therein.

[0041] Although it may be erroneously believed that the mold shown in the drawings has multiple imprints for needs of production affordability, it has a number of imprints which was selected and experimentally verified to allow the tolerances and the physical features to be obtained, which are required for the precision projectile which is the object of the present invention.

[0042] The injection is started at 110+/-10 bar with a speed calibrated to 25%+/-5% less with respect to the maximum speed allowed by the injecting machine.

[0043] The molds of the casting nozzles have variable diameter between the exterior of the imprints and the inner part thereof to ensure the homogeneous distribu-

tion of the mass by stabilizing the pressure in the mold.

[0044] The material is pushed at a maximum pressure of 110+/-10 bar with a post-maintenance pressure of 25+/- 10 bar and with a counter return pressure of 15+/- 5 bar.

[0045] As mentioned above, such a process allows a mathematical mass distribution with minimum reject tolerances among the various imprints.

[0046] The emission temperature in the mold is important in determining the mass distribution but acts in fundamental manner for reducing the casting micro bubbles.

[0047] The temperature we have optimized through experimentation is 220+/-20°C at the nozzle, 225+/- 10°C at mid-chamber and 230+/-10°C at the start of the molding chamber, starting the injection in the mold preheated to 40+/-10°C.

[0048] The cooling of the casting mold in dedicated chamber at 10+/-5°C, in conjunction with a cooling system obtained in both parts forming the mold itself, contribute to stabilizing the cooling curve of the mixture and to causing the hardness features which allow the successive working step. The outermost part of the projectiles is harder than the innermost part.

[0049] In order to work a plastic material as though it were a metal, in essence action was taken on the mineral feature thereof while keeping the specifications of product biodegradability, and a production process was conceived which allows a hardening thereof, while maintaining the desired physical features.

[0050] The polishing and grinding step is carried out by using a disc with steel grooves with counter-grinding wheel having medium grain. The components are leveled with 11+/-0.01 mm steel balls and brought to measurement with decreasing micrometric calibrations in grooves having variable roughness in order to obtain, at the end of the polishing, the porous effect of the surface of the projectile which was noted during the experimentations by the visual inspection under microscope of the projectile, which causes the aerodynamic component which is fundamental for the stabilization of the projectile in air.

[0051] The roughness of the finishing grooves is carried out in a craftsman-like and unique manner, which can only be replicated by making and adjusting prototypes up to optimizing the required result.

[0052] Such a feature is a unique and necessary aspect which cannot be repeated if the decreasing calibrations put into place according to the present invention are not implemented and which allow a perfect ball to be made, with accuracy to the hundredth of millimeter and to the hundredth of gram, with a surface roughness which reduces the aerodynamic CX [drag factor] thereof, thus causing an optimal stabilization in the fluid means while increasing accuracy and speed, thrust being equal, with respect to any projectile made in similar manner.

Claims

1. Process for the production of a biodegradable polymer projectile, in particular for non-lethal firearms, usable for recreational-sporting purposes, **characterized in that** it provides at least the following steps:
 - mixing a biodegradable polymer to be used for producing the projectile,
 - 110+/-10 bar maximum pressure injection of the same polymer inside multiple imprints molds from which the raw projectile will exit, after having been shelled out from the casting container,

