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(54) **GOLF BALL**

(57) A golf ball 2 has a plurality of dimples on a surface thereof. A ratio So of a sum of areas of the dimples relative to a surface area of a phantom sphere of the golf ball is equal to or greater than 81.0%. A ratio Rs of a number of the dimples each having a diameter of equal to or greater than 9.60% but equal to or less than 10.37%, of a diameter of the golf ball, relative to a total number of the dimples, is equal to or greater than 50%. A dimple pattern of each hemisphere of the phantom sphere 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. The golf ball meets the following mathematical formula (1).

$$Rs \geq -2.5 * So + 273 \quad (1)$$

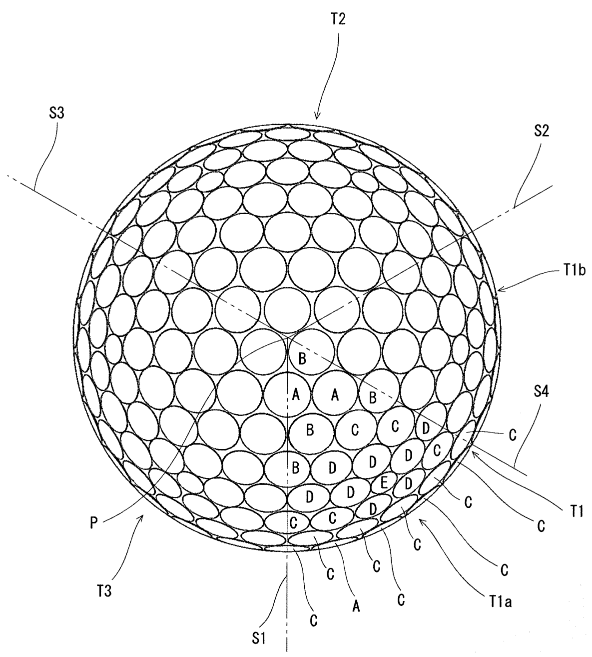

FIG. 2

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Description

[0001] This application claims priority on Patent Application No. 2015-238800 filed in JAPAN on December 7, 2015. The entire contents of this Japanese Patent Application 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 improvement of flight performance of golf balls.

Description of the Related Art

[0003] 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.

[0004] There have been various proposals for dimples. JP2009-172192 (US2009/0191982) discloses a golf ball on which dimples are randomly arranged. The dimple pattern of the golf ball is referred to as a random pattern. The random pattern can contribute to the flight performance of the golf ball. JP2012-10822 (US2012/0004053) also discloses a golf ball having a random pattern.

[0005] JP2007-175267 (US2007/0149321) discloses a dimple pattern in which the number of units in a high-latitude region is different from the number of units in a low-latitude region. JP2007-195591 (US2007/0173354) discloses a dimple pattern in which the number of the types of dimples in a low-latitude region is larger than the number of the types of dimples in a high-latitude region. JP2013-153966 (US2013/0196791) discloses a dimple pattern having a high dimple density and small variation in dimple size.

[0006] There have been also various proposals for improvement of compositions of golf balls for the purpose of improving flight performance. JP2008-212681 (US2008/0214324) discloses a golf ball including a core formed from a rubber composition including a copper salt. The golf ball including the core has excellent resilience performance upon a shot with a driver. JP2008-194471 (USP7,344,455) discloses a golf ball including a core formed from a rubber composition including an anti-aging agent. The core contributes to flight performance upon a shot with a driver at a low head speed.

[0007] The greatest interest to golf players concerning golf balls is flight performance. Golf players desire golf balls having excellent flight performance. In light of flight performance, there is room for improvement of dimple patterns.

[0008] An object of the present invention is to provide a golf ball having excellent flight performance.

SUMMARY OF THE INVENTION

[0009] A golf ball according to the present invention has a plurality of dimples on a surface thereof. A ratio So of a sum of areas of the dimples relative to a surface area of a phantom sphere of the golf ball is equal to or greater than 81.0%. A ratio Rs of a number of the dimples each having a diameter of equal to or greater than 9.60% but equal to or less than 10.37%, of a diameter of the golf ball, relative to a total number of the dimples, is equal to or greater than 50%. A dimple pattern of each hemisphere of the phantom sphere 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. The golf ball meets the following mathematical formula (1).

$$Rs \geq -2.5 * So + 273 \quad (1)$$

[0010] The golf ball according to the present invention has a superior dimple effect upon a shot with a driver. The golf ball has excellent flight performance.

[0011] Preferably, the golf ball meets the following mathematical formula (2).

$$Rs \geq -2.5 * So + 278 \quad (2)$$

[0012] Preferably, the golf ball meets the following mathematical formula (3).

$$Rs \geq -2.5 * So + 283 \quad (3)$$

[0013] Preferably, a ratio Rs' of a number of the dimples each having a diameter of equal to or greater than 10.10% but equal to or less than 10.37%, of the diameter of the golf ball, relative to the total number of the dimples, is equal to or greater than 50%. Preferably, the golf ball meets the following mathematical formula (4).

$$Rs' \geq -2.2 * So + 245 \quad (4)$$

[0014] Preferably, the golf ball meets the following mathematical formula (5).

$$Rs' \geq -2.2 * So + 252 \quad (5)$$

[0015] Preferably, a depth of a deepest part of each dimple from a surface of the phantom sphere is equal to or greater than 0.10 mm but equal to or less than 0.65 mm. Preferably, a total volume of the dimples is equal to or greater than 450 mm^3 but equal to or less than 750 mm^3.

