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(54) **GOLF BALL**

(57) A golf ball 2 has a large number of dimples 10 on a surface thereof. A dimple pattern of each hemisphere of the golf ball 2 includes three units (T1, T2, and T3) that are rotationally symmetrical to each other. A dimple pattern of each unit includes two small units (T1a, T1b) that are mirror-symmetrical to each other. A stand-

ard deviation Su of areas of all the dimples 10 is not greater than 1.7 mm². A standard deviation Pd of distances L between dimples 10 of all neighboring dimple pairs is less than 0.500 mm. A ratio So of a sum of areas of the dimples 10 relative to a surface area of a phantom sphere of the golf ball 2 is not less than 78.0%.

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Description

[0001] This application claims priority on Patent Application No. 2017-123925 filed in JAPAN on June 26, 2017 and Patent Application No. 2018-031918 filed in JAPAN on February 26, 2018. The entire contents of these Japanese Patent Applications are hereby incorporated by reference.

BACKGROUND OF THE INVENTION**Field of the Invention**

[0002] The present invention relates to golf balls. Specifically, the present invention relates to dimple patterns of golf balls.

Description of the Related Art

[0003] The face of a golf club has a loft angle. When a golf ball is hit with the golf club, backspin due to the loft angle occurs in the golf ball. The golf ball flies with the backspin.

[0004] Golf balls have a large number of dimples on the surfaces thereof. The dimples disturb the air flow around the golf ball during flight to cause turbulent flow separation. This phenomenon is referred to as "turbulization". Due to the turbulization, separation points of the air from the golf ball shift backwards leading to a reduction of drag. The turbulization promotes the displacement between the separation point on the upper side and the separation point on the lower side of the golf ball, which results from the backspin, thereby enhancing the lift force that acts upon the golf ball. The reduction of drag and the enhancement of lift force are referred to as a "dimple effect". Excellent dimples efficiently disturb the air flow. The excellent dimples produce a long flight distance.

[0005] JP50-8630 discloses a golf ball having a large number of dimple pairs each having a distance of less than 0.065 inches between a dimple and another dimple adjacent to this dimple. In the golf ball, a large number of dimples are densely arranged.

[0006] JP2008-389 discloses a golf ball having dimple pairs each having an interval that is sufficiently small when being compared to the average diameter of dimples. In the golf ball, a large number of dimples are densely arranged.

[0007] JP2013-153966 discloses a golf ball in which a large number of dimples are densely arranged and the sizes of the dimples are less varied. A similar golf ball is also disclosed in JP2015-24079.

[0008] Densely arranged dimples contribute to the flight performance of a golf ball. However, golf players desire further improvement in flight distance. In light of flight performance, there is room for improvement of dimples.

[0009] An object of the present invention is to provide a golf ball having excellent flight performance.

SUMMARY OF THE INVENTION

[0010] A golf ball according to the present invention has a plurality of dimples on a surface thereof. A standard deviation S_u of areas of all the dimples is not greater than 1.7 mm^2 . A standard deviation P_d of distances L between dimples of all neighboring dimple pairs is less than 0.500 mm. When the golf ball according to the present invention flies, the lift force coefficient and the drag coefficient are appropriate. The golf ball has excellent flight performance.

[0011] Preferably, the standard deviation P_d is less than 0.400 mm.

[0012] Preferably, a dimple pattern of each hemisphere of a phantom sphere of the golf ball includes three units that are rotationally symmetrical to each other. A dimple pattern of each unit includes two small units that are mirror-symmetrical to each other.

[0013] Preferably, a ratio S_o of a sum of areas of the dimples relative to a surface area of the phantom sphere is not less than 78.0%.

[0014] Preferably, a sum of volumes of all the dimples is not less than 450 mm^3 and not greater than 750 mm^3 .

[0015] Preferably, a total number of the dimples is not less than 300 and not greater than 390.

BRIEF DESCRIPTION OF THE DRAWINGS**[0016]**

FIG. 1 is a schematic cross-sectional view of a golf ball according to an embodiment of the present invention;
 FIG. 2 is an enlarged plan view of the golf ball in FIG. 1;
 FIG. 3 is a front view of the golf ball in FIG. 2;
 FIG. 4 is a partially enlarged cross-sectional view of the golf ball in FIG. 1;

FIG. 5 is a partially enlarged view of the golf ball in FIGS. 2 and 3;
 FIG. 6 is an explanatory diagram for the definition of neighboring dimples in the golf ball in FIGS. 2 and 3;
 FIG. 7 is an explanatory diagram for the definition of neighboring dimples in the golf ball in FIGS. 2 and 3;
 FIG. 8 is an explanatory diagram for the definition of neighboring dimples in the golf ball in FIGS. 2 and 3;
 FIG. 9 is an explanatory diagram for the definition of neighboring dimples in the golf ball in FIGS. 2 and 3;
 FIG. 10 is a plan view of a golf ball according to Example 2 of the present invention;
 FIG. 11 is a front view of the golf ball in FIG. 10;
 FIG. 12 is a plan view of a golf ball according to Example 3 of the present invention;
 FIG. 13 is a front view of the golf ball in FIG. 12;
 FIG. 14 is a plan view of a golf ball according to Example 4 of the present invention;
 FIG. 15 is a front view of the golf ball in FIG. 14;
 FIG. 16 is a plan view of a golf ball according to Comparative Example 1;
 FIG. 17 is a front view of the golf ball in FIG. 16;
 FIG. 18 is a plan view of a golf ball according to Comparative Example 2;
 FIG. 19 is a front view of the golf ball in FIG. 18;
 FIG. 20 is a plan view of a golf ball according to Example 5; and
 FIG. 21 is a front view of the golf ball in FIG. 20.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] The following will describe in detail the present invention based on preferred embodiments with appropriate reference to the drawings.

[0018] A golf ball 2 shown in FIG. 1 includes a spherical core 4, a mid layer 6 positioned outside the core 4, and a cover 8 positioned outside the mid layer 6. The golf ball 2 has a large number of dimples 10 on the surface thereof. Of the surface of the golf ball 2, a part other than the dimples 10 is a land 12. The golf ball 2 includes a paint layer and a mark layer on the external side of the cover 8 although these layers are not shown in the drawing.

[0019] The golf ball 2 preferably has a diameter of not less than 40 mm and not greater than 45 mm. From the standpoint of conformity to the rules established by the United States Golf Association (USGA), the diameter is particularly preferably not less than 42.67 mm. In light of suppression of air resistance, the diameter is more preferably not greater than 44 mm and particularly preferably not greater than 42.80 mm.

[0020] The golf ball 2 preferably has a weight of not less than 40 g and not greater than 50 g. In light of attainment of great inertia, the weight is more preferably not less than 44 g and particularly preferably not less than 45.00 g. From the standpoint of conformity to the rules established by the USGA, the weight is particularly preferably not greater than 45.93 g.

[0021] The core 4 is formed by crosslinking a rubber composition. Examples of the base rubber of the rubber composition include polybutadienes, polyisoprenes, styrene-butadiene copolymers, ethylene-propylene-diene copolymers, and natural rubbers. Two or more rubbers may be used in combination. In light of resilience performance, polybutadienes are preferable, and high-cis polybutadienes are particularly preferable.

[0022] The rubber composition of the core 4 includes a co-crosslinking agent. Examples of preferable co-crosslinking agents in light of resilience performance include zinc acrylate, magnesium acrylate, zinc methacrylate, and magnesium methacrylate. The rubber composition preferably includes an organic peroxide together with a co-crosslinking agent. Examples of preferable organic peroxides include dicumyl peroxide, 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, 2,5-dimethyl-2,5-di(t-butylperoxy)hexane, and di-t-butyl peroxide.

[0023] The rubber composition of the core 4 may include additives such as a filler, sulfur, a vulcanization accelerator, a sulfur compound, an anti-aging agent, a coloring agent, a plasticizer, and a dispersant. The rubber composition may include a carboxylic acid or a carboxylate. The rubber composition may include synthetic resin powder or crosslinked rubber powder.

[0024] The core 4 has a diameter of preferably not less than 30.0 mm and particularly preferably not less than 38.0 mm. The diameter of the core 4 is preferably not greater than 42.0 mm and particularly preferably not greater than 41.5 mm. The core 4 may have two or more layers. The core 4 may have a rib on the surface thereof. The core 4 may be hollow.

[0025] The mid layer 6 is formed from a resin composition. A preferable base polymer of the resin composition is an ionomer resin. Examples of preferable ionomer resins include binary copolymers formed with an α -olefin and an α,β -unsaturated carboxylic acid having 3 to 8 carbon atoms. Examples of other preferable ionomer resins include ternary copolymers formed with: an α -olefin; an α,β -unsaturated carboxylic acid having 3 to 8 carbon atoms; and an α,β -unsaturated carboxylate ester having 2 to 22 carbon atoms. For the binary copolymer and the ternary copolymer, preferable α -olefins are ethylene and propylene, while preferable α,β -unsaturated carboxylic acids are acrylic acid and methacrylic acid. In the binary copolymer and the ternary copolymer, some of the carboxyl groups are neutralized with metal ions. Examples of metal ions for use in neutralization include sodium ion, potassium ion, lithium ion, zinc ion, calcium ion, magnesium ion, aluminum ion, and neodymium ion.

[0026] Instead of an ionomer resin, the resin composition of the mid layer 6 may include another polymer. Examples of the other polymer include polystyrenes, polyamides, polyesters, polyolefins, and polyurethanes. The resin composition may include two or more polymers.

[0027] The resin composition of the mid layer 6 may include a coloring agent such as titanium dioxide, a filler such as barium sulfate, a dispersant, an antioxidant, an ultraviolet absorber, a light stabilizer, a fluorescent material, a fluorescent brightener, and the like. For the purpose of adjusting specific gravity, the resin composition may include powder of a metal with a high specific gravity such as tungsten, molybdenum, and the like.

[0028] The mid layer 6 has a thickness of preferably not less than 0.2 mm and particularly preferably not less than 0.3 mm. The thickness of the mid layer 6 is preferably not greater than 2.5 mm and particularly preferably not greater than 2.2 mm. The mid layer 6 has a specific gravity of preferably not less than 0.90 and particularly preferably not less than 0.95. The specific gravity of the mid layer 6 is preferably not greater than 1.10 and particularly preferably not greater than 1.05. The mid layer 6 may have two or more layers.

[0029] The cover 8 is formed from a resin composition. A preferable base polymer of the resin composition is a polyurethane. The resin composition may include a thermoplastic polyurethane or may include a thermosetting polyurethane. In light of productivity, the thermoplastic polyurethane is preferable. The thermoplastic polyurethane includes a polyurethane component as a hard segment, and a polyester component or a polyether component as a soft segment.

[0030] The polyurethane has a urethane bond within the molecule. The urethane bond can be formed by reacting a polyol with a polyisocyanate.

[0031] The polyol, which is a material for the urethane bond, has a plurality of hydroxyl groups. Low-molecular-weight polyols and high-molecular-weight polyols can be used.

[0032] Examples of an isocyanate for the polyurethane component include alicyclic diisocyanates, aromatic diisocyanates, and aliphatic diisocyanates. Alicyclic diisocyanates are particularly preferable. Since an alicyclic diisocyanate does not have any double bond in the main chain, the alicyclic diisocyanate suppresses yellowing of the cover 8. Examples of alicyclic diisocyanates include 4,4'-dicyclohexylmethane diisocyanate (H_{12} MDI), 1,3-bis(isocyanatomethyl)cyclohexane (H_6 XDI), isophorone diisocyanate (IPDI), and trans-1,4-cyclohexane diisocyanate (CHDI). In light of versatility and processability, H_{12} MDI is preferable.

[0033] Instead of a polyurethane, the resin composition of the cover 8 may include another polymer. Examples of the other polymer include ionomer resins, polystyrenes, polyamides, polyesters, and polyolefins. The resin composition may include two or more polymers.

[0034] The resin composition of the cover 8 may include a coloring agent such as titanium dioxide, a filler such as barium sulfate, a dispersant, an antioxidant, an ultraviolet absorber, a light stabilizer, a fluorescent material, a fluorescent brightener, and the like.

[0035] The cover 8 has a thickness of preferably not less than 0.2 mm and particularly preferably not less than 0.3 mm. The thickness of the cover 8 is preferably not greater than 2.5 mm and particularly preferably not greater than 2.2 mm. The cover 8 has a specific gravity of preferably not less than 0.90 and particularly preferably not less than 0.95. The specific gravity of the cover 8 is preferably not greater than 1.10 and particularly preferably not greater than 1.05. The cover 8 may have two or more layers.

[0036] The golf ball 2 may include a reinforcing layer between the mid layer 6 and the cover 8. The reinforcing layer firmly adheres to the mid layer 6 and also to the cover 8. The reinforcing layer suppresses separation of the cover 8 from the mid layer 6. The reinforcing layer is formed from a polymer composition. Examples of the base polymer of the reinforcing layer include two-component curing type epoxy resins and two-component curing type urethane resins.

[0037] As shown in FIGS. 2 and 3, the contour of each dimple 10 is circular. The golf ball 2 has dimples A each having a diameter of 4.40 mm; dimples B each having a diameter of 4.30 mm; dimples C each having a diameter of 4.15 mm; dimples D each having a diameter of 3.90 mm; and dimples E each having a diameter of 3.00 mm. The number of types of the dimples 10 is five.

[0038] The number of the dimples A is 60; the number of the dimples B is 158; the number of the dimples C is 72; the number of the dimples D is 36; and the number of the dimples E is 12. The total number of the dimples 10 is 338. A dimple pattern is formed by these dimples 10 and the land 12.

[0039] FIG. 4 shows a cross section of the golf ball 2 along a plane passing through the central point of the dimple 10 and the central point of the golf ball 2. In FIG. 4, the top-to-bottom direction is the depth direction of the dimple 10. In FIG. 4, a chain double-dashed line 14 indicates a phantom sphere 14. The surface of the phantom sphere 14 is the surface of the golf ball 2 when it is postulated that no dimple 10 exists. The diameter of the phantom sphere 14 is equal to the diameter of the golf ball 2. The dimple 10 is recessed from the surface of the phantom sphere 14. The land 12 coincides with the surface of the phantom sphere 14. In the present embodiment, the cross-sectional shape of each dimple 10 is substantially a circular arc. The curvature radius of this circular arc is shown by reference character CR in FIG. 4.