in which the desired reference weight can be obtained by calibrating the density of the polymer mixture; said projectiles being spherical or ogival.
2. Process according to the preceding claim, **characterized in that** the injection of said mixture at a maximum pressure of 110+/-10 bar with a maintaining post-pressure of 25+/-10 bar is provided for the purpose of optimizing the mass distribution and minimizing the formation of bubbles, as well as obtaining micro bubbles more homogeneously distributed inside the raw projectiles; such a uniform distribution of micro bubbles contributing effectively to the stability of the projectile along its trajectory.
3. Process according to any one of the preceding claims, **characterized in that** is provided in the mold an emission temperature of 220+/-20°C at the nozzle, 225+/-10° at mid-chamber and 230+/-10°C at the beginning of the molding chamber, the injection starting in the mold preheated to 40+/-10°C.
4. Process according to any one of the preceding claims, **characterized in that** a cooling temperature of 10+/-5°C of the casting mold is provided in a dedicated chamber, in conjunction with a cooling system obtained in both parts forming the mold itself, which contribute to stabilizing the cooling curve of the mixture and to causing the hardness features which allow the successive working step.
5. Process according to any one of the preceding claims, **characterized in that** the raw projectiles thus obtained are inserted into a machine configured to carry out an automatic polishing and grinding process; for this purpose, being provided a system of plates acting on the grinding wheels specifically designed to eliminate imperfections in the molding and reach the desired gauge.
6. Process according to the preceding claim, **characterized in that** said machine is configured to perform a grinding step enabling to achieve a sphericity with an approximation degree of 0.01 mm; for this purpose being provided the use of a disc with steel grooves with medium grain counter-grinding wheel, wherein said grooves have variable roughness to obtain, at the end of the polishing, a porous effect of the projectile surface which causes the aerodynamic component that is fundamental for the stabilization of the projectile in air.
7. Process according to the preceding claim, **characterized in that**, once the grinding step is terminated, the balls are washed and dried, and finally passed through a mechanical calibration control system, in order to eliminate all the balls not meeting the required features.
8. Process according to any one of the preceding claims, **characterized in that** said biodegradable polymeric material consists of a mixture of Polystyrene (PS) and Barium Sulfate (BaSO₄), which is used as an additive in order to make the plastic biodegradable once it contacts the bacteria present in the soil.
9. Biodegradable polymer projectile, in particular for non-lethal firearms, usable for recreational-sporting purposes and equipped with a barrel and inert gas for the expulsion of the projectile itself, **characterized in that** it has a spherical or ogival shape with a porous effect that causes the aerodynamic component that is fundamental for the stabilization of the projectile in air, and also a distribution of the internal masses configured to be stable to the penetration of the air.
10. A projectile according to the preceding claim, **characterized in that** it is made of a biodegradable polymeric material consisting of a mixture of Polystyrene (PS), a mineral component and Barium Sulfate (BaSO₄), which is present as an additive in order to make the plastic biodegradable once it contacts the bacteria present in the soil.
11. Projectile according to the preceding claim, **characterized in that** said mixture is composed of 70% ± 10% of PS, with 3% ± 1% of mineral origin filler, and of 30% ± 10% of BaSO₄.
12. A projectile according to claim 9, **characterized in that** it is made of a biodegradable polymeric material consisting of a mixture of ABS or NYLON or PLA and Barium Sulfate (BaSO₄), which is present as an additive in order to make the plastic biodegradable once that it contacts the bacteria in the soil.
13. A projectile according to any one of the claims from 10 onwards, **characterized in that** the elastic features of the polymer used for the construction thereof, its perfect sphericity, the micrometer-level work-

ing of the gauge, are such to enable the projectile to be deformable when subjected to an inert gas launch pressure and adhere to the inner surface of the barrel in such a way to obtain an optimal exploitation of the working pressure in the barrel of the firearm.

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14. A projectile according to any one of the claims from 9 onwards, **characterized in that** it has a surface with a surface grinding operation, whose surface roughness is configured to allow the projectile to create a "golf ball" effect in its flight trajectory, wherein the roughness acts as an element generating aerodynamic lift determining a stretched and stable external trajectory, both in terms of accuracy of the shot and of concentration of the rose, as well as limiting the effects of falling of the ball when close to the distance of the useful shot.