[0016] Preferably, a ratio of a number of the dimples each having a diameter exceeding 10.37% of the diameter of the golf ball, relative to the total number of the dimples, is less than 50%.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a cross-sectional view of a golf ball according to one embodiment of the present invention;
FIG. 2 is a 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 graph showing a relationship between a ratio So and a ratio Rs;
FIG. 6 is a graph showing a relationship between the ratio So and a ratio Rs';
FIG. 7 is a plan view of a golf ball according to Example 2 of the present invention;
FIG. 8 is a front view of the golf ball in FIG. 7;
FIG. 9 is a plan view of a golf ball according to Example 3 of the present invention;
FIG. 10 is a front view of the golf ball in FIG. 9;
FIG. 11 is a plan view of a golf ball according to Example 4 of the present invention;
FIG. 12 is a front view of the golf ball in FIG. 11;
FIG. 13 is a plan view of a golf ball according to Comparative Example 1;
FIG. 14 is a front view of the golf ball in FIG. 13;
FIG. 15 is a plan view of a golf ball according to Comparative Example 2;
FIG. 16 is a front view of the golf ball in FIG. 15;
FIG. 17 is a plan view of a golf ball according to Comparative Example 3;
FIG. 18 is a front view of the golf ball in FIG. 17;
FIG. 19 is a plan view of a golf ball according to Comparative Example 4;
FIG. 20 is a bottom view of the golf ball in FIG. 19;
FIG. 21 is a right side view of the golf ball in FIG. 19;
FIG. 22 is a front view of the golf ball in FIG. 19;
FIG. 23 is a left side view of the golf ball in FIG. 19;
FIG. 24 is a back view of the golf ball in FIG. 19;
FIG. 25 is a plan view of a golf ball according to Comparative Example 5; and
FIG. 26 is a front view of the golf ball in FIG. 25.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] The following will describe in detail the present invention based on preferred embodiments with appropriate reference to the drawings.

[0019] 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.

[0020] The golf ball 2 preferably has a diameter of equal to or greater than 40 mm but equal to or less than 45 mm. From the standpoint of conformity to the rules established by the United States Golf Association (USGA), the diameter is particularly preferably equal to or greater than 42.67 mm. In light of suppression of air resistance, the diameter is more preferably equal to or less than 44 mm and particularly preferably equal to or less than 42.80 mm. The diameter of the golf ball 2 according to the present embodiment is 42.70 mm. Thirty points on the land 12 are selected at random. A diameter at each of the points as an end is measured. The diameter of the golf ball 2 is calculated by averaging these diameters.

[0021] The golf ball 2 preferably has a weight of equal to or greater than 40 g but equal to or less than 50 g. In light of attainment of great inertia, the weight is more preferably equal to or greater than 44 g and particularly preferably equal to or greater than 45.00 g. From the standpoint of conformity to the rules established by the USGA, the weight is particularly preferably equal to or less than 45.93 g.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] The core 4 has a diameter of preferably equal to or greater than 30.0 mm and particularly preferably equal to or greater than 38.0 mm. The diameter of the core 4 is preferably equal to or less than 42.0 mm and particularly preferably equal to or less 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.

[0026] 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.

[0027] 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.

[0028] 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.

[0029] The mid layer 6 has a thickness of preferably equal to or greater than 0.2 mm and particularly preferably equal to or greater than 0.3 mm. The thickness of the mid layer 6 is preferably equal to or less than 2.5 mm and particularly preferably equal to or less than 2.2 mm. The mid layer 6 has a specific gravity of preferably equal to or greater than 0.90 and particularly preferably equal to or greater than 0.95. The specific gravity of the mid layer 6 is preferably equal to or less than 1.10 and particularly preferably equal to or less than 1.05. The mid layer 6 may have two or more layers.

[0030] 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.

[0031] The polyurethane has a urethane bond within the molecule. The urethane bond can be formed by reacting a polyol with a polyisocyanate.

[0032] 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.

[0033] 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_6XDI), isophorone diisocyanate (IPDI), and trans-1,4-cyclohexane diisocyanate (CHDI). In light of versatility and processability, $H_{12}MDI$ is preferable.

[0034] 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.

[0035] 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.

[0036] The cover 8 has a thickness of preferably equal to or greater than 0.2 mm and particularly preferably equal to or greater than 0.3 mm. The thickness of the cover 8 is preferably equal to or less than 2.5 mm and particularly preferably equal to or less than 2.2 mm. The cover 8 has a specific gravity of preferably equal to or greater than 0.90 and particularly preferably equal to or greater than 0.95. The specific gravity of the cover 8 is preferably equal to or less than 1.10 and particularly preferably equal to or less than 1.05. The cover 8 may have two or more layers.

[0037] 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.

[0038] 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 4.70 mm; dimples B each having a diameter of 4.60 mm; dimples C each having a diameter of 4.40 mm; dimples D each having a diameter of 4.30 mm; and dimples E each having a diameter of 3.00 mm. The number of types of the dimples 10 is five. The golf ball 2 may have non-circular dimples instead of the circular dimples 10 or together with circular dimples 10.

[0039] The number of the dimples A is 30; the number of the dimples B is 30; the number of the dimples C is 150; the number of the dimples D is 90; and the number of the dimples E is 12. The total number of the dimples 10 is 312. A dimple pattern is formed by these dimples 10 and the land 12.

[0040] 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.

[0041] 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. 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.