[0040] In FIG. 4, an arrow Dm indicates the diameter of the dimple 10. The diameter Dm is the distance between two tangent points Ed appearing on a tangent line Tg that is drawn tangent to the far opposite ends of the dimple 10. Each

tangent point Ed is also the edge of the dimple 10. The edge Ed defines the contour of the dimple 10.

[0041] The diameter Dm of each dimple 10 is preferably not less than 2.0 mm and not greater than 6.0 mm. The dimple 10 having a diameter Dm of not less than 2.0 mm contributes to turbulization. From this viewpoint, the diameter Dm is more preferably not less than 2.5 mm and particularly preferably not less than 2.8 mm. The dimple 10 having a diameter Dm of not greater than 6.0 mm does not impair a fundamental feature of the golf ball 2 being substantially a sphere. From this viewpoint, the diameter Dm is more preferably not greater than 5.5 mm and particularly preferably not greater than 5.0 mm.

[0042] In FIG. 4, a double ended arrow Dp1 indicates a first depth of the dimple 10. The first depth Dp1 is the distance between the deepest part of the dimple 10 and the surface of the phantom sphere 14. In FIG. 4, a double ended arrow Dp2 indicates a second depth of the dimple 10. The second depth Dp2 is the distance between the deepest part of the dimple 10 and the tangent line Tg.

[0043] In light of suppression of rising of the golf ball 2 during flight, the first depth Dp1 of each dimple 10 is preferably not less than 0.10 mm, more preferably not less than 0.13 mm, and particularly preferably not less than 0.15 mm. In light of suppression of dropping of the golf ball 2 during flight, the first depth Dp1 is preferably not greater than 0.65 mm, more preferably not greater than 0.60 mm, and particularly preferably not greater than 0.55 mm.

[0044] The area S of the dimple 10 is the area of a region surrounded by the contour line of the dimple 10 when the central point of the golf ball 2 is viewed at infinity. In the case of a circular dimple 10, the area S is calculated by the following mathematical formula.

$$S = (Dm / 2)^2 * \pi$$

[0045] In the golf ball 2 shown in FIGS. 2 and 3, the area of each dimple A is 15.21 mm²; the area of each dimple B is 14.52 mm²; the area of each dimple C is 13.53 mm²; the area of each dimple D is 11.95 mm²; and the area of each dimple E is 7.07 mm².

[0046] In the present invention, the ratio of the sum of the areas S of all the dimples 10 relative to the surface area of the phantom sphere 14 is referred to as an occupation ratio So. From the standpoint of achieving sufficient turbulization, the occupation ratio So is preferably not less than 78%, more preferably not less than 80%, and particularly preferably not less than 82%. The occupation ratio So is preferably not greater than 95%. In the golf ball 2 shown in FIGS. 2 and 3, the total area of the dimples 10 is 4695.6 mm². The surface area of the phantom sphere 14 of the golf ball 2 is 5728 mm², so that the occupation ratio So is 82.0%.

[0047] The standard deviation Su of the areas of all the dimples 10 is preferably not greater than 1.7 mm². The golf ball 2 having a standard deviation Su of not greater than 1.7 mm² has excellent flight performance. From this viewpoint, the standard deviation Su is more preferably not greater than 1.61 mm² and particularly preferably not greater than 1.44 mm². The standard deviation Su is preferably not less than 1.2 mm². In the present embodiment, the average of the areas of all the dimples 10 is 13.89 mm². Therefore, the standard deviation Su of the areas of these dimples is calculated by the following mathematical formula.

$$\begin{aligned} Su &= ((15.20 - 13.89)^2 * 60 + (14.52 - 13.89)^2 * 158 \\ &\quad + (13.53 - 13.89)^2 * 72 + (11.95 - 13.89)^2 * 36 + \\ &\quad (7.07 - 13.89)^2 * 12) / 338)^{1/2} \\ &= 1.61 \end{aligned}$$

[0048] From the standpoint of achieving a sufficient occupation ratio So, the total number of the dimples 10 is preferably not less than 250, more preferably not less than 280, and particularly preferably not less than 300. From the standpoint that each dimple 10 can contribute to turbulization, the total number of the dimples 10 is preferably not greater than 450, more preferably not greater than 410, and particularly preferably not greater than 390.

[0049] In the present invention, the "volume V of the dimple" means the volume of a portion surrounded by the surface of the phantom sphere 14 and the surface of the dimple 10. The total volume TV of the dimples 10 is preferably not less than 450 mm³ and not greater than 750 mm³. With the golf ball 2 having a total volume TV of not less than 450 mm³, rising of the golf ball 2 during flight is suppressed. From this viewpoint, the total volume TV is more preferably not less than 480 mm³ and particularly preferably not less than 500 mm³. With the golf ball 2 having a total volume TV of not greater than 750 mm³, dropping of the golf ball 2 during flight is suppressed. From this viewpoint, the total volume TV is more preferably not greater than 730 mm³ and particularly preferably not greater than 710 mm³.

[0050] As shown in FIG. 3, the surface of the golf ball 2 (or the phantom sphere 14) can be divided into two hemispheres HE by an equator Eq. Specifically, the surface can be divided into a northern hemisphere NH and a southern hemisphere SH. Each hemisphere HE has a pole P. The pole P corresponds to a deepest point of a mold for the golf ball 2.

[0051] The plan view in FIG. 2 shows the northern hemisphere. The southern hemisphere (corresponding to a bottom view) has a pattern obtained by rotating the dimple pattern in FIG. 2 about the pole P. Line segments S1, S2, and S3 shown in FIG. 2 each extend from the pole P. The angle at the pole P between the line segment S1 and the line segment S2 is 120° . The angle at the pole P between the line segment S2 and the line segment S3 is 120° . The angle at the pole P between the line segment S3 and the line segment S1 is 120° .

[0052] Of the surface of the golf ball 2 (or the phantom sphere 14), a zone surrounded by the line segment S1, the line segment S2, and the equator Eq (see FIG. 3) is a first spherical triangle T1. Of the surface of the golf ball 2 (or the phantom sphere 14), a zone surrounded by the line segment S2, the line segment S3, and the equator Eq is a second spherical triangle T2. Of the surface of the golf ball 2 (or the phantom sphere 14), a zone surrounded by the line segment S3, the line segment S1, and the equator Eq is a third spherical triangle T3. Each spherical triangle is a unit. The hemisphere HE can be divided into the three units.

[0053] When the dimple pattern of the first spherical triangle T1 is rotated by 120° about a straight line connecting the two poles P, the resultant dimple pattern substantially overlaps the dimple pattern of the second spherical triangle T2. When the dimple pattern of the second spherical triangle T2 is rotated by 120° about the straight line connecting the two poles P, the resultant dimple pattern substantially overlaps the dimple pattern of the third spherical triangle T3. When the dimple pattern of the third spherical triangle T3 is rotated by 120° about the straight line connecting the two poles P, the resultant dimple pattern substantially overlaps the dimple pattern of the first spherical triangle T1. In other words, the dimple pattern of the hemisphere is composed of three units that are rotationally symmetrical to each other.

[0054] A pattern obtained by rotating the dimple pattern of each hemisphere HE by 120° about the straight line connecting the two poles P substantially overlaps the dimple pattern that has not been rotated. The dimple pattern of each hemisphere HE has 120° rotational symmetry.

[0055] A line segment S4 shown in FIG. 2 extends from the pole P. The angle at the pole P between the line segment S4 and the line segment S1 is 60° . The angle at the pole P between the line segment S4 and the line segment S2 is 60° . The first spherical triangle T1 (unit) can be divided into a small spherical triangle T1a and another small spherical triangle T1b by the line segment S4. The spherical triangle T1a and the spherical triangle T1b are small units.

[0056] A pattern obtained by inverting the dimple pattern of the spherical triangle T1a with respect to a plane containing the line segment S4 and the straight line connecting both poles P substantially overlaps the dimple pattern of the spherical triangle T1b. In other words, the dimple pattern of the first spherical triangle T1 (unit) is composed of two small units that are mirror-symmetrical to each other.

[0057] Although not shown, similar to the first spherical triangle T1, the dimple pattern of the second spherical triangle T2 is also composed of two small units that are mirror-symmetrical to each other. The dimple pattern of the third spherical triangle T3 is also composed of two small units that are mirror-symmetrical to each other. The dimple pattern of the hemisphere HE is composed of the six small units.

[0058] According to the findings by the present inventor, with the golf ball 2 of which the dimple pattern of each hemisphere is composed of three units that are rotationally symmetrical to each other by 120° and the dimple pattern of each unit is composed of two small units that are mirror-symmetrical to each other, turbulization is promoted. The golf ball 2 has excellent flight performance.

[0059] The golf ball may have a dimple pattern in which each unit is not divided into two small units that are mirror-symmetrical to each other. The golf ball may have a dimple pattern in which each hemisphere is not divided into three units that are rotationally symmetrical to each other by 120° .

[0060] FIG. 5 is a partially enlarged view of the golf ball 2 in FIG. 2. FIG. 5 shows a first dimple 10a and a second dimple 10b. For the first dimple 10a, the second dimple 10b is a neighboring dimple. For the second dimple 10b, the first dimple 10a is a neighboring dimple. The first dimple 10a and the second dimple 10b form one neighboring dimple pair 16.

[0061] In FIG. 5, reference character CL represents the line segment that connects the center of the first dimple 10a and the center of the second dimple 10b to each other. In FIG. 5, reference character L represents the distance between the dimples 10 of the neighboring dimple pair 16. The distance L is measured along the line segment CL.

[0062] The surface of the golf ball 2 is a curved surface. The size of each dimple 10 is sufficiently small as compared to the size of the golf ball 2. Thus, in FIG. 5, the curved surface is approximated to a plane, the line segment CL is drawn, and the distance L is measured. Also in FIGS. 6 to 9 described below, similarly, the curved surface is approximated to a plane.

[0063] The following will describe the definition of neighboring dimples. FIG. 6 shows a first dimple 10a and a second dimple 10b. The line segment CL that connects the center of the first dimple 10a and the center of the second dimple 10b to each other does not intersect any dimple 10 other than the first dimple 10a and the second dimple 10b.

[0064] In FIG. 6, reference character Tg1 represents a first common inscribed line of the first dimple 10a and the

second dimple 10b. The first common inscribed line Tg1 has an end on the circumference of the first dimple 10a, and another end on the circumference of the second dimple 10b. The first common inscribed line Tg1 does not intersect any dimple 10.

[0065] In FIG. 6, reference character Tg2 represents a second common inscribed line of the first dimple 10a and the second dimple 10b. The second common inscribed line Tg2 has an end on the circumference of the first dimple 10a, and another end on the circumference of the second dimple 10b. The second common inscribed line Tg2 does not intersect any dimple 10.

[0066] In the present invention, when two dimples 10 satisfy both of conditions (1) and (2) described below, these dimples 10 are referred to as a "neighboring dimple pair".

- (1) The straight line that connects the centers of these dimples to each other does not intersect any other dimple.
- (2) Each of the two common inscribed lines of these dimples does not intersect any dimple.

[0067] When a neighboring dimple pair 16 is present, one dimple 10 of the neighboring dimple pair 16 is a neighboring dimple with respect to the other dimple 10, and the other dimple 10 is a neighboring dimple with respect to the one dimple 10.

[0068] The first dimple 10a and the second dimple 10b shown in FIG. 6 form a neighboring dimple pair 16. The first dimple 10a is a neighboring dimple with respect to the second dimple 10b, and the second dimple 10b is a neighboring dimple with respect to the first dimple 10a.

[0069] FIG. 7 shows a first dimple 10a, a second dimple 10b, and a third dimple 10c. The line segment CL that connects the center of the first dimple 10a and the center of the second dimple 10b to each other intersects the third dimple 10c. Therefore, a pair of the first dimple 10a and the second dimple 10b is not a neighboring dimple pair 16. The first dimple 10a is not a neighboring dimple with respect to the second dimple 10b, and the second dimple 10b is not a neighboring dimple with respect to the first dimple 10a.

[0070] FIG. 8 shows a first dimple 10a, a second dimple 10b, and a third dimple 10c. The line segment CL that connects the center of the first dimple 10a and the center of the second dimple 10b to each other does not intersect any dimple 10 other than the first dimple 10a and the second dimple 10b. The first common inscribed line Tg1 does not intersect any dimple 10. However, the second common inscribed line Tg2 intersects the third dimple 10c. Therefore, a pair of the first dimple 10a and the second dimple 10b is not a neighboring dimple pair 16. The first dimple 10a is not a neighboring dimple with respect to the second dimple 10b, and the second dimple 10b is not a neighboring dimple with respect to the first dimple 10a.

[0071] FIG. 9 shows a first dimple 10a, a second dimple 10b, a third dimple 10c, a fourth dimple 10d, and a fifth dimple 10e.

[0072] The line segment that connects the center of the first dimple 10a and the center of the second dimple 10b to each other does not intersect any dimple 10 other than the first dimple 10a and the second dimple 10b. Furthermore, each of the two common inscribed lines of the first dimple 10a and the second dimple 10b does not intersect any dimple 10. The first dimple 10a and the second dimple 10b form a neighboring dimple pair 16.

[0073] The line segment that connects the center of the first dimple 10a and the center of the third dimple 10c to each other does not intersect any dimple 10 other than the first dimple 10a and the third dimple 10c. Furthermore, each of the two common inscribed lines of the first dimple 10a and the third dimple 10c does not intersect any dimple 10. The first dimple 10a and the third dimple 10c form a neighboring dimple pair 16.

[0074] One of the two common inscribed lines of the first dimple 10a and the fourth dimple 10d intersects the second dimple 10b. Therefore, the first dimple 10a and the fourth dimple 10d do not form a neighboring dimple pair 16.

[0075] The line segment that connects the center of the first dimple 10a and the center of the fifth dimple 10e to each other intersects the third dimple 10c. Therefore, the first dimple 10a and the fifth dimple 10e do not form a neighboring dimple pair 16.

[0076] As described above, the first dimple 10a and the second dimple 10b form a neighboring dimple pair 16, and the first dimple 10a and the third dimple 10c also form a neighboring dimple pair 16. In FIG. 9, at least two neighboring dimple pairs 16 are present.