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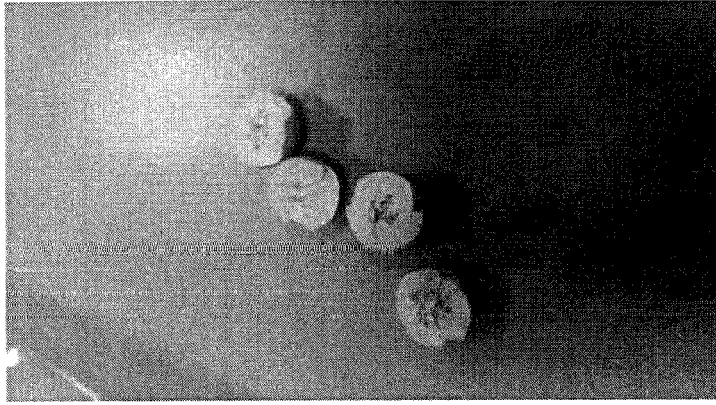


FIG. 1

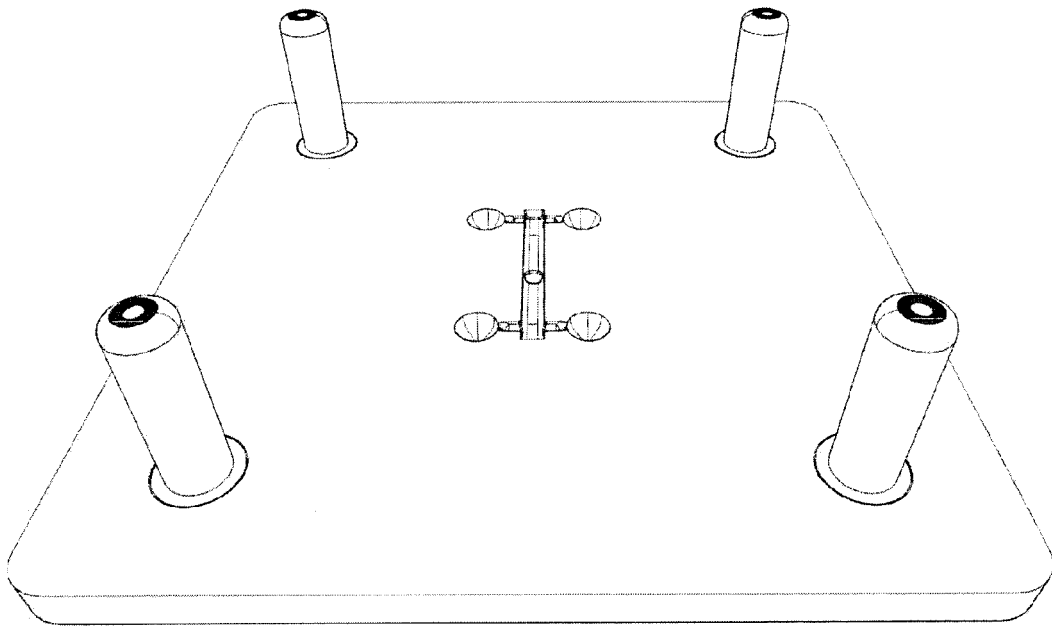


FIG. 2A

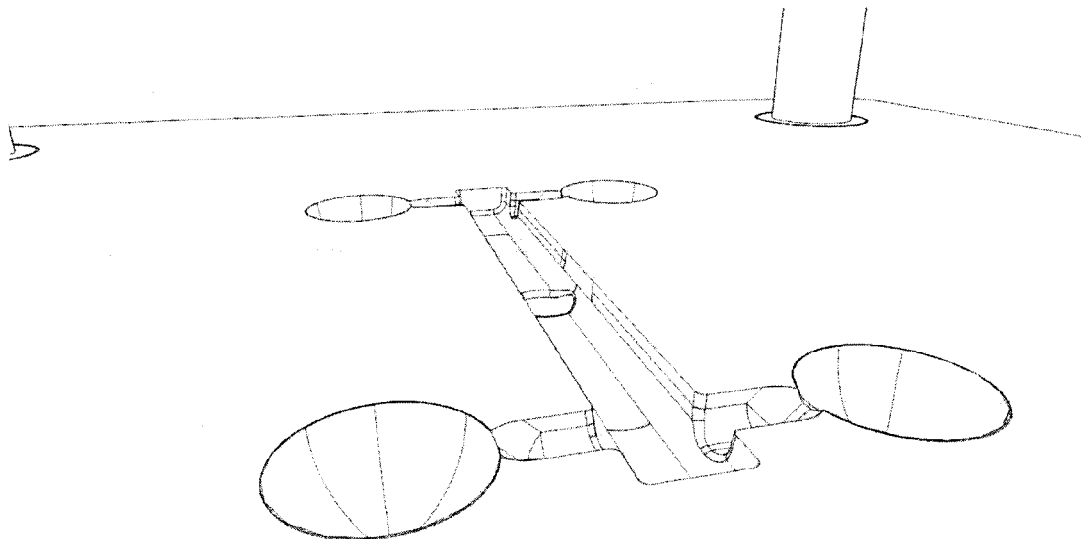