[0042] The diameter Dm of each dimple 10 is preferably equal to or greater than 2.0 mm but equal to or less than 6.0 mm. The dimple 10 having a diameter Dm of equal to or greater than 2.0 mm contributes to turbulization. In this respect, the diameter Dm is more preferably equal to or greater than 2.5 mm and particularly preferably equal to or greater than 2.8 mm. The dimple 10 having a diameter Dm of equal to or less than 6.0 mm does not impair a fundamental feature of the golf ball 2 being substantially a sphere. In this respect, the diameter Dm is more preferably equal to or less than 5.5 mm and particularly preferably equal to or less than 5.0 mm.

[0043] In the case of a non-circular dimple, a circular dimple 10 having the same area as that of the non-circular dimple is assumed. The diameter of the assumed dimple 10 can be regarded as the diameter of the non-circular dimple.

[0044] The ratio Pd of the diameter Dm of each dimple 10 relative to the diameter of the golf ball 2 is preferably equal to or greater than 9.60% but equal to or less than 10.37%. The dimple 10 having a ratio Pd of equal to or greater than 9.60% contributes to turbulization. In this respect, the ratio Pd is more preferably equal to or greater than 9.90% and particularly preferably equal to or greater than 10.10%. The dimple 10 having a ratio Pd of equal to or less than 10.37% does not impair a fundamental feature of the golf ball 2 being substantially a sphere. In this respect, the ratio Pd is more preferably equal to or less than 10.32% and particularly preferably equal to or less than 10.27%.

[0045] The ratio Rs of the number of the dimples 10 each having a ratio Pd of equal to or greater than 9.60% but equal to or less than 10.37%, relative to the total number of the dimples 10, is preferably equal to or greater than 50%. The dimple pattern having a ratio Rs of equal to or greater than 50% contributes to turbulization. In this respect, the ratio Rs is more preferably equal to or greater than 60% and particularly preferably equal to or greater than 70%. The ratio Rs may be 100%.

[0046] The ratio Rs' of the number of the dimples 10 each having a ratio Pd of equal to or greater than 10.10% but equal to or less than 10.37%, relative to the total number of the dimples 10, is preferably equal to or greater than 50%. The dimple pattern having a ratio Rs' of equal to or greater than 50% contributes to turbulization. In this respect, the ratio Rs' is more preferably equal to or greater than 60% and particularly preferably equal to or greater than 70%. The ratio Rs' may be 100%.

[0047] The ratio of the number of the dimples 10 each having a ratio Pd exceeding 10.37%, relative to the total number of the dimples 10, is preferably less than 50%. With the dimple pattern in which this ratio is less than 50%, the degree of freedom in designing a dimple pattern is high, and therefore the width of the land 12 is less likely to be excessively large. In this respect, this ratio is more preferably equal to or less than 30% and particularly preferably equal to or less than 10%. This ratio may be zero.

[0048] In light of suppression of rising of the golf ball 2 during flight, the first depth Dp1 of each dimple 10 is preferably equal to or greater than 0.10 mm, more preferably equal to or greater than 0.13 mm, and particularly preferably equal to or greater than 0.15 mm. In light of suppression of dropping of the golf ball 2 during flight, the first depth Dp1 is preferably equal to or less than 0.65 mm, more preferably equal to or less than 0.60 mm, and particularly preferably equal to or less than 0.55 mm.

[0049] 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.

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

[0050] In the golf ball 2 shown in FIGS. 2 and 3, the area of each dimple A is 17.35 mm^2; the area of each dimple B is 16.62 mm^2; the area of each dimple C is 15.20 mm^2; the area of each dimple D is 14.52 mm^2; and the area of each dimple E is 7.07 mm^2.

[0051] 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 that sufficient turbulization is achieved, the occupation ratio So is preferably equal to or greater than 81.0%, more preferably equal to or greater than 82.0%, and particularly preferably equal to or greater than 83.0%. The occupation ratio So is preferably equal to or less than 95%. In the golf ball 2 shown in FIGS. 2 and 3, the total area of the dimples 10 is 4691.5 mm^2. The surface area of the phantom sphere 14 of the golf ball 2 is 5728.0 mm^2, so that the occupation ratio is 81.9%.

[0052] From the standpoint that a sufficient occupation ratio is achieved, the total number N of the dimples 10 is preferably equal to or greater than 250, more preferably equal to or greater than 280, and particularly preferably equal to or greater than 300. From the standpoint that each dimple 10 can contribute to turbulization, the total number N of the dimples 10 is preferably equal to or less than 450, more preferably equal to or less than 400, and particularly preferably equal to or less than 380.

[0053] In the present invention, the "volume 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. In light of suppression of rising of the golf ball 2 during flight, the total volume of all the dimples 10 is preferably equal to or greater than 450 mm^3, more preferably equal to or greater than 480 mm^3, and particularly preferably equal to or greater than 500 mm^3. In light of suppression of dropping of the golf ball 2 during flight, the total volume is preferably equal to or less than 750 mm^3, more preferably equal to or less than 730 mm^3, and particularly preferably equal to or less than 710 mm^3.

[0054] In a graph shown in FIG. 5, the horizontal axis indicates the occupation ratio So of the dimples. In this graph, the vertical axis indicates the ratio Rs of the number of the dimples 10 each having a ratio Pd of equal to or greater than 9.60% but equal to or less than 10.37%, relative to the total number of the dimples 10. A straight line indicated by reference sign L1 in this graph is represented by the following mathematical formula.

$$Rs = -2.5 * So + 273$$

The golf ball 2 that is plotted in the zone above the straight line L1 in this graph meets the following mathematical formula (1).

$$Rs \geq -2.5 * So + 273 \quad (1)$$

With the golf ball 2 that meets the mathematical formula (1), turbulization is promoted. The golf ball 2 has excellent flight performance upon a shot with a driver.