[0077] As described above, for the first dimple 10a, the second dimple 10b is a neighboring dimple, and the third dimple 10c is also a neighboring dimple. For the first dimple 10a, at least two neighboring dimples are present. Therefore, the first dimple 10a has at least two distances L (see FIG. 5). For the first dimple 10a, still another neighboring dimple may be present. In the entire golf ball 2, for each dimple 10, a neighboring dimple can be present. In the golf ball 2, a large number of neighboring dimple pairs 16 are present.

[0078] The standard deviation Pd of the distances L between the dimples 10 of all the neighboring dimple pairs 16 is preferably less than 0.500 mm. In other words, the standard deviation Pd is preferably small. As described above, in the golf ball 2, the standard deviation Su of the areas of the dimples 10 is small. In the golf ball 2 having a small standard deviation Su and a small standard deviation Pd, the dimples 10, the sizes of which are less varied, are uniformly arranged.

The golf ball 2 has excellent flight performance. In light of flight performance, the standard deviation Pd is more preferably not greater than 0.458 mm and particularly preferably not greater than 0.317 mm.

[0079] The average of the distances L between the dimples 10 of all the neighboring dimple pairs 16 is preferably not greater than 1.0 mm, more preferably not greater than 0.7 mm, and particularly preferably not greater than 0.5 mm. The average is preferably not less than 0.0 mm.

EXAMPLES

[Example 1]

[0080] A rubber composition was obtained by kneading 100 parts by weight of a high-cis polybutadiene (trade name "BR-730", manufactured by JSR Corporation), 22.5 parts by weight of zinc diacrylate, 5 parts by weight of zinc oxide, 5 parts by weight of barium sulfate, 0.5 parts by weight of diphenyl disulfide, and 0.6 parts by weight of dicumyl peroxide. This rubber composition was placed into a mold including upper and lower mold halves each having a hemispherical cavity, and heated at 170°C for 18 minutes to obtain a core with a diameter of 38.5 mm.

[0081] A resin composition was obtained by kneading 50 parts by weight of an ionomer resin (trade name "Himilan 1605", manufactured by Du Pont-MITSUI POLYCHEMICALS Co., Ltd.), 50 parts by weight of another ionomer resin (trade name "Himilan AM7329", manufactured by Du Pont-MITSUI POLYCHEMICALS Co., Ltd.), and 4 parts by weight of titanium dioxide with a twin-screw kneading extruder. The core was covered with this resin composition by injection molding to form a mid layer with a thickness of 1.6 mm.

[0082] A paint composition (trade name "POLIN 750LE", manufactured by SHINTO PAINT CO., LTD.) including a two-component curing type epoxy resin as a base polymer was prepared. The base material liquid of this paint composition includes 30 parts by weight of a bisphenol A type solid epoxy resin and 70 parts by weight of a solvent. The curing agent liquid of this paint composition includes 40 parts by weight of a modified polyamide amine, 55 parts by weight of a solvent, and 5 parts by weight of titanium dioxide. The weight ratio of the base material liquid to the curing agent liquid is 1:1. This paint composition was applied to the surface of the mid layer with a spray gun, and kept at 23°C for 6 hours to obtain a reinforcing layer with a thickness of 10 μm.

[0083] A resin composition was obtained by kneading 100 parts by weight of a thermoplastic polyurethane elastomer (trade name "Elastollan XNY85A", manufactured by BASF Japan Ltd.) and 4 parts by weight of titanium dioxide with a twin-screw kneading extruder. Half shells were obtained from this resin composition by compression molding. The sphere consisting of the core, the mid layer, and the reinforcing layer was covered with two of these half shells. These half shells and the sphere were placed into a final mold that includes upper and lower mold halves each having a hemispherical cavity and having a large number of pimples on its cavity face, and a cover was obtained by compression molding. The thickness of the cover was 0.5 mm. Dimples having a shape that is the inverted shape of the pimples were formed on the cover. A clear paint including a two-component curing type polyurethane as a base material was applied to this cover to obtain a golf ball of Example 1 with a diameter of about 42.7 mm and a weight of about 45.6 g. The dimple pattern of the golf ball is shown in FIGS. 2 and 3. The specifications of the dimples of the golf ball are shown in Table 1 below. The dimple pattern of each hemisphere of the golf ball is composed of three units that are rotationally symmetrical to each other. The dimple pattern of each unit is composed of two small units that are mirror-symmetrical to each other.

[Examples 2 to 4 and Comparative Examples 1 and 2]

[0084] Golf balls of Examples 2 to 4 and Comparative Examples 1 and 2 were obtained in the same manner as Example 1, except the final mold was changed and the specifications of the dimples were as shown in Tables 1 and 2 below. The specifications of the dimples of each golf ball are shown in Tables 1 and 2 below. The dimple pattern of each hemisphere of the golf ball is composed of three units that are rotationally symmetrical to each other. The dimple pattern of each unit is composed of two small units that are mirror-symmetrical to each other.

[Example 5]

[0085] A golf ball of Example 5 was obtained in the same manner as Example 1, except the final mold was changed and the specifications of the dimples were as shown in Table 2 below. The specifications of the dimples of the golf ball are shown in Table 2 below. The dimple pattern of each hemisphere of the golf ball cannot be divided into three units that are rotationally symmetrical to each other.

[Flight Test #1]

[0086] A driver with a head made of a titanium alloy (trade name "XXIO 10", manufactured by Sumitomo Rubber

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Industries, Ltd., shaft hardness: R, loft angle: 10.5°) was attached to a swing machine manufactured by Golf Laboratories, Inc. A golf ball was hit under the conditions of a head speed of 40 m/sec, a launch angle of about 12°, and a backspin rate of about 2300 rpm, and the distance from the launch point to the stop point was measured. During the test, the weather was almost windless. The average value of data obtained by 20 measurements is shown in Tables 3 and 4 below.

[Flight Test #2]

[0087] A driver with a head made of a titanium alloy (trade name "SRIXON Z-TX", manufactured by Sumitomo Rubber Industries, Ltd., shaft hardness: X, loft angle: 8.5°) was attached to a swing machine manufactured by Golf Laboratories, Inc. A golf ball was hit under the conditions of a head speed of 50 m/sec, a launch angle of about 10°, and a backspin rate of about 2500 rpm, and the distance from the launch point to the stop point was measured. During the test, the weather was almost windless. The average value of data obtained by 20 measurements is shown in Tables 3 and 4 below.

Table 1 Specifications of Dimples

	Number	Dm (mm)	Dp2 (mm)	Dp1 (mm)	CR (mm)	S (mm ²)	V (mm ³)
Example 1							
A	60	4.40	0.138	0.2517	17.61	15.21	1.915
B	158	4.30	0.137	0.2455	16.94	14.52	1.785
C	72	4.15	0.134	0.2351	16.13	13.53	1.592
D	36	3.90	0.123	0.2122	15.52	11.95	1.269
E	12	3.00	0.122	0.1748	9.28	7.07	0.619
Example 2							
A	36	4.40	0.135	0.2487	17.99	15.21	1.892
B	170	4.30	0.135	0.2435	17.19	14.52	1.770
D	84	4.20	0.135	0.2385	16.40	13.85	1.654
E	36	4.10	0.135	0.2336	15.63	13.20	1.544
F	12	3.00	0.135	0.1878	8.40	7.07	0.665
Example 3							
A	314	4.20	0.135	0.2385	16.40	13.85	1.654
B	12	3.90	0.135	0.2242	14.15	11.95	1.341
C	12	3.00	0.135	0.1878	8.40	7.07	0.665
Example 4							
A	102	4.50	0.135	0.2539	18.82	15.90	2.021
B	24	4.40	0.135	0.2487	17.99	15.21	1.892
C	30	4.30	0.135	0.2435	17.19	14.52	1.770
D	54	4.20	0.135	0.2385	16.40	13.85	1.654
E	108	4.00	0.135	0.2289	14.88	12.57	1.440
F	12	3.50	0.135	0.2068	11.41	9.62	0.997

Table 2 Specifications of Dimples

	Number	Dm (mm)	Dp2 (mm)	Dp1 (mm)	CR (mm)	S (mm ²)	V (mm ³)
Comparative Example 1							
A	338	4.11	0.135	7.0000	15.67	13.23	1.550

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(continued)

Comparative Example 2							
A	30	4.60	0.135	0.2592	19.66	16.62	2.157
B	54	4.50	0.135	0.2539	18.82	15.90	2.021
C	72	4.30	0.135	0.2435	17.19	14.52	1.770
D	54	4.20	0.135	0.2385	16.40	13.85	1.654
E	108	4.00	0.135	0.2289	14.88	12.57	1.440
F	12	2.70	0.135	0.1777	6.82	5.73	0.510
Example 5							
A	16	4.60	0.135	0.2592	19.66	16.62	2.157
B	30	4.50	0.135	0.2539	18.82	15.90	2.021
C	30	4.40	0.135	0.2487	17.99	15.21	1.892
D	150	4.30	0.135	0.2435	17.19	14.52	1.770
E	30	4.20	0.135	0.2385	16.40	13.85	1.654
F	66	4.10	0.135	0.2336	15.63	13.20	1.544
G	10	3.80	0.135	0.2197	13.44	11.34	1.247
H	12	3.40	0.135	0.2028	10.77	9.08	0.922

Table 3 Results of Evaluation

	Example 1	Example 2	Example 3	Example 4
Plan view	FIG. 2	FIG. 10	FIG. 12	FIG. 14
Front view	FIG. 3	FIG. 11	FIG. 13	FIG. 15
Number of dimples	338	338	338	330
Number of units	3	3	3	3
Number of small units	6	6	6	6
Occupation ratio So (%)	82.0	82.8	79.9	81.1
Total volume TV (mm ³)	564.6	571.6	543.5	561.5
Standard deviation Su of S (mm ²)	1.61	1.44	1.29	1.62
Number of neighboring dimple pairs	1068	1068	1068	1014
Average of L (mm)	0.295	0.280	0.345	0.332
Standard deviation Pd of L (mm)	0.302	0.314	0.317	0.458
Flight distance #1 (m)	198.6	199.0	198.2	197.5
Flight distance #2 (m)	263.5	264.0	263.0	262.0

Table 4 Results of Evaluation

	Compa. Example 1	Compa. Example 2	Example 5
Plan view	FIG. 16	FIG. 18	FIG. 20
Front view	FIG. 17	FIG. 19	FIG. 21
Number of dimples	338	330	344

(continued)

	Compa. Example 1	Compa. Example 2	Example 5
Number of units	3	3	-
Number of small units	6	6	-
Occupation ratio S_o (%)	78.1	79.9	85.3
Total volume TV (mm^3)	523.7	552.2	592.5
Standard deviation S_u of S (mm^2)	0.00	2.10	1.42
Number of neighboring dimple pairs	1068	1014	1038
Average of L (mm)	0.434	0.375	0.190
Standard deviation Pd of L (mm)	0.502	0.452	0.306
Flight distance #1 (m)	196.4	196.1	197.0
Flight distance #2 (m)	261.4	261.0	260.6

[0088] As shown in Tables 3 and 4, the golf ball of each Example has excellent flight performance under a condition of a head speed of 40 m/sec. In other words, the golf ball of each Example is suitable for golf players having an average head speed. Furthermore, the golf balls according to Examples 1 to 4 also have excellent flight performance under a condition of a head speed of 50 m/sec. From these evaluation results, advantages of the present invention are clear.

[0089] The aforementioned dimple pattern is applicable to golf balls having various structures such as a one-piece golf ball, a two-piece golf ball, a four-piece golf ball, a five-piece golf ball, a six-piece golf ball, a thread-wound golf ball, and the like in addition to a three-piece golf ball. The above descriptions are merely illustrative examples, and various modifications can be made without departing from the principles of the present invention.

Claims

1. A golf ball having a plurality of dimples on a surface thereof, wherein

a standard deviation S_u of areas of all the dimples is not greater than 1.7 mm^2 , and

a standard deviation Pd of distances L between dimples of all neighboring dimple pairs is less than 0.500 mm.

2. The golf ball according to claim 1, wherein the standard deviation Pd is less than 0.400 mm.

3. The golf ball according to claim 1 or 2, wherein

a dimple pattern of each hemisphere of a phantom sphere of the golf ball includes three units that are rotationally symmetrical to each other, and

a dimple pattern of each unit includes two small units that are mirror-symmetrical to each other.

4. The golf ball according to any one of claims 1 to 3, wherein a ratio S_o of a sum of areas of the dimples relative to a surface area of the phantom sphere is not less than 78.0%.

5. The golf ball according to any one of claims 1 to 4, wherein a sum of volumes of all the dimples is not less than 450 mm^3 and not greater than 750 mm^3 .

6. The golf ball according to any one of claims 1 to 5, wherein a total number of the dimples is not less than 300 and not greater than 390.