FIG. 2B

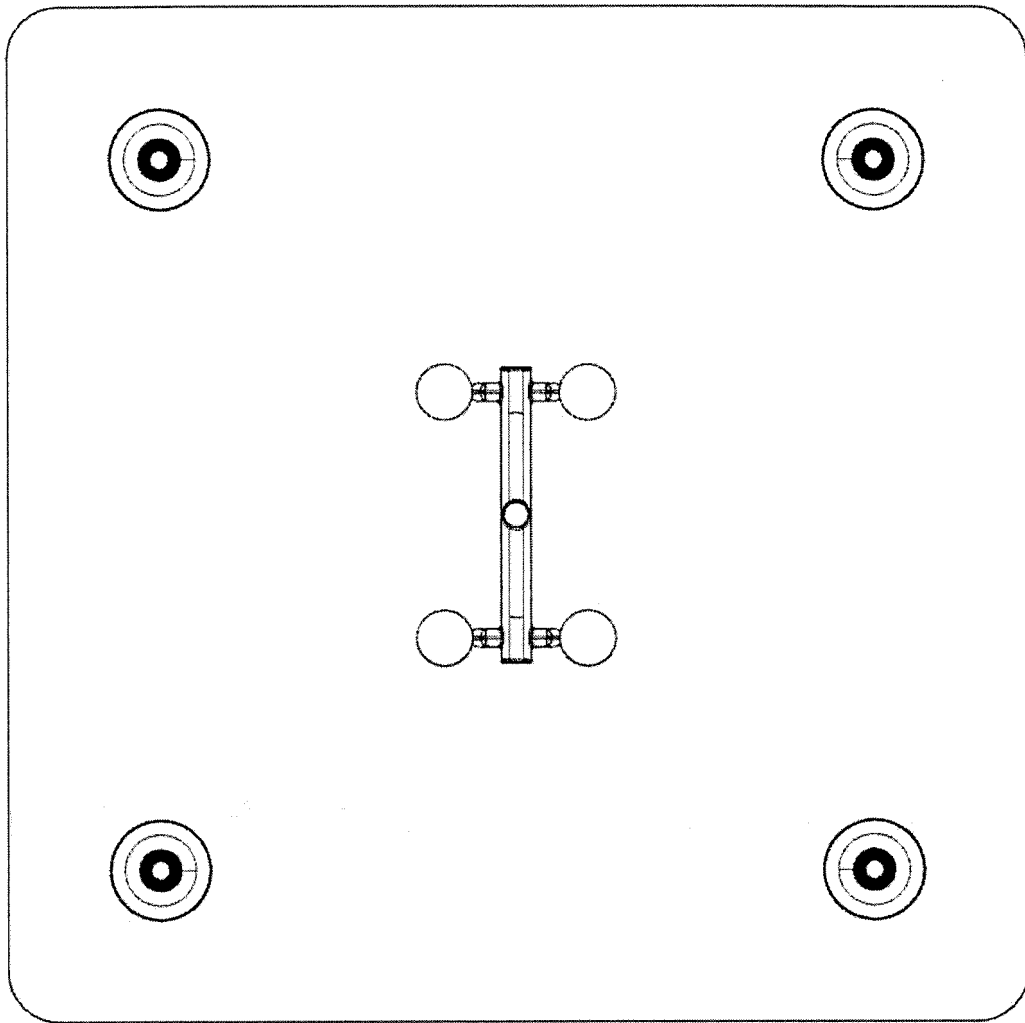


FIG. 3

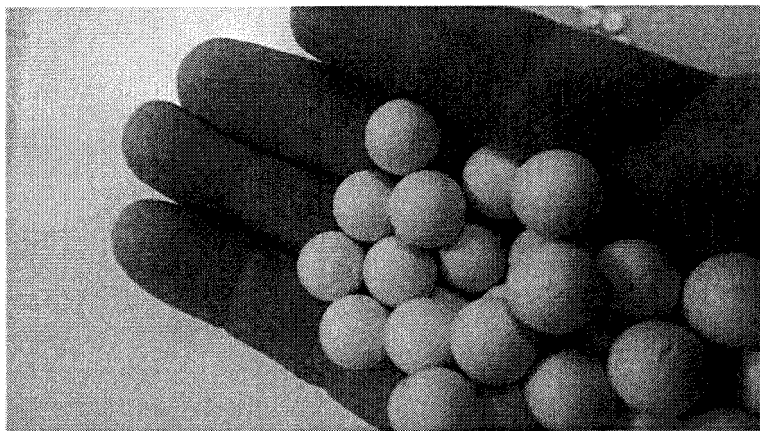


FIG. 4

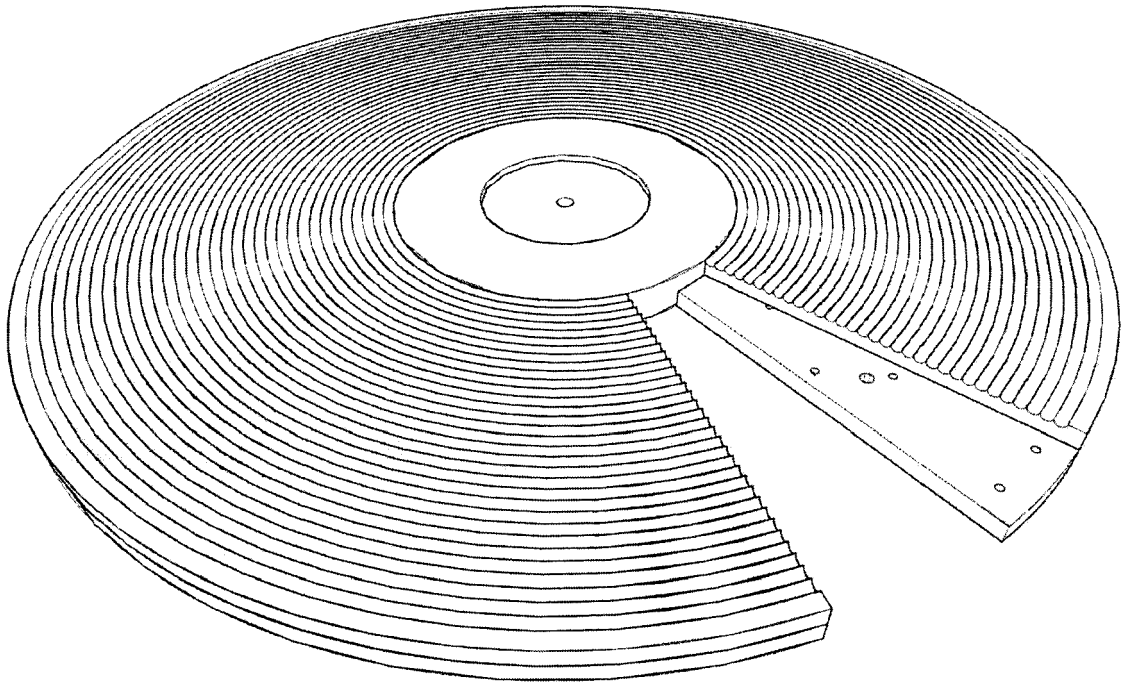


FIG. 5

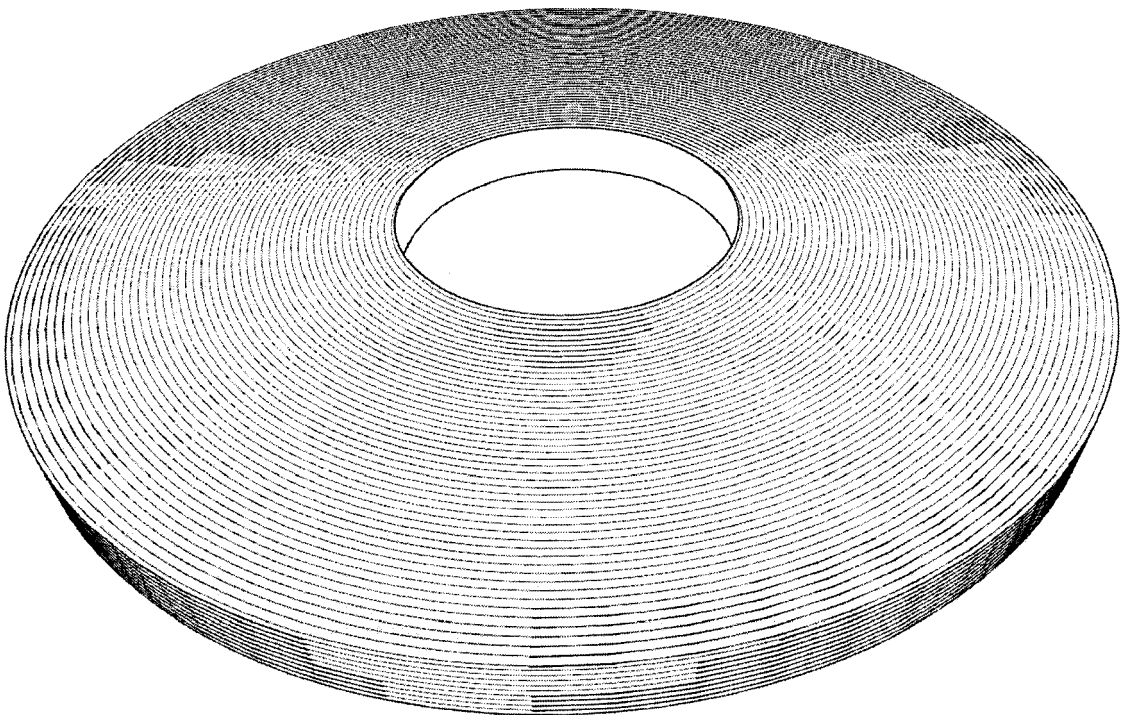