[0055] A straight line indicated by reference sign L2 in the graph of FIG. 5 is represented by the following mathematical formula.

$$Rs = -2.5 * So + 278$$

[0056] The golf ball 2 that is plotted in the zone above the straight line L2 in this graph meets the following mathematical formula (2).

$$Rs \geq -2.5 * So + 278 \quad (2)$$

With the golf ball 2 that meets the mathematical formula (2), turbulization is promoted. The golf ball 2 has excellent flight performance upon a shot with a driver.

[0057] A straight line indicated by reference sign L3 in the graph of FIG. 5 is represented by the following mathematical formula.

$$Rs = -2.5 * So + 283$$

[0058] The golf ball 2 that is plotted in the zone above the straight line L3 in this graph meets the following mathematical formula (3).

$$Rs \geq -2.5 * So + 283 \quad (3)$$

With the golf ball 2 that meets the mathematical formula (3), turbulization is promoted. The golf ball 2 has excellent flight performance upon a shot with a driver.

[0059] In a graph shown in FIG. 6, the horizontal axis indicates the occupation ratio So of the dimples. In this graph, the vertical axis indicates the ratio Rs' of the number of the dimples 10 each having a ratio Pd of equal to or greater than 10.10% but equal to or less than 10.37%, relative to the total number of the dimples 10. A straight line indicated by reference sign L4 in this graph is represented by the following mathematical formula.

$$Rs' = -2.2 * So + 245$$

[0060] The golf ball 2 that is plotted in the zone above the straight line L4 in this graph meets the following mathematical formula (4).

$$Rs' \geq -2.2 * So + 245 \quad (4)$$

With the golf ball 2 that meets the mathematical formula (4), turbulization is promoted. The golf ball 2 has excellent flight performance upon a shot with a driver.

[0061] A straight line indicated by reference sign L5 in the graph of FIG. 6 is represented by the following mathematical formula.

$$Rs' = -2.2 * So + 252$$

The golf ball 2 that is plotted in the zone above the straight line L5 in this graph meets the following mathematical formula (5).

$$Rs' \geq -2.2 * So + 252 \quad (5)$$

With the golf ball 2 that meets the mathematical formula (5), turbulization is promoted. The golf ball 2 has excellent flight performance upon a shot with a driver.

[0062] 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.

[0063] FIG. 2 shows the northern hemisphere. The southern hemisphere 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°.

[0064] 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 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.

[0065] 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.

[0066] 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.

[0067] 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 a small spherical triangle T1b by the line segment S4. The spherical triangle T1a and the spherical triangle T1b are small units.

[0068] 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 is composed of two small units that are mirror-symmetrical to each other.

[0069] Similarly, 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.

[0070] According to the finding 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 upon a shot with a driver.

EXAMPLES

[Example 1]

[0071] 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.

[0072] 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.

[0073] 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.

[0074] 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 42.70 mm and a weight of about 45.6 g. The amount of compressive deformation of the golf ball when a load was 98 N to 1274 N was 2.45 mm. The specifications of the dimples of the golf ball are shown in Table 1 below.

[Examples 2 to 4 and Comparative Examples 1 to 3]

[0075] Golf balls of Examples 2 to 4 and Comparative Examples 1 to 3 were obtained in the same manner as Example 1, except the specifications of the dimples were as shown in Tables 1 and 2 below. In each golf ball, the dimple pattern of each hemisphere 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. The number of the small units in each hemisphere is six. The dimple pattern of each hemisphere of the golf ball according to Example 4 has 60° rotational symmetry, has 120° rotational symmetry, and has 180° rotational symmetry.

[Comparative Examples 4 and 5]

[0076] Golf balls of Comparative Examples 4 and 5 were obtained in the same manner as Example 1, except the specifications of the dimples were as shown in Table 2 below. The dimple pattern of the golf ball according to Comparative Example 4 is the same as the dimple pattern of the golf ball according to Example 1 in JP2013-153966. The dimple pattern of each hemisphere of the golf ball according to Comparative Example 4 does not have rotational symmetry. The dimple pattern of the golf ball according to Comparative Example 5 is the same as the dimple pattern of the golf ball according to Comparative Example 1 in JP2013-153966. The dimple pattern of each hemisphere of the golf ball according to Comparative Example 5 does not have rotational symmetry.

[Flight Test]

[0077] A driver with a head made of a titanium alloy (trade name "SRIXON Z-TX", manufactured by DUNLOP SPORTS CO. 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. At the test, the weather was almost windless. The average value of data obtained by 20 measurements is shown in Tables 3 to 5 below.

Table 1 Specifications of Dimples

		Number	Dm (mm)	Dp2 (mm)	Dp1 (mm)	R (mm)	Volume (mm^3)	Pd (%)
Ex. 1	A	30	4.70	0.135	0.2647	20.52	1.172	11.01
	B	30	4.60	0.135	0.2592	19.66	1.123	10.77
	C	150	4.40	0.135	0.2487	17.99	1.028	10.30
	D	90	4.30	0.135	0.2435	17.19	0.982	10.07
	E	12	3.00	0.135	0.1878	8.40	0.478	7.03
Ex. 2	A	24	4.60	0.135	0.2592	19.66	1.123	10.77
	B	54	4.50	0.135	0.2539	18.82	1.075	10.54
	C	210	4.40	0.135	0.2487	17.99	1.028	10.30
	D	24	4.00	0.135	0.2289	14.88	0.850	9.37
	E	12	3.00	0.135	0.1878	8.40	0.478	7.03
Ex. 3	A	24	4.60	0.135	0.2592	19.66	1.123	10.77
	B	12	4.50	0.135	0.2539	18.82	1.075	10.54
	C	252	4.35	0.135	0.2461	17.59	1.004	10.19
	D	24	4.00	0.135	0.2289	14.88	0.850	9.37
	E	12	3.00	0.135	0.1878	8.40	0.478	7.03
Ex. 4	A	12	4.60	0.135	0.2592	19.66	1.123	10.77
	B	48	4.50	0.135	0.2539	18.82	1.075	10.54
	C	86	4.40	0.135	0.2487	17.99	1.028	10.30
	D	60	4.30	0.135	0.2435	17.19	0.982	10.07
	E	120	4.20	0.135	0.2385	16.40	0.936	9.84
	F	12	3.05	0.135	0.1895	8.68	0.494	7.14