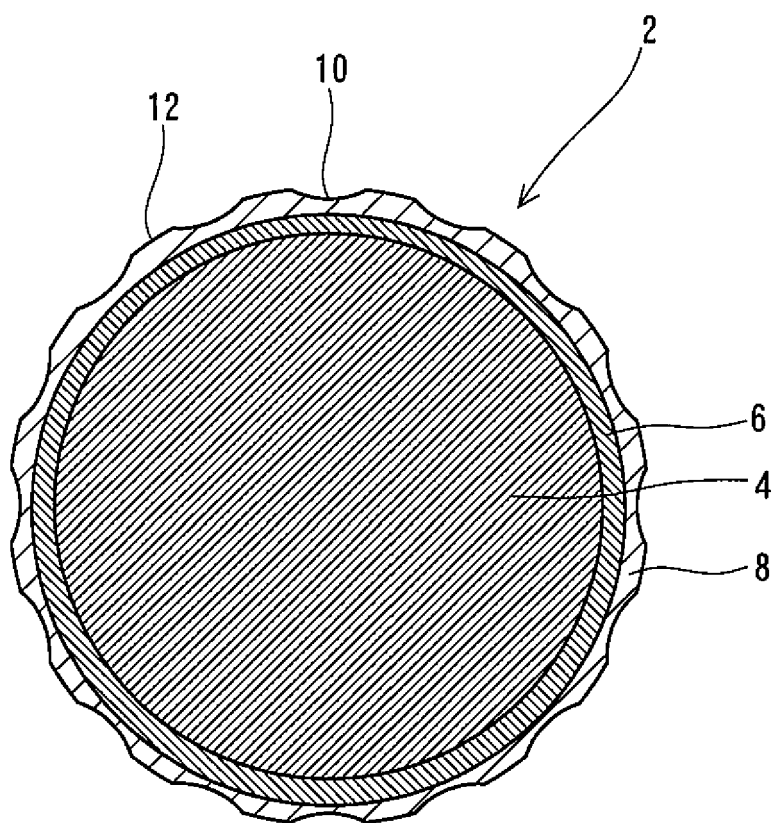


FIG. 1

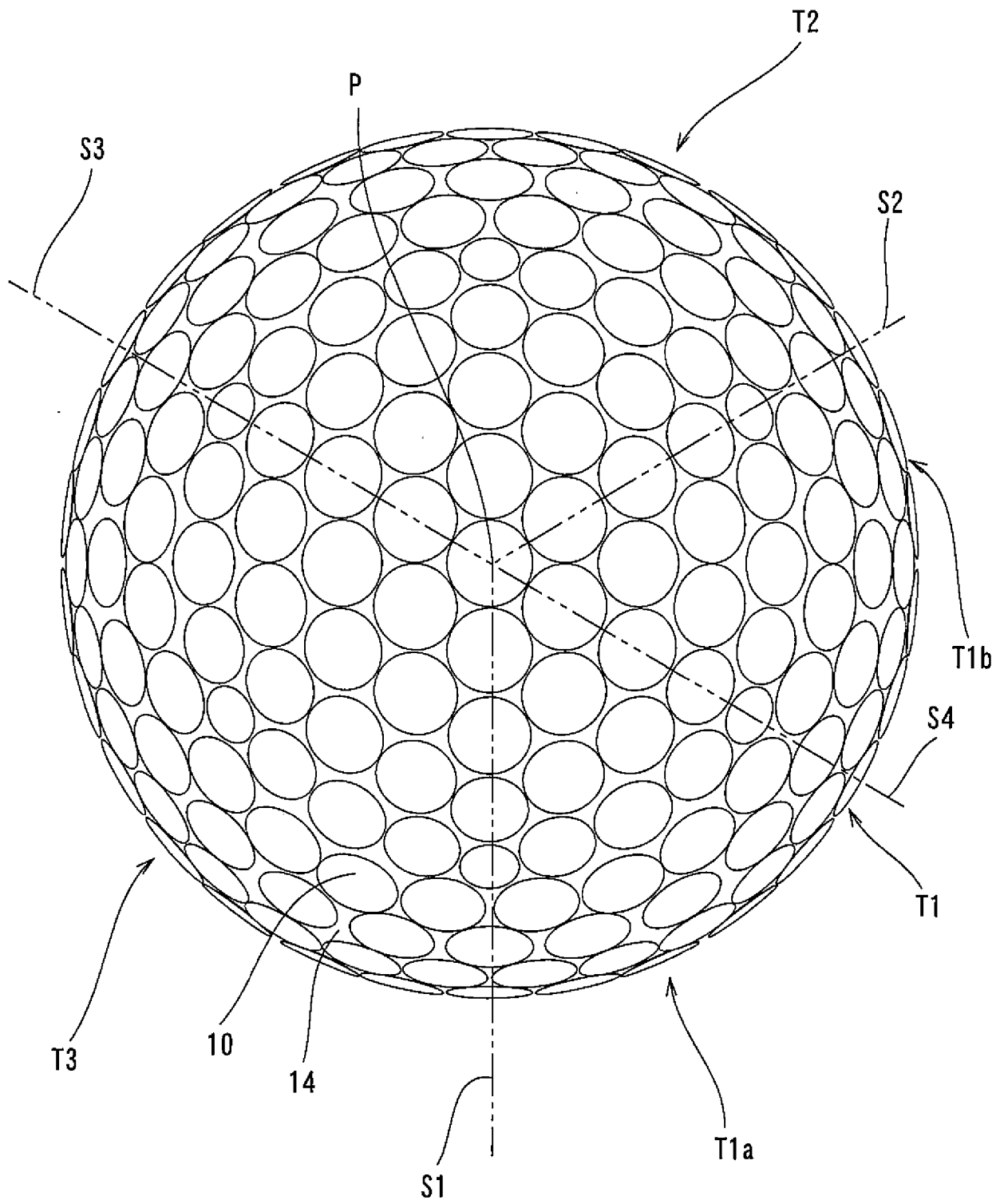


FIG. 2

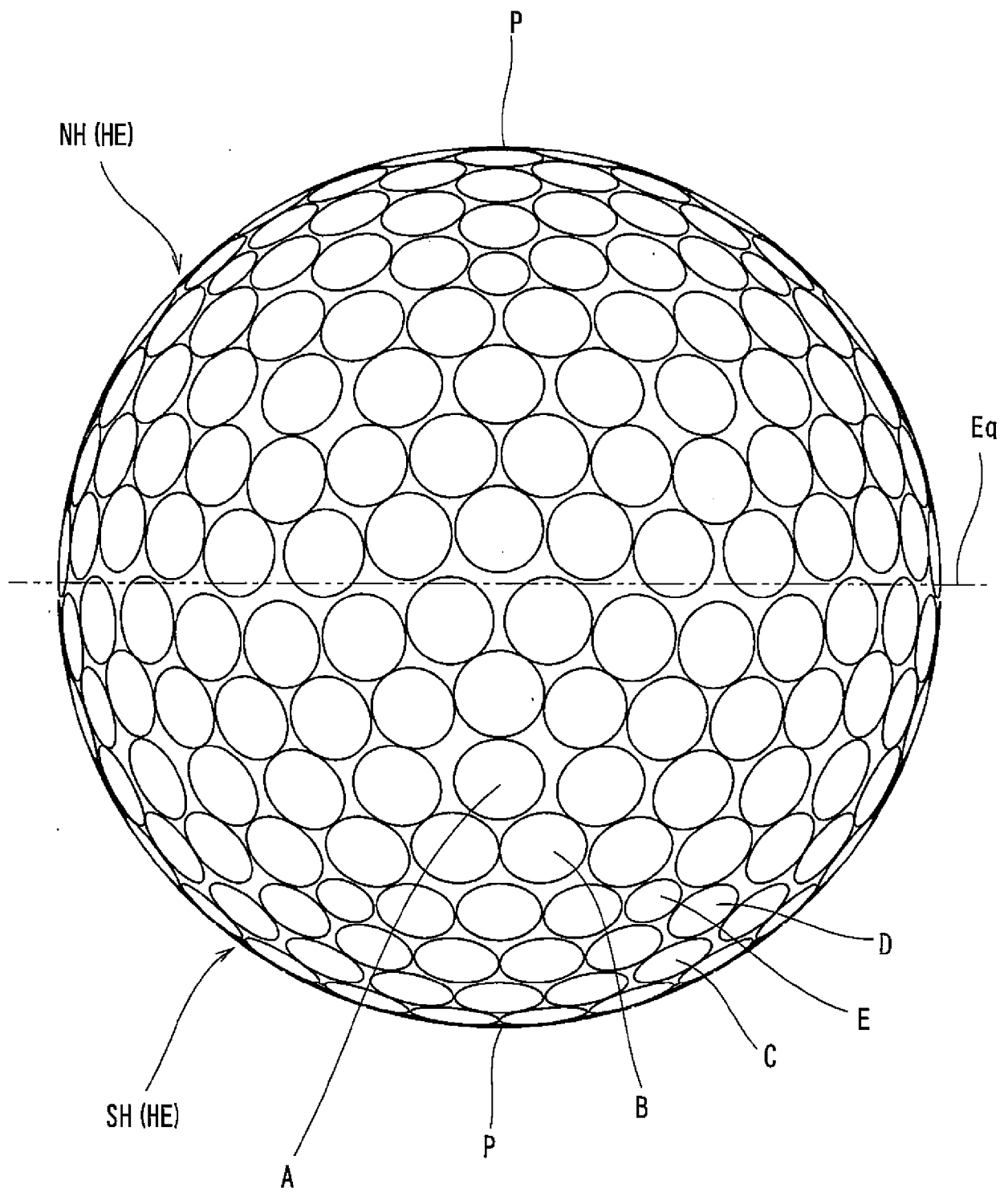


FIG. 3

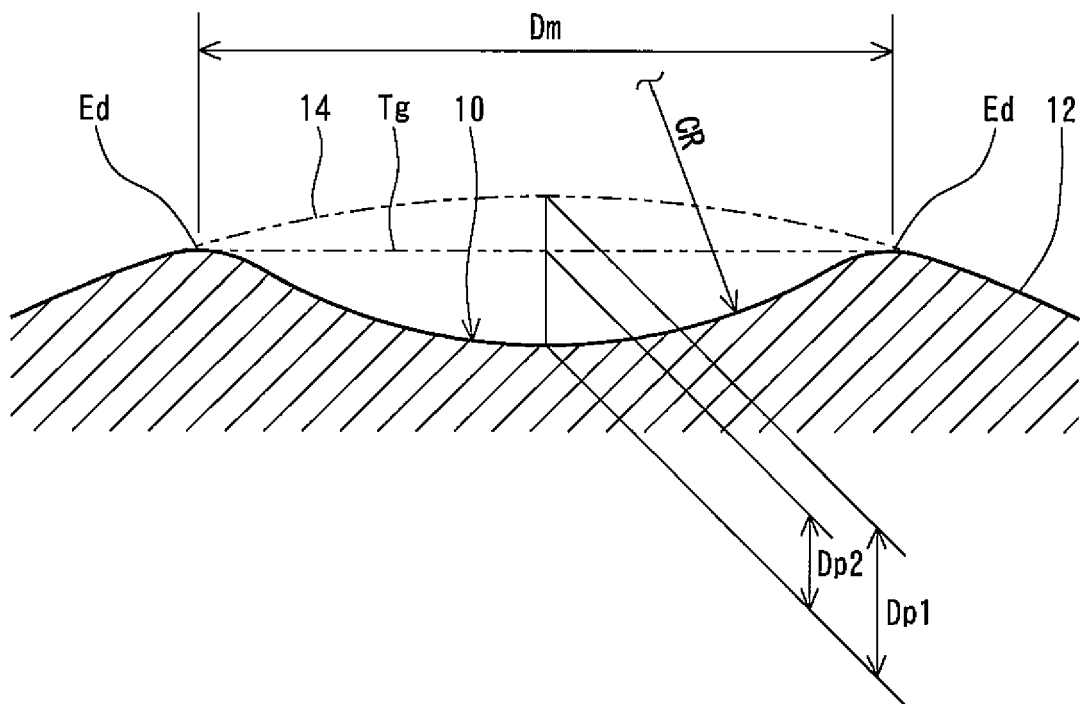


FIG. 4

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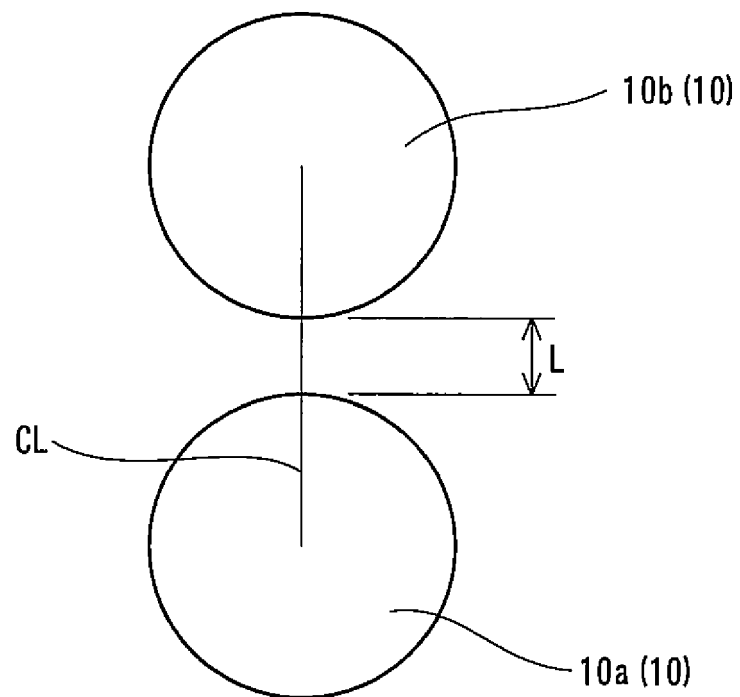