FIG. 6

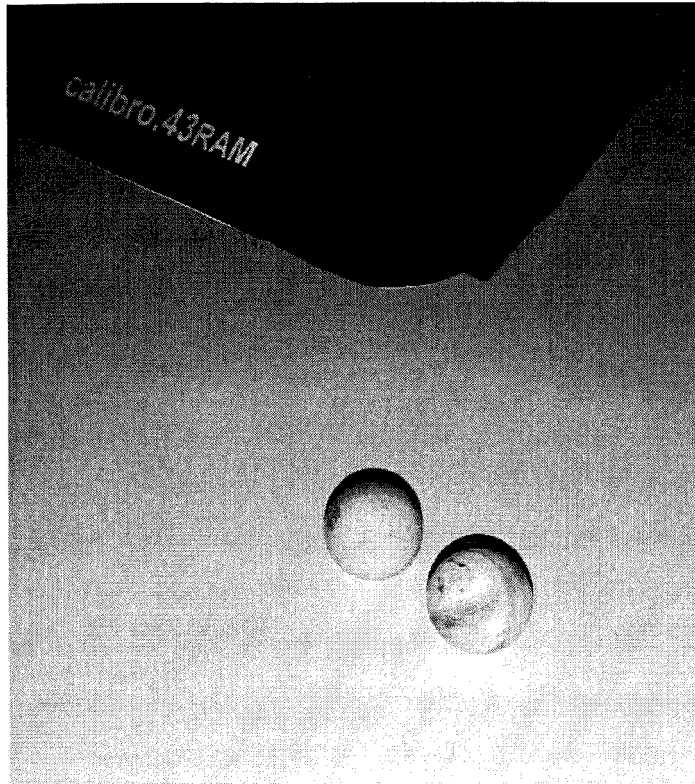


FIG. 7

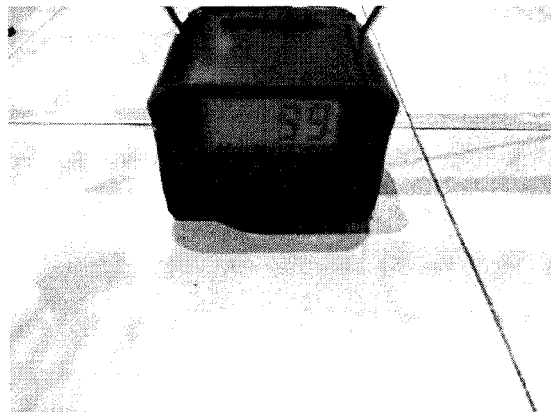


FIG. 8

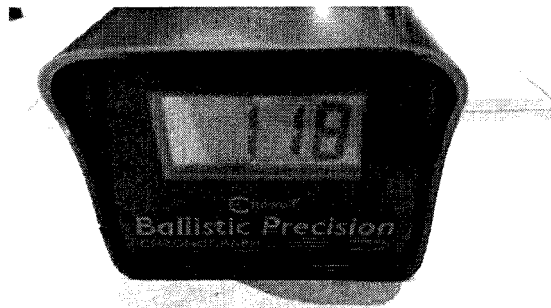


FIG. 9