Table 2 Specifications of Dimples

		Num.	Dm (mm)	Dp2 (mm)	Dp1 (mm)	R (mm)	Volume (mm^3)	Pd (%)
Com. EX. 1	A	108	4.60	0.135	0.2592	19.66	1.123	10.77
	B	84	4.50	0.135	0.2539	18.82	1.075	10.54
	C	108	4.40	0.135	0.2487	17.99	1.028	10.30
	D	12	3.00	0.135	0.1878	8.40	0.478	7.03
Com. EX. 2	A	30	4.70	0.135	0.2647	20.52	1.172	11.01
	B	18	4.65	0.135	0.2620	20.09	1.148	10.89
	C	48	4.40	0.135	0.2487	17.99	1.028	10.30
	D	66	4.35	0.135	0.2461	17.59	1.004	10.19
	E	126	4.20	0.135	0.2385	16.40	0.936	9.84
	F	12	4.00	0.135	0.2289	14.88	0.850	9.37
	G	12	3.00	0.135	0.1878	8.40	0.478	7.03

(continued)

		Num.	Dm (mm)	Dp2 (mm)	Dp1 (mm)	R (mm)	Volume (mm^3)	Pd (%)
Com. EX. 3	A	24	4.60	0.135	0.2592	19.66	1.123	10.77
	B	12	4.50	0.135	0.2539	18.82	1.075	10.54
	C	210	4.35	0.135	0.2461	17.59	1.004	10.19
	D	66	4.05	0.135	0.2313	15.26	0.871	9.48
	E	12	3.00	0.135	0.1878	8.40	0.478	7.03
Com. EX. 4	A	16	4.60	0.135	0.2592	19.66	1.123	10.77
	B	30	4.50	0.135	0.2539	18.82	1.075	10.54
	C	30	4.40	0.135	0.2487	17.99	1.028	10.30
	D	150	4.30	0.135	0.2435	17.19	0.982	10.07
	E	30	4.20	0.135	0.2385	16.40	0.936	9.84
	F	66	4.10	0.135	0.2336	15.63	0.892	9.60
	G	10	3.80	0.135	0.2197	13.44	0.767	8.90
	H	12	3.40	0.135	0.2028	10.77	0.614	7.96
Com. EX 5	A	26	4.50	0.135	0.2539	18.82	1.075	10.54
	B	88	4.40	0.135	0.2487	17.99	1.028	10.30
	C	102	4.30	0.135	0.2435	17.19	0.982	10.07
	D	94	4.10	0.135	0.2336	15.63	0.892	9.60
	E	14	3.60	0.135	0.2110	12.07	0.688	8.43

Table 3 Results of Evaluation

	Example 1	Example 2	Example 3
Plan view	FIG. 2	FIG. 7	FIG. 9
Front view	FIG. 3	FIG. 8	FIG. 10
Number	312	324	324
Number of units	3	3	3
Number of small units	6	6	6
So (%)	81.9	84.4	82.4
Rs (%)	76.9	64.8	77.8
Rs+2.5*So-273	8.65	2.80	10.80
Mathematical formula (1)	Met	Met	Met
Rs+2.5*So-278	3.65	-2.20	5.80
Mathematical formula (2)	Met	Unmet	Met
Rs+2.5*So-283	-1.35	-7.20	0.80
Mathematical formula (3)	Unmet	Unmet	Met
Rs' (%)	48.1	64.8	77.8
Rs'+2.2*So-245	-16.72	5.48	14.08
Mathematical formula (4)	Unmet	Met	Met

(continued)

	Example 1	Example 2	Example 3
Rs'+2.2*So-252	-23.72	-1.52	7.08
Mathematical formula (5)	Unmet	Unmet	Met
Flight distance (m)	261.2	261.8	262.1

Table 4 Results of Evaluation

	Example 4	Comp. Example 1	Comp. Example 2
Plan view	FIG. 11	FIG. 13	FIG. 15
Front view	FIG. 12	FIG. 14	FIG. 16
Number	338	312	312
Number of units	3	3	3
Number of small units	6	6	6
So (%)	85.4	84.8	78.9
Rs (%)	78.7	34.6	76.9
Rs+2.5*So-273	19.20	-26.40	1.15
Mathematical formula (1)	Met	Unmet	Met
Rs+2.5*So-278	14.20	-31.40	-3.85
Mathematical formula (2)	Met	Unmet	Unmet
Rs+2.5*So-283	9.20	-36.40	-8.85
Mathematical formula (3)	Met	Unmet	Unmet
Rs' (%)	25.4	34.6	36.5
Rs'+2.2*So-245	-31.72	-23.84	-34.92
Mathematical formula (4)	Unmet	Unmet	Unmet
Rs'+2.2*So-252	-38.72	-30.84	-41.92
Mathematical formula (5)	Unmet	Unmet	Unmet
Flight distance (m)	261.5	257.4	257.6