FIG. 5

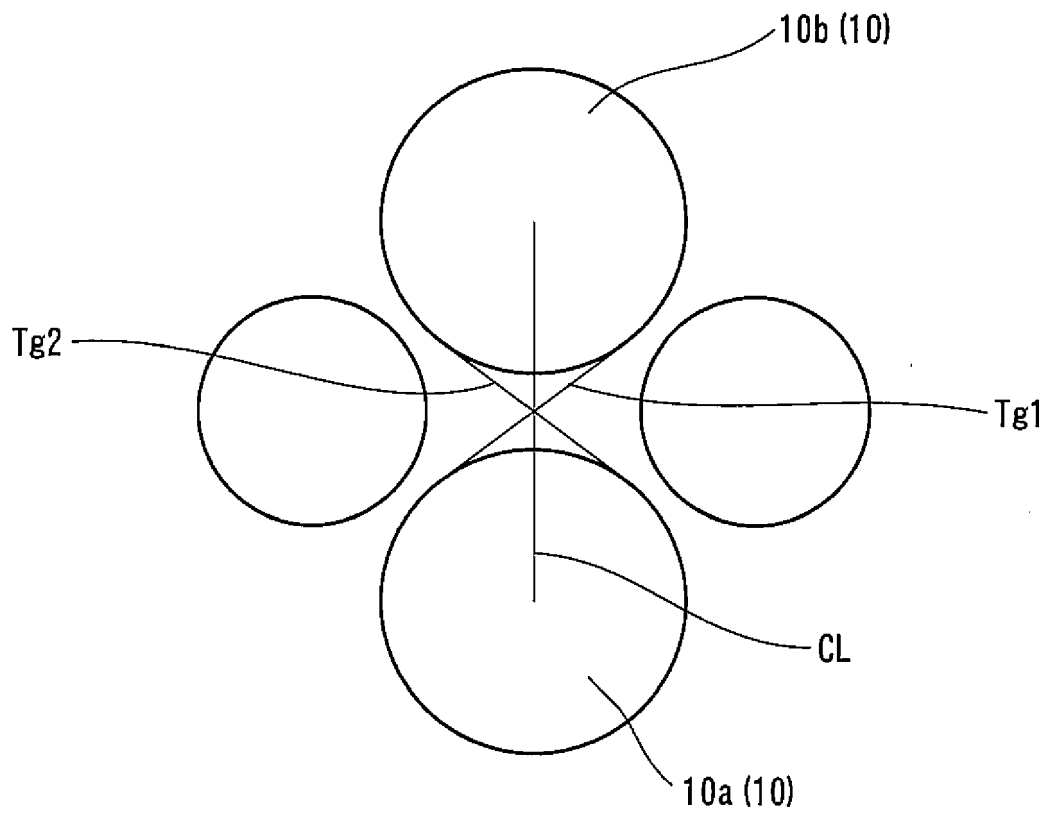


FIG. 6

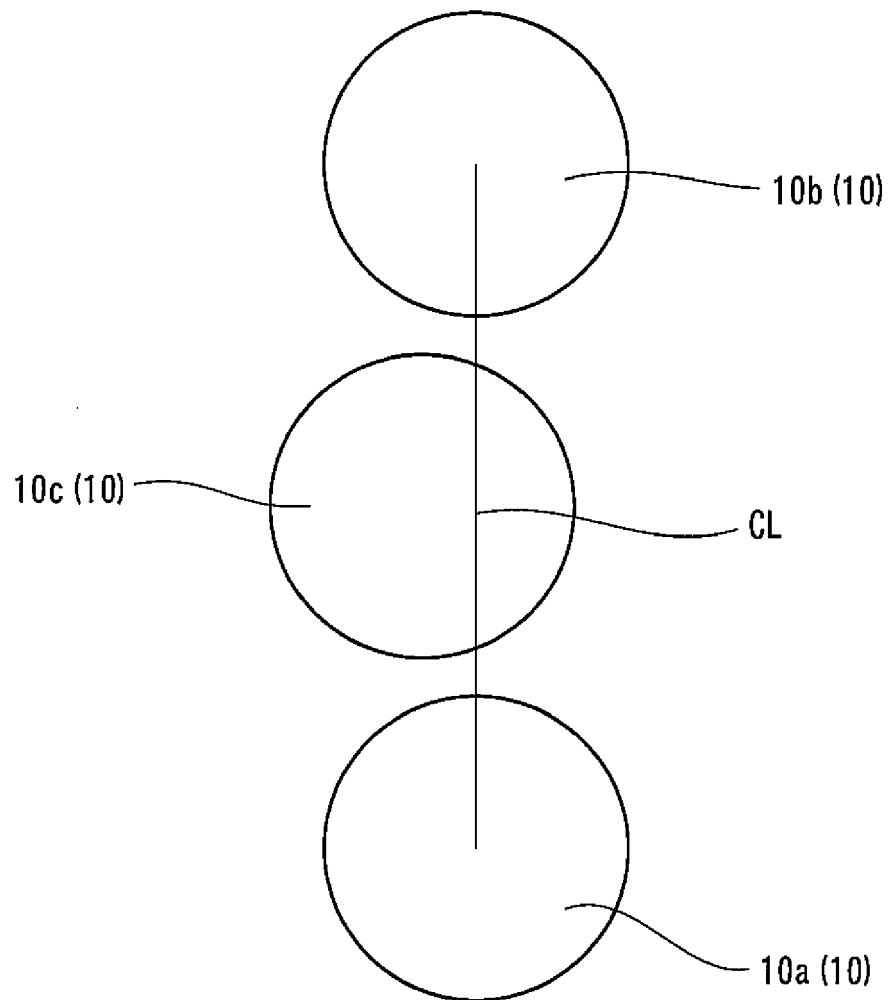


FIG. 7

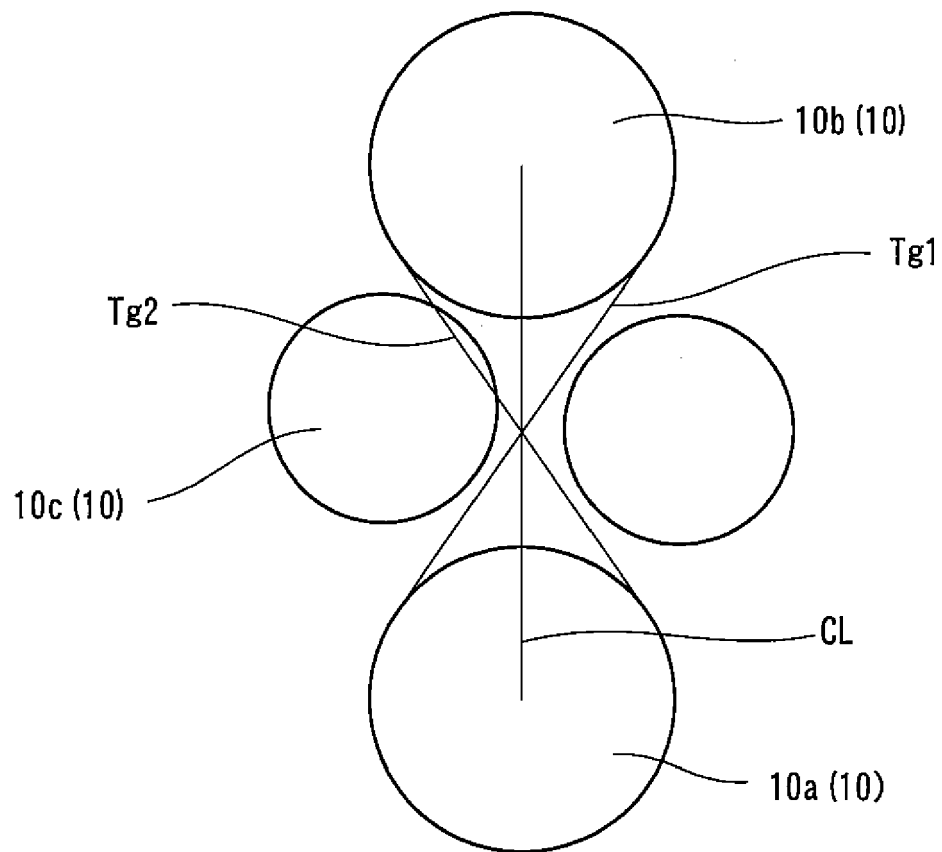


FIG. 8

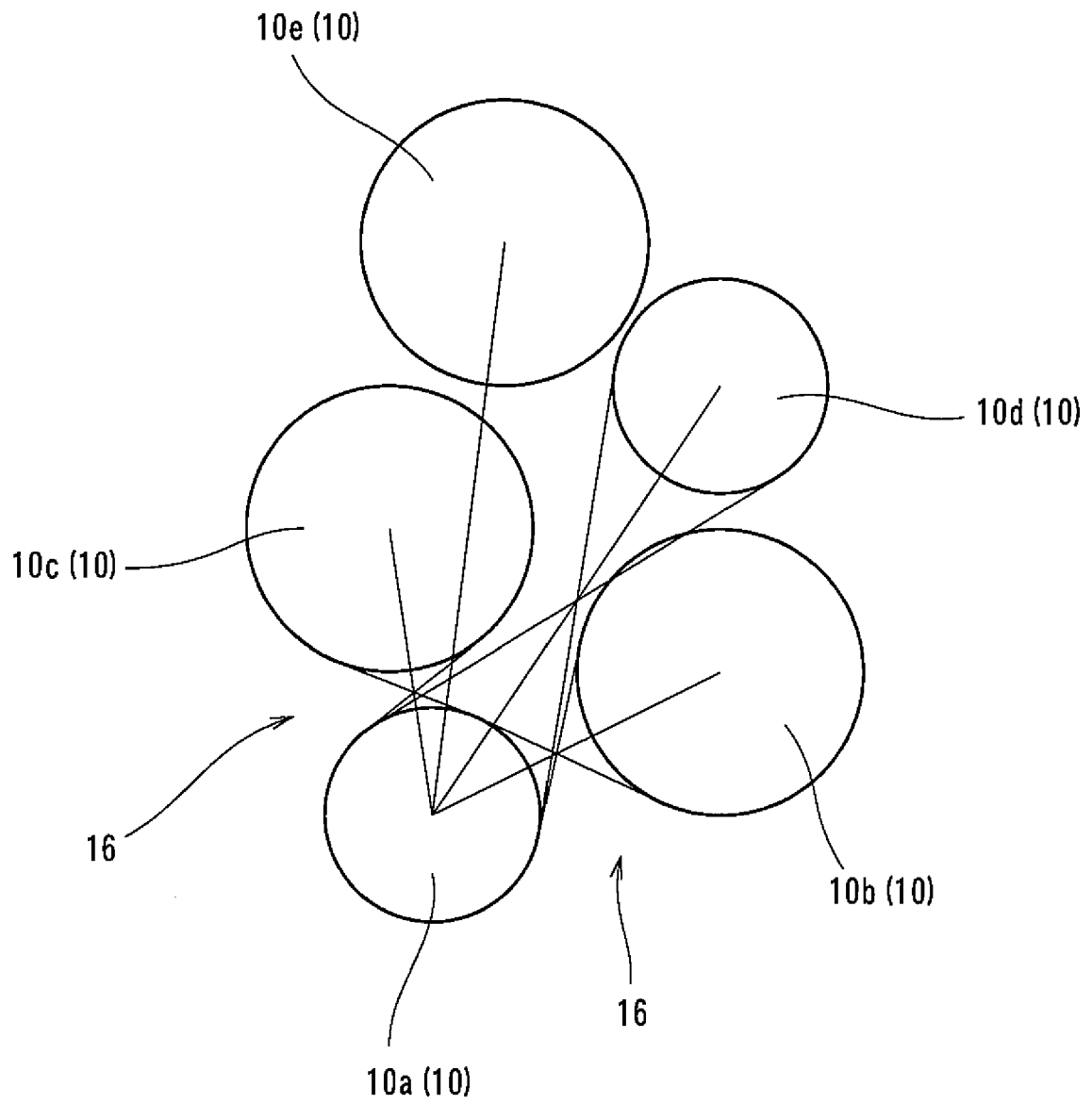


FIG. 9

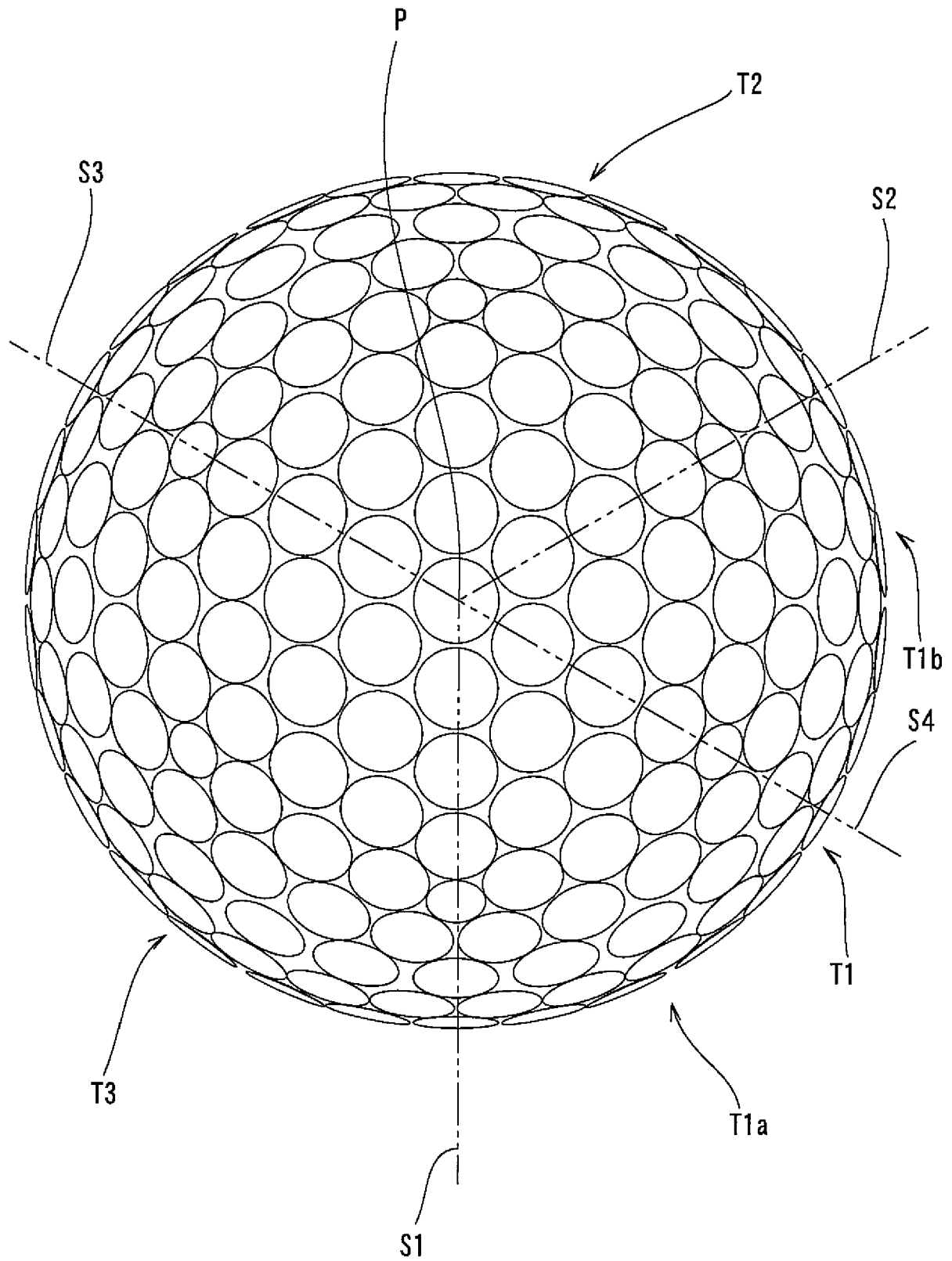


FIG. 10

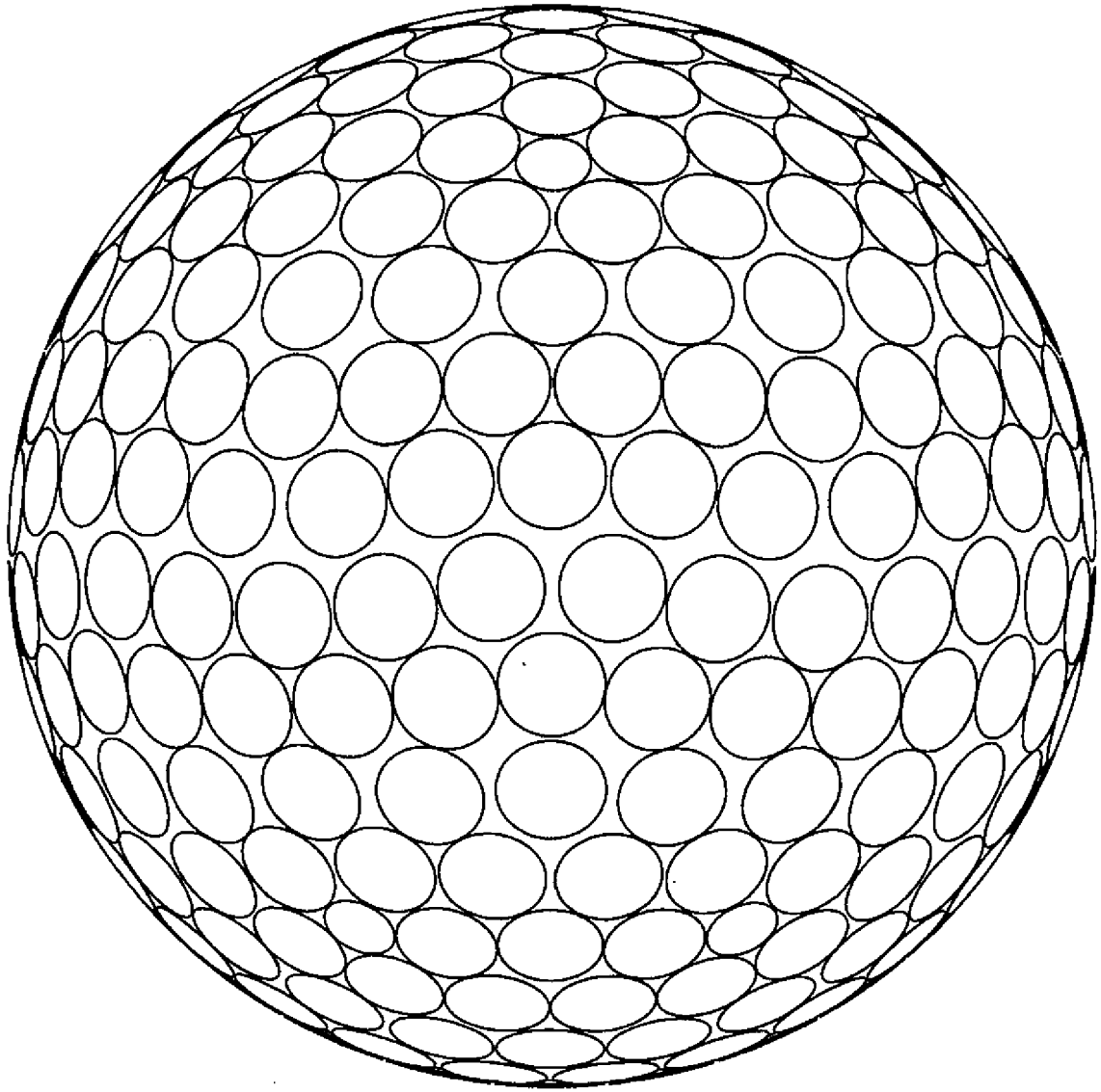


FIG. 11

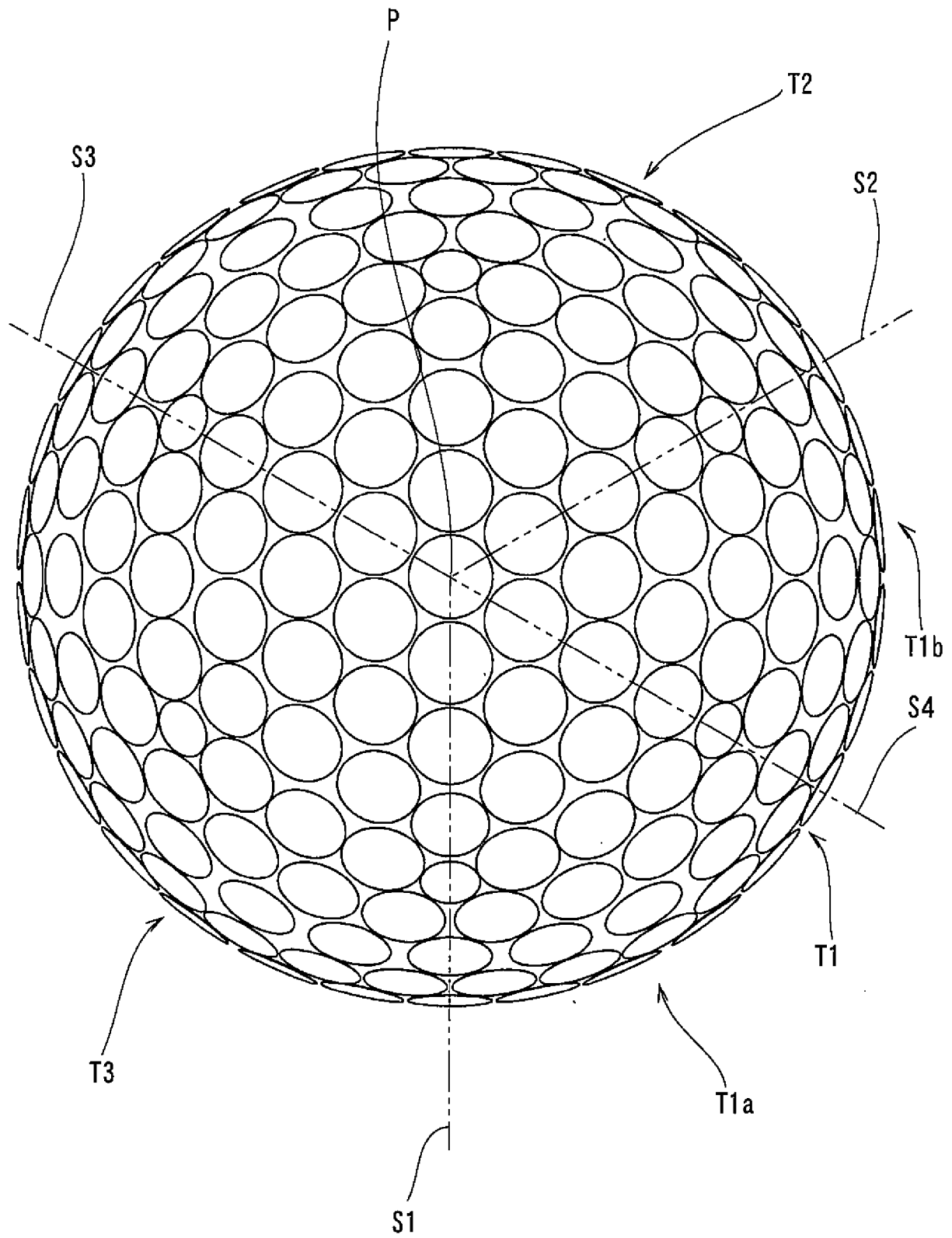


FIG. 12

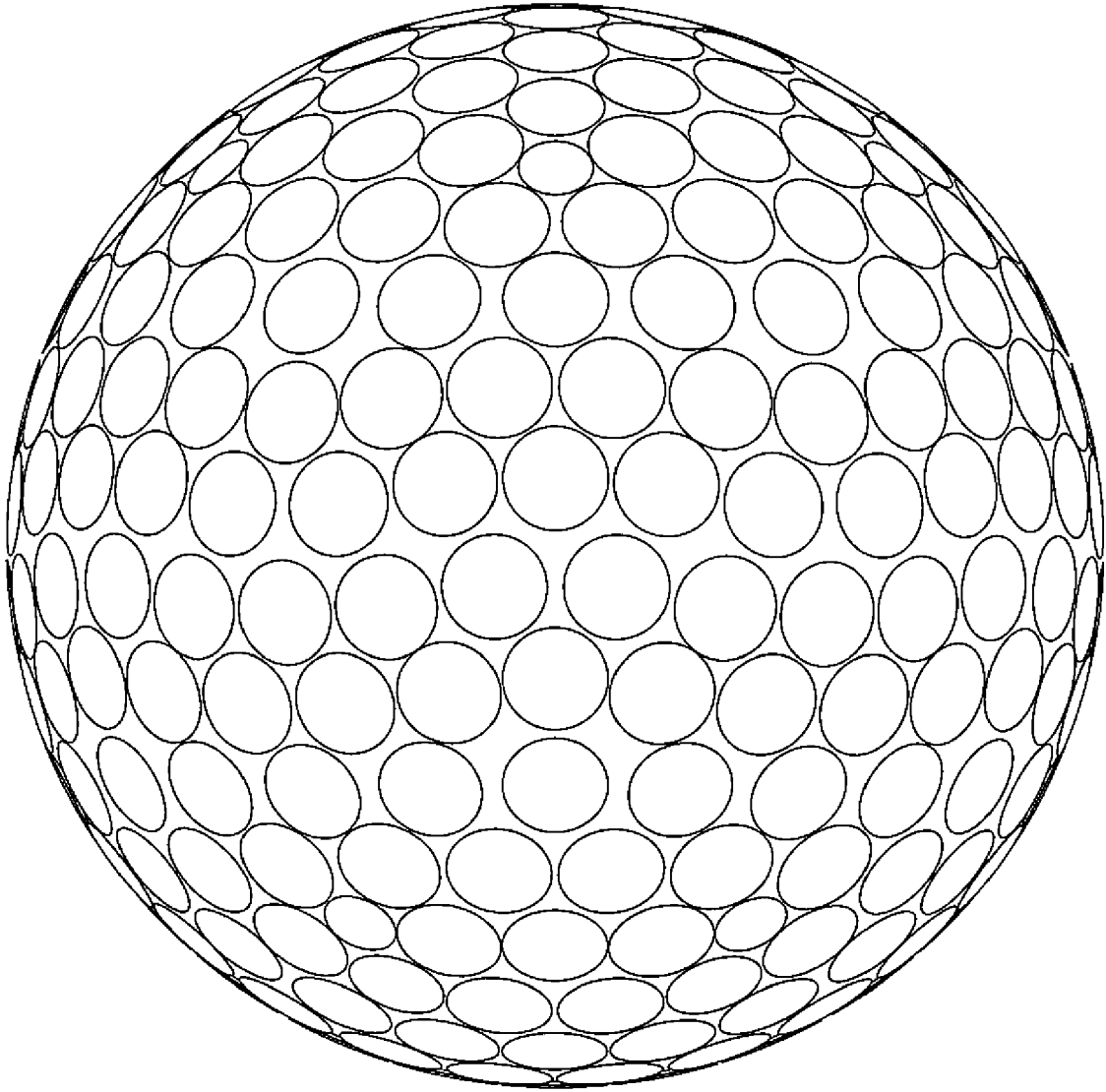


FIG. 13

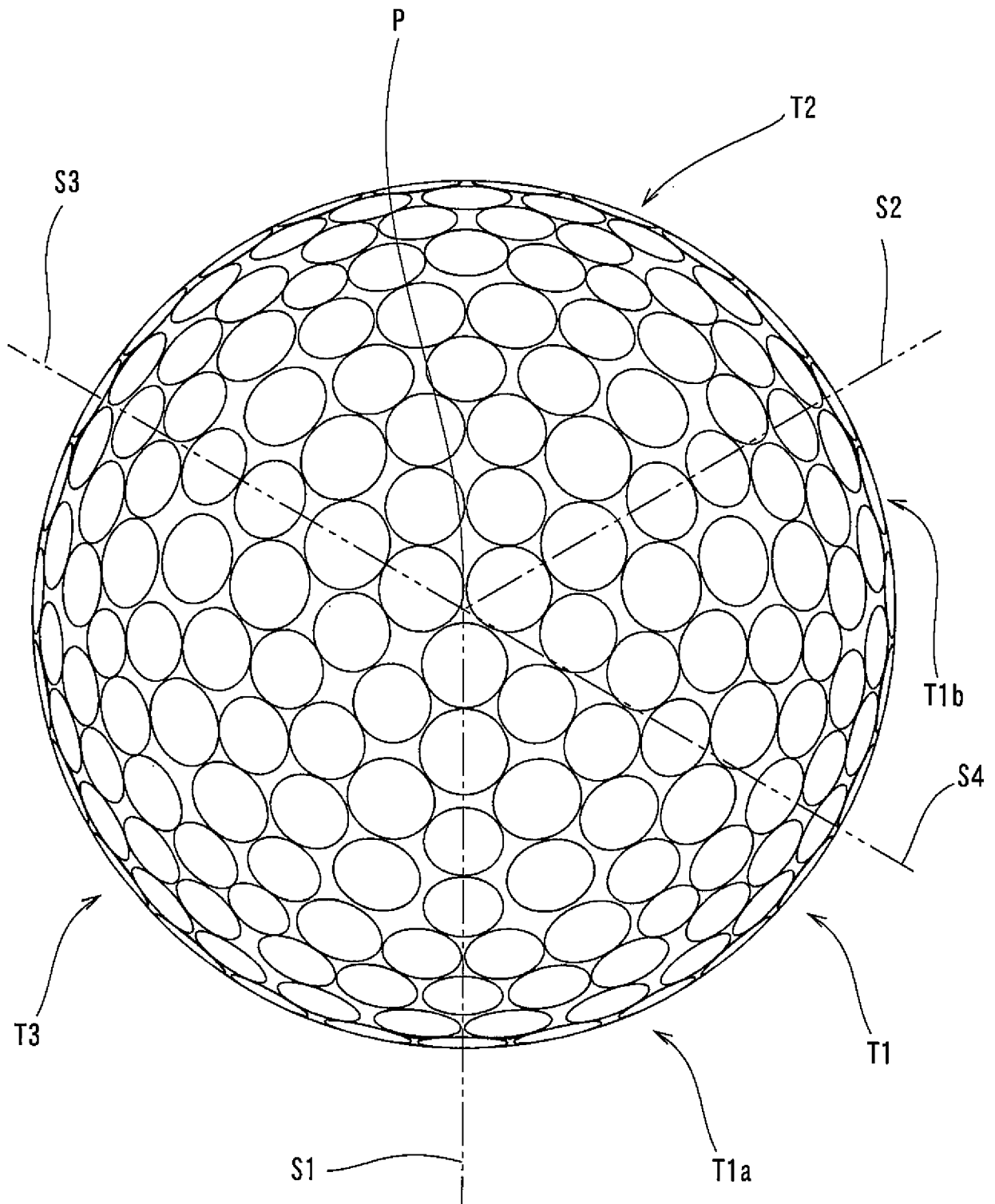


FIG. 14

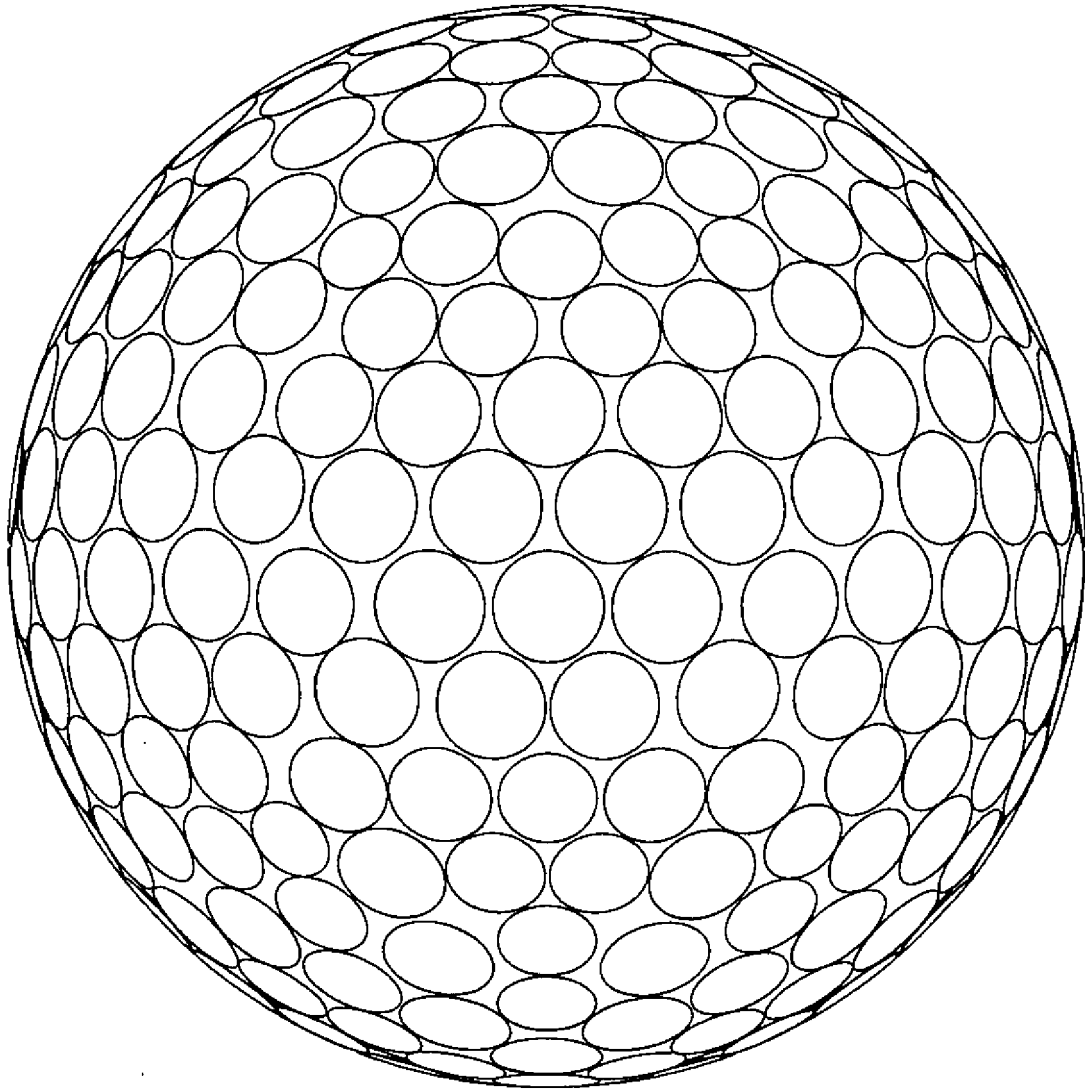


FIG. 15