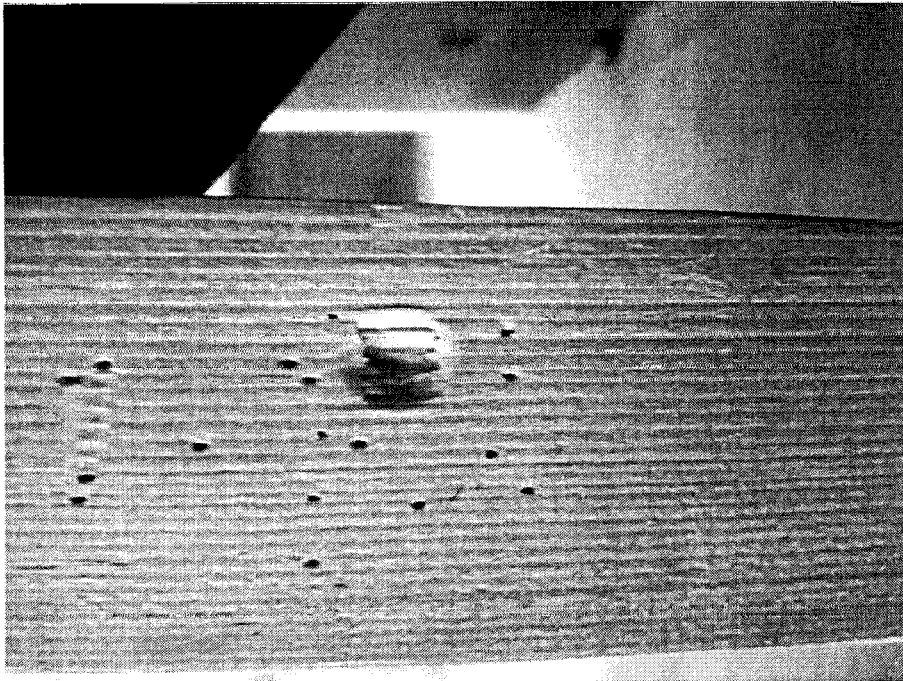


FIG. 10

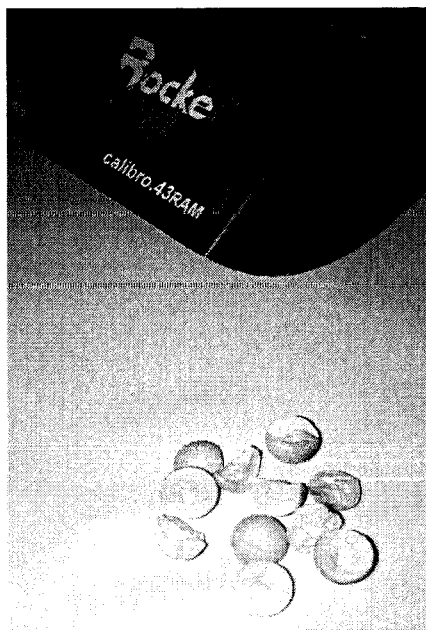


FIG. 11

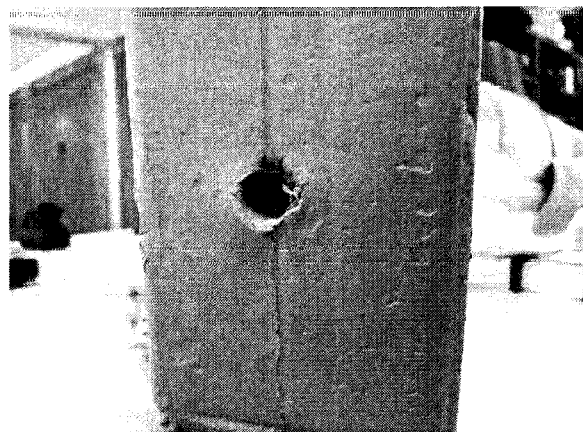


FIG. 12

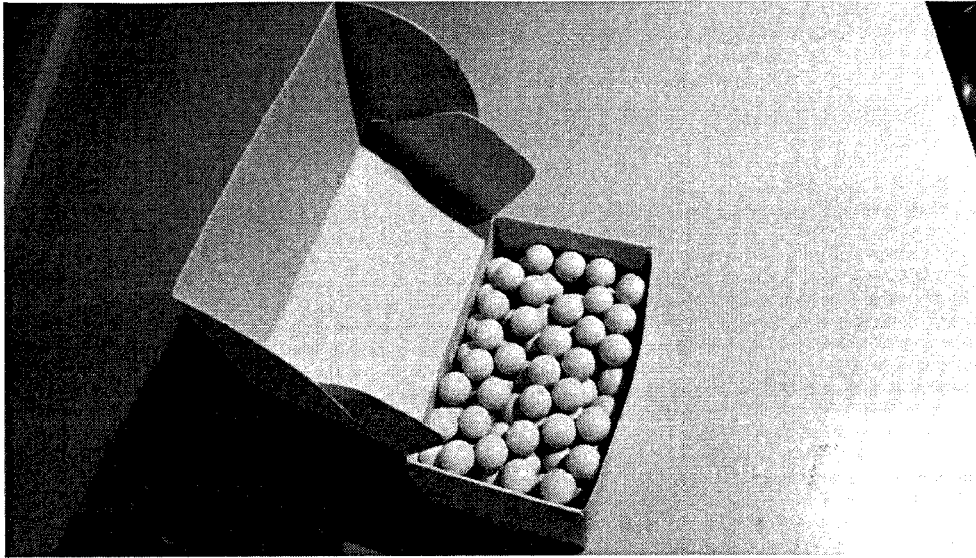


FIG. 13



EUROPEAN SEARCH REPORT

Application Number
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EPO FORM 1503 03.82 (P04C01)

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 17 July 2019	Examiner Schwingel, Dirk
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ON EUROPEAN PATENT APPLICATION NO.**

EP 19 42 5020

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