Table 5 Results of Evaluation

	Comp. Example 3	Comp. Example 4	Comp. Example 5
Plan view	FIG. 17	FIG. 19	FIG. 25
Front view	FIG. 18	FIG. 22	FIG. 26
Number	324	344	324
Number of units	3	-	-
Number of small units	6	-	-
So (%)	81.1	85.3	80.6
Rs (%)	64.8	61.0	87.7
Rs+2.5*So-273	-5.45	1.25	16.20

(continued)

	Comp. Example 3	Comp. Example 4	Comp. Example 5
Mathematical formula (1)	Unmet	Met	Met
Rs+2.5*So-278	-10.45	-3.75	11.20
Mathematical formula (2)	Unmet	Unmet	Met
Rs+2.5*So-283	-15.45	-8.75	6.20
Mathematical formula (3)	Unmet	Unmet	Met
Rs' (%)	64.8	8 . 7	27.2
Rs'+2.2*So-245	-1.78	-48.64	-40.48
Mathematical formula (4)	Unmet	Unmet	Unmet
Rs'+2.2*So-252	-8.78	-55.64	-47.48
Mathematical formula (5)	Unmet	Unmet	Unmet
Flight distance (m)	260.8	260.6	255.4

[0078] As shown in Tables 3 to 5, the golf ball of each Example has excellent flight performance. From the results of evaluation, advantages of the present invention are clear.

[0079] 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 ratio So of a sum of areas of the dimples relative to a surface area of a phantom sphere of the golf ball is equal to or greater than 81.0%,
a ratio Rs of a number of the dimples each having a diameter of equal to or greater than 9.60% but equal to or less than 10.37%, of a diameter of the golf ball, relative to a total number of the dimples, is equal to or greater than 50%,
a dimple pattern of each hemisphere of the phantom sphere 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, and
the golf ball meets the following mathematical formula (1) :

$$Rs \geq -2.5 * So + 273 \quad (1).$$

2. The golf ball according to claim 1, wherein the golf ball meets the following mathematical formula (2):

$$Rs \geq -2.5 * So + 278 \quad (2).$$

3. The golf ball according to claim 2, wherein the golf ball meets the following mathematical formula (3):

$$Rs \geq -2.5 * So + 283 \quad (3).$$

4. The golf ball according to any one of claims 1 to 3, wherein

a ratio Rs' of a number of the dimples each having a diameter of equal to or greater than 10.10% but equal to or less than 10.37%, of the diameter of the golf ball, relative to the total number of the dimples, is equal to or greater than 50%, and
the golf ball meets the following mathematical formula (4) :

$$Rs' \geq -2.2 * So + 245 \quad (4).$$

5. The golf ball according to claim 4, wherein the golf ball meets the following mathematical formula (5):

$$Rs' \geq -2.2 * So + 252 \quad (5).$$

6. The golf ball according to any one of claims 1 to 5, wherein a depth of a deepest part of each dimple from a surface of the phantom sphere is equal to or greater than 0.10 mm but equal to or less than 0.65 mm.

7. The golf ball according to any one of claims 1 to 6, wherein a total volume of the dimples is equal to or greater than 450 mm^3 but equal to or less than 750 mm^3.

8. The golf ball according to any one of claims 1 to 7, wherein a ratio of a number of the dimples each having a diameter exceeding 10.37% of the diameter of the golf ball, relative to the total number of the dimples, is less than 50%.