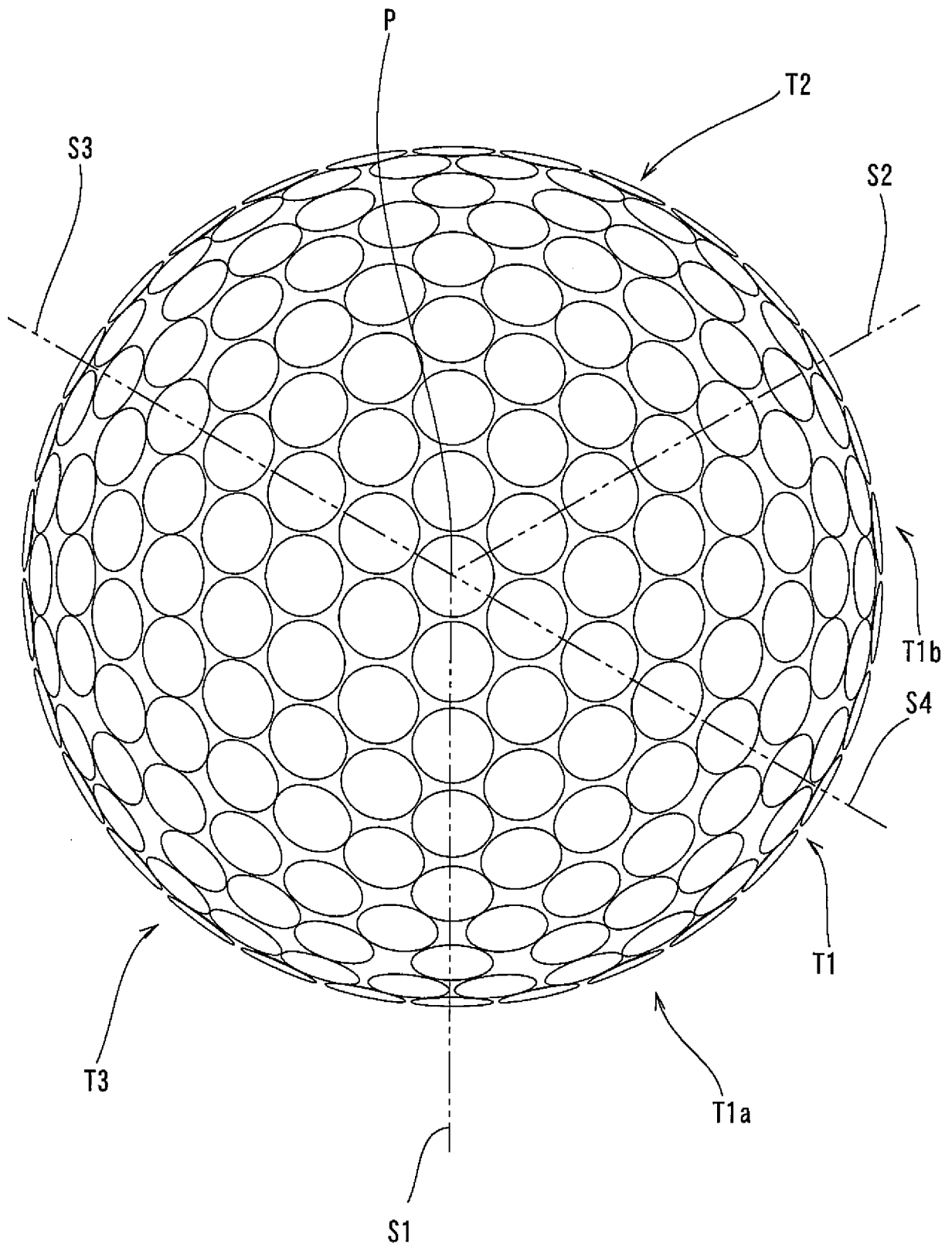


FIG. 16

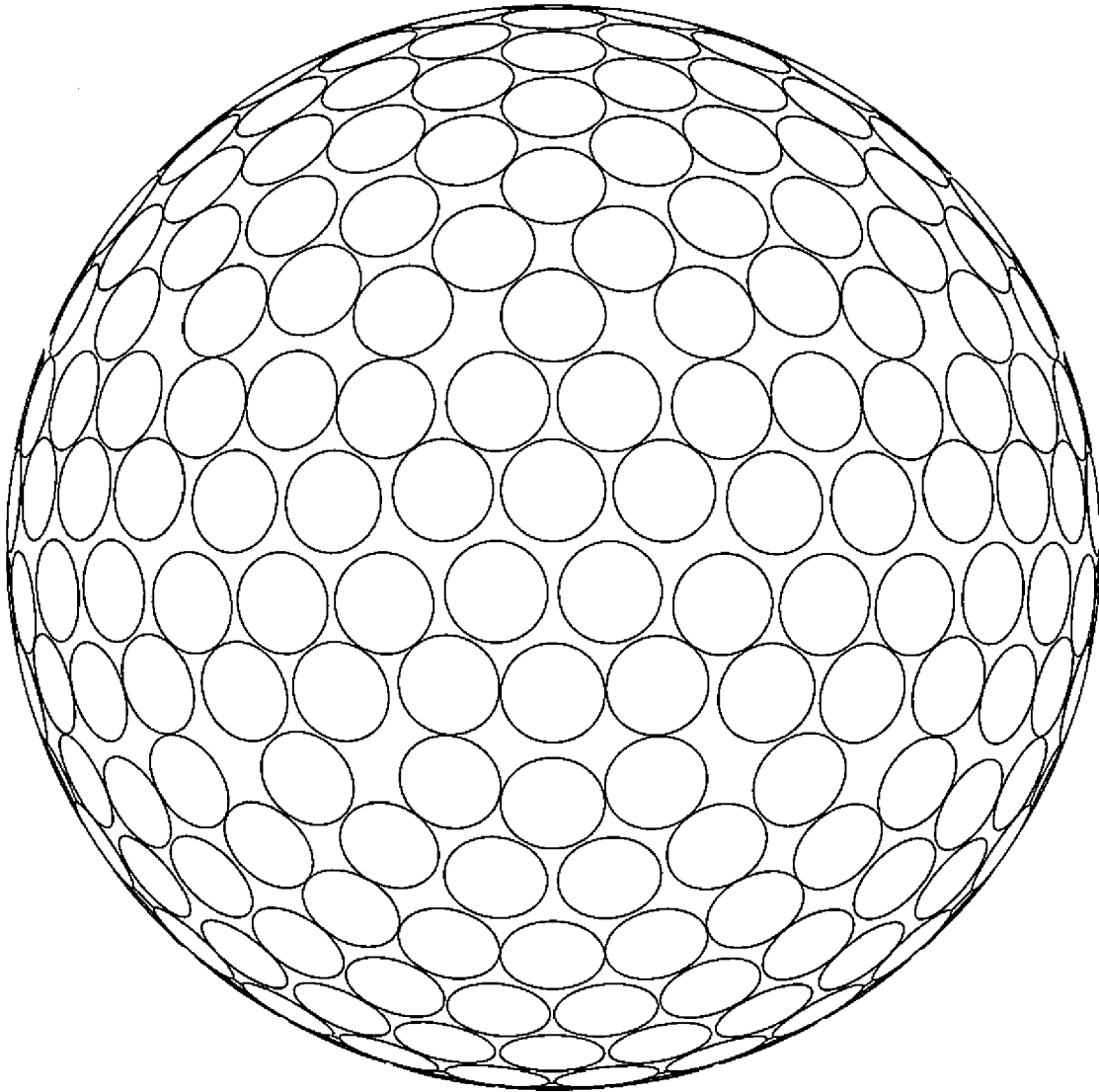


FIG. 17

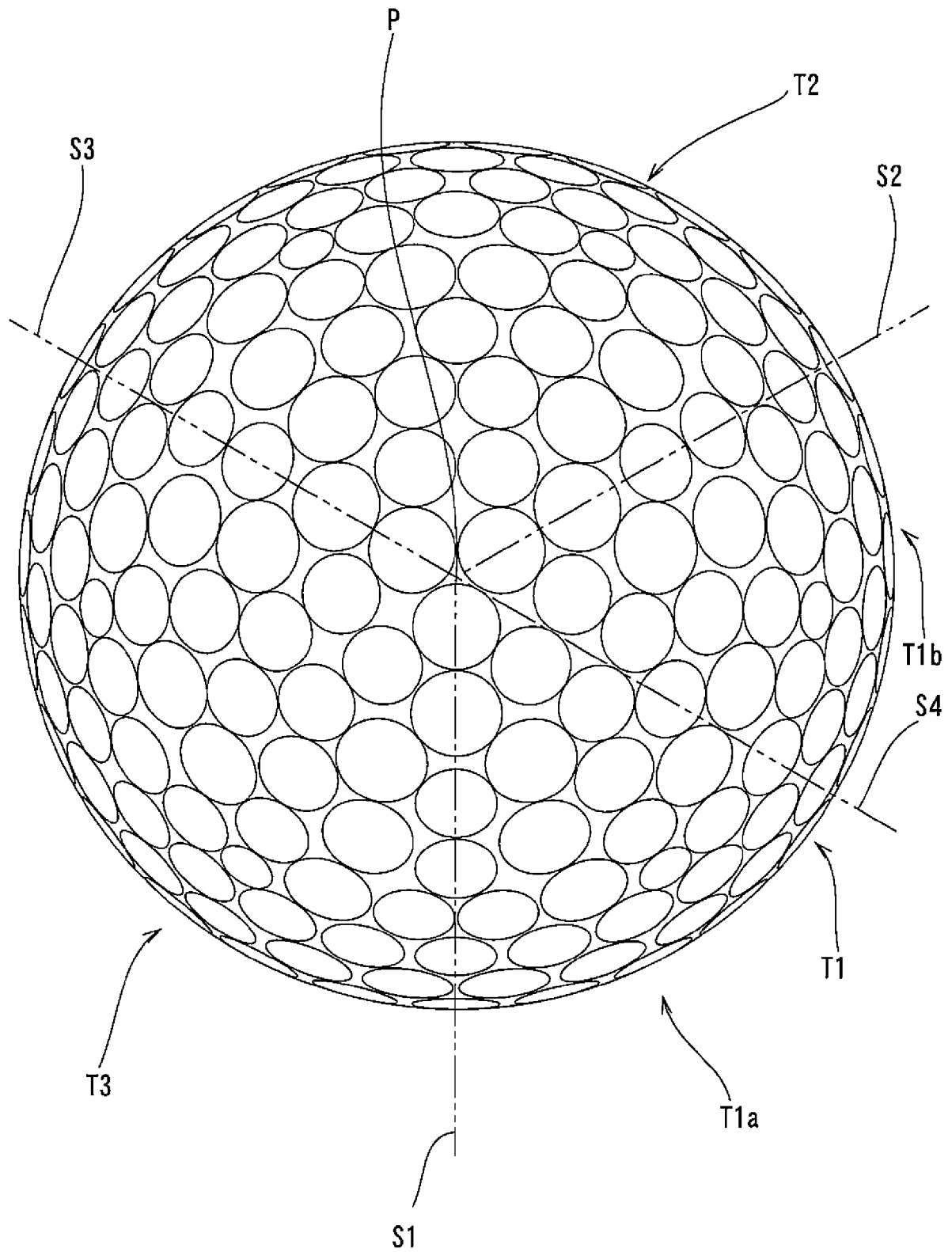


FIG. 18

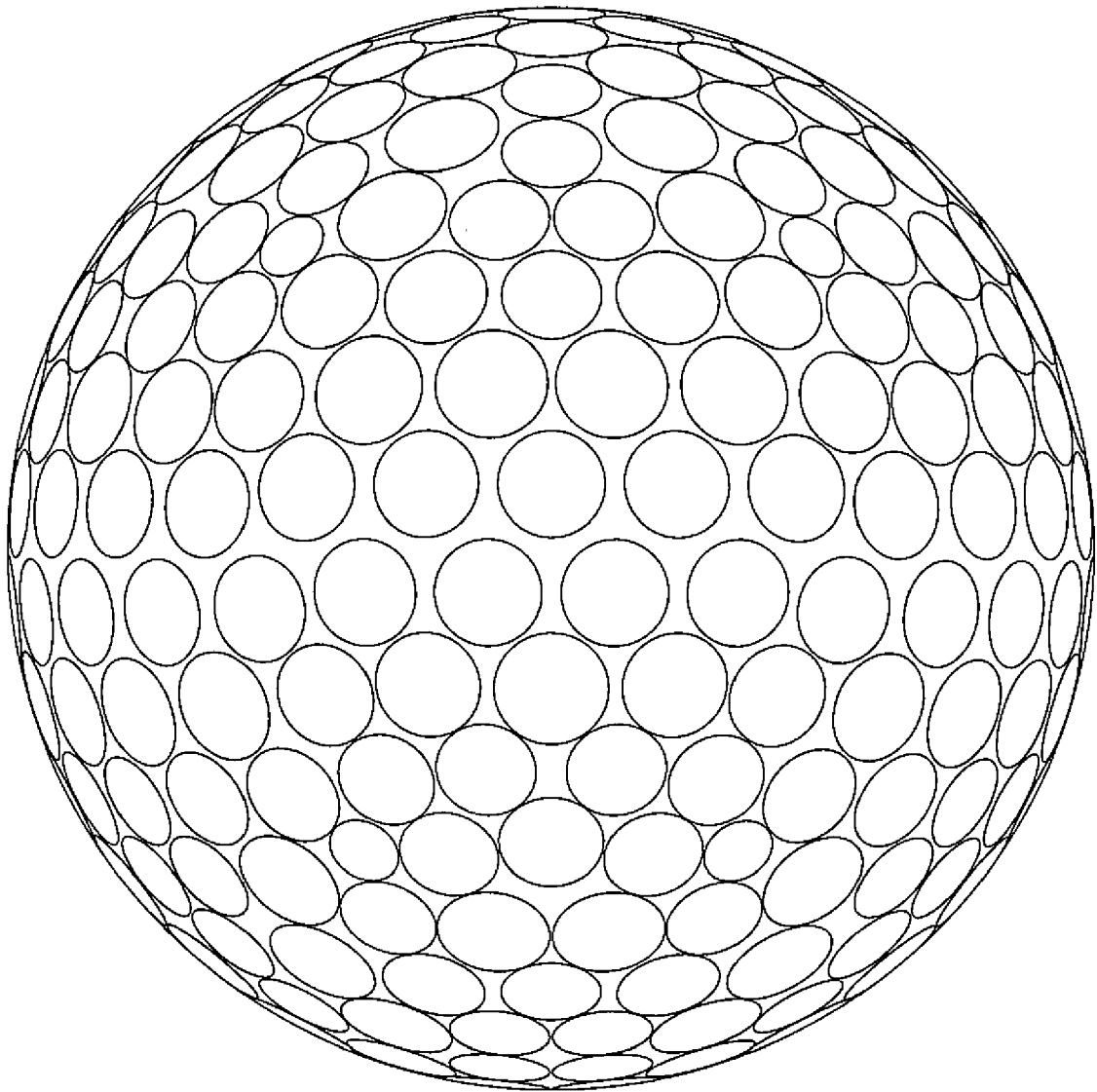


FIG. 19

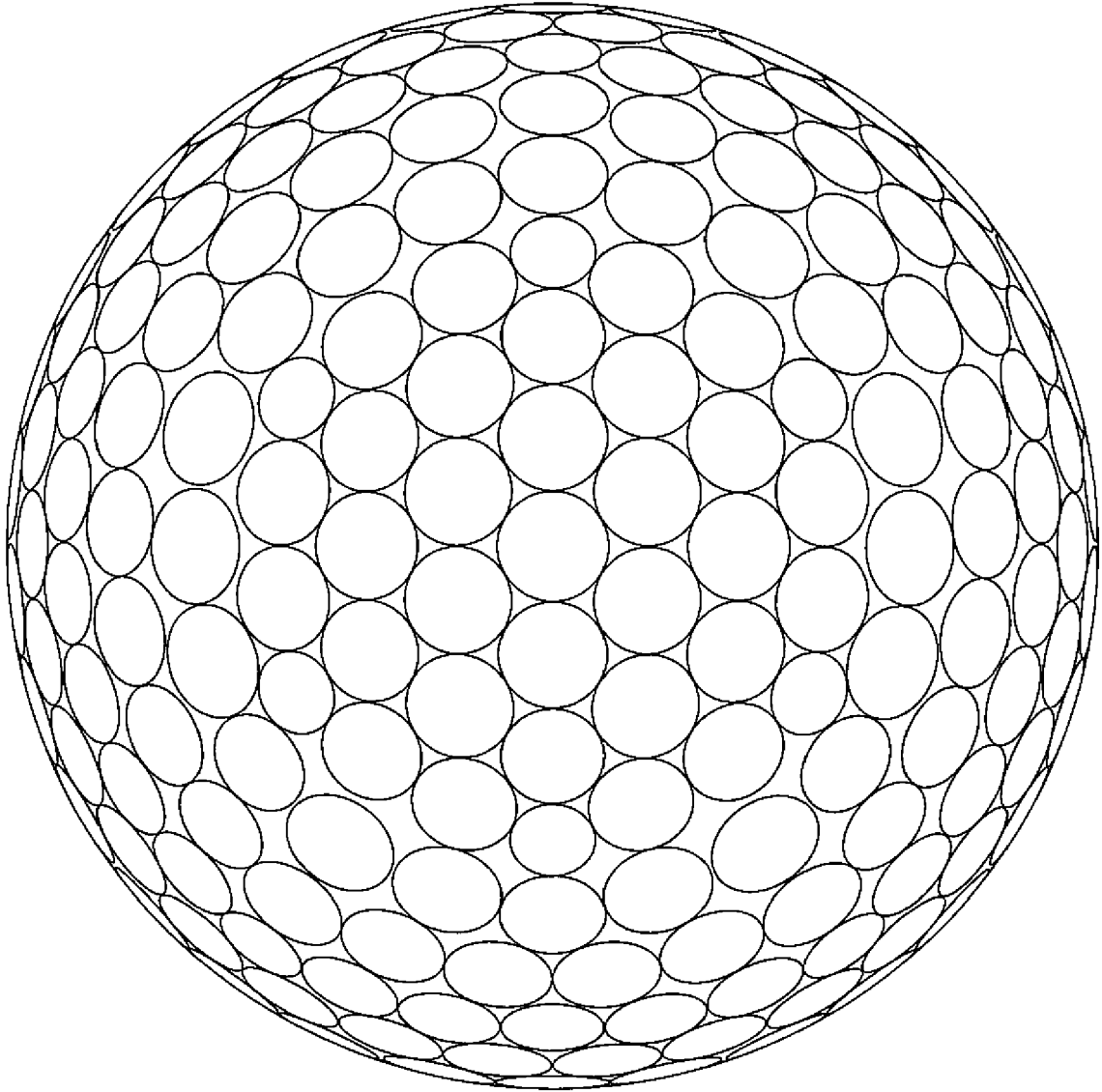


FIG. 20

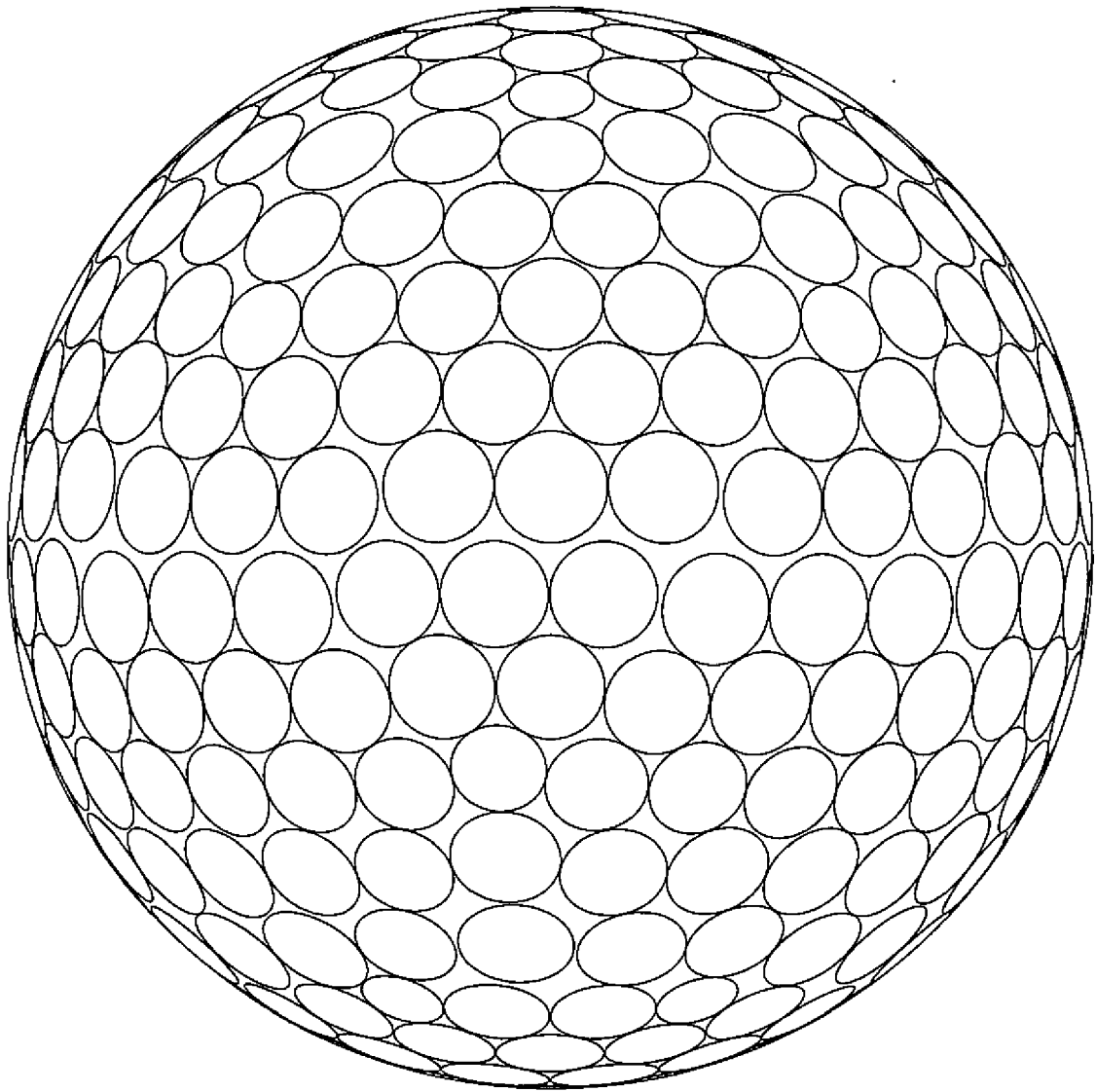


FIG. 21



EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2016/096076 A1 (MIMURA KOHEI [JP] ET AL) 7 April 2016 (2016-04-07) * claims 1,3 * * figures 9, 20-23 * * paragraph [0120] *	1-6	INV. A63B37/00
X	EP 2 832 402 A1 (DUNLOP SPORTS CO LTD [JP]) 4 February 2015 (2015-02-04) * table 6 * * figure 52 * * paragraph [0042] *	1-6	
			TECHNICAL FIELDS SEARCHED (IPC)
			A63B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 8 August 2018	Examiner Tejada Biarge, Diego
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 17 8631

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08-08-2018

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016096076 A1	07-04-2016	JP 2016067846 A	09-05-2016
		US 2016096076 A1	07-04-2016

EP 2832402 A1	04-02-2015	CN 104338295 A	11-02-2015
		EP 2832402 A1	04-02-2015
		EP 3263190 A1	03-01-2018
		JP 6346737 B2	20-06-2018
		JP 2015024079 A	05-02-2015
		KR 20150014389 A	06-02-2015
		KR 20160071359 A	21-06-2016
		US 2015031477 A1	29-01-2015

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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Patent documents cited in the description

- JP 2017123925FILEDIN B [0001]
- JP 2018031918 A [0001]
- JP 50008630 A [0005]
- JP 2008000389 A [0006]
- JP 2013153966 A [0007]
- JP 2015024079 A [0007]