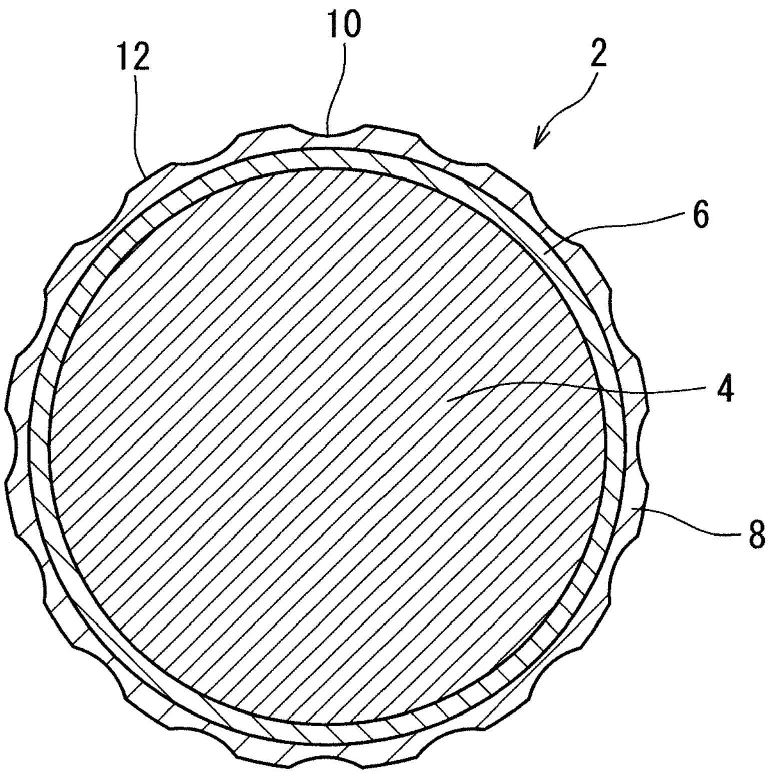
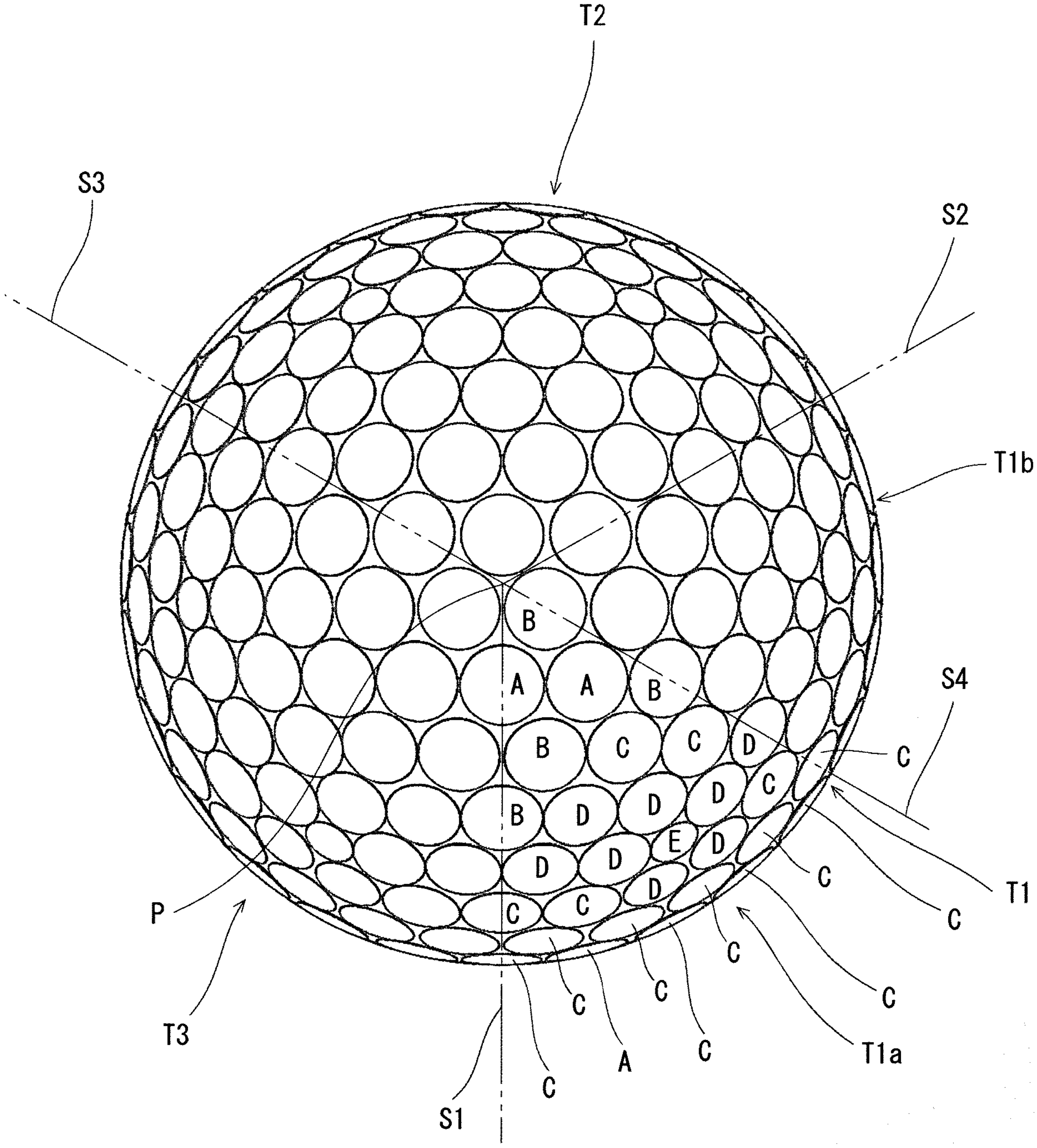


FIG. 1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S3
S2
T1b
B
A
A
B
B
C
C
D
C
S4
B
D
D
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D
D
E
D
C
D
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T1a
C
S1

FIG. 2

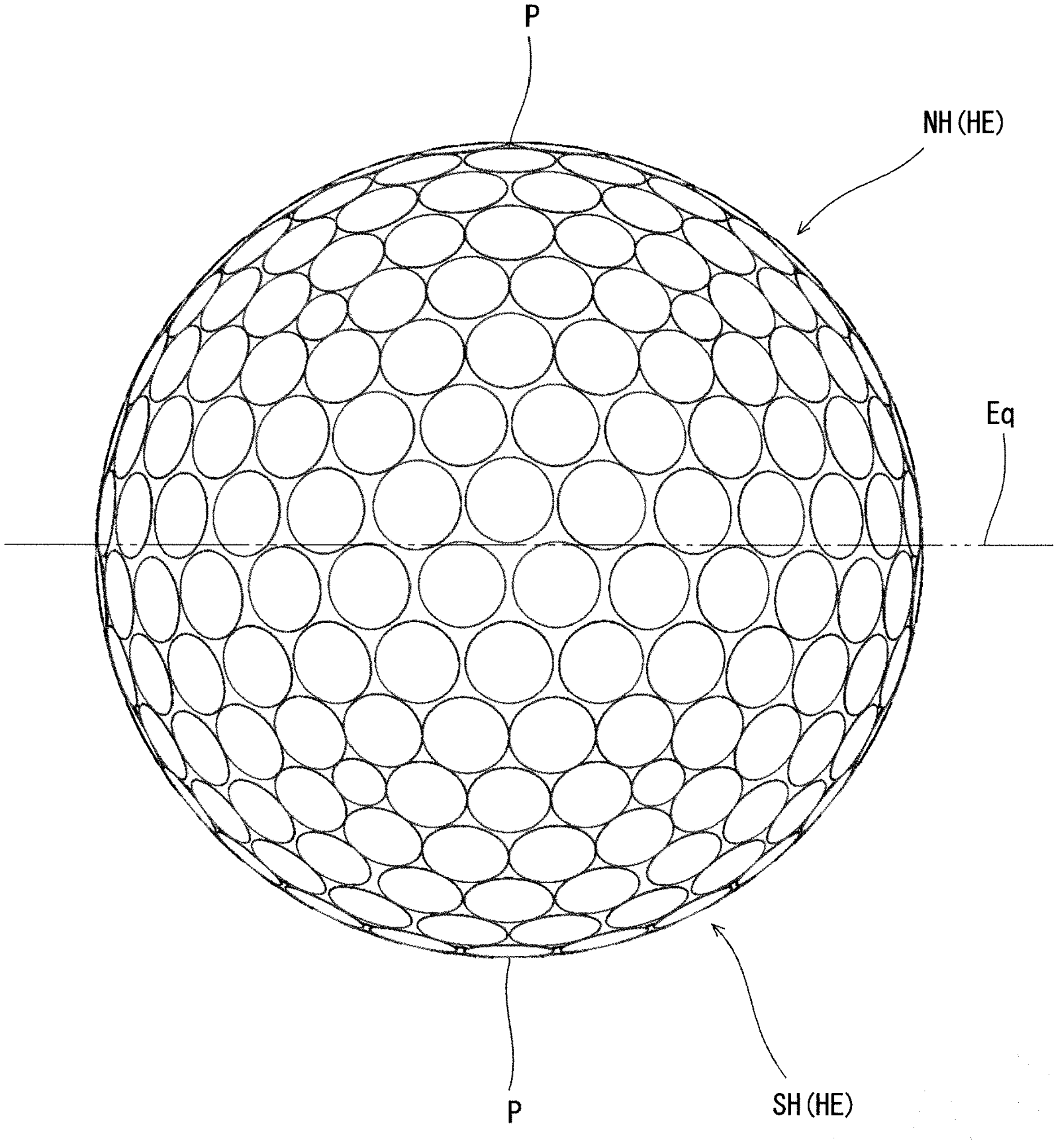


FIG. 3

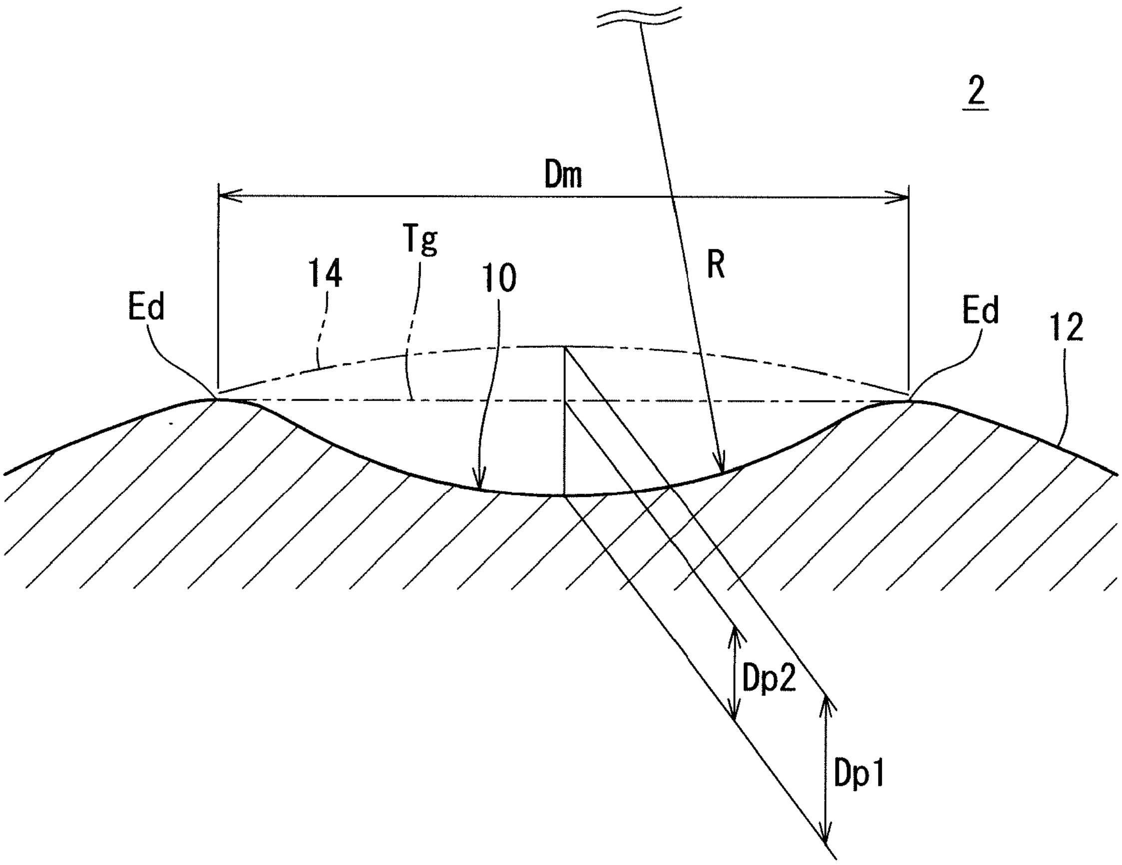


FIG. 4

E1 : Example 1
E2 : Example 2
E3 : Example 3
E4 : Example 4

C1 : Comparative Example 1
C2 : Comparative Example 2
C3 : Comparative Example 3
C4 : Comparative Example 4
C5 : Comparative Example 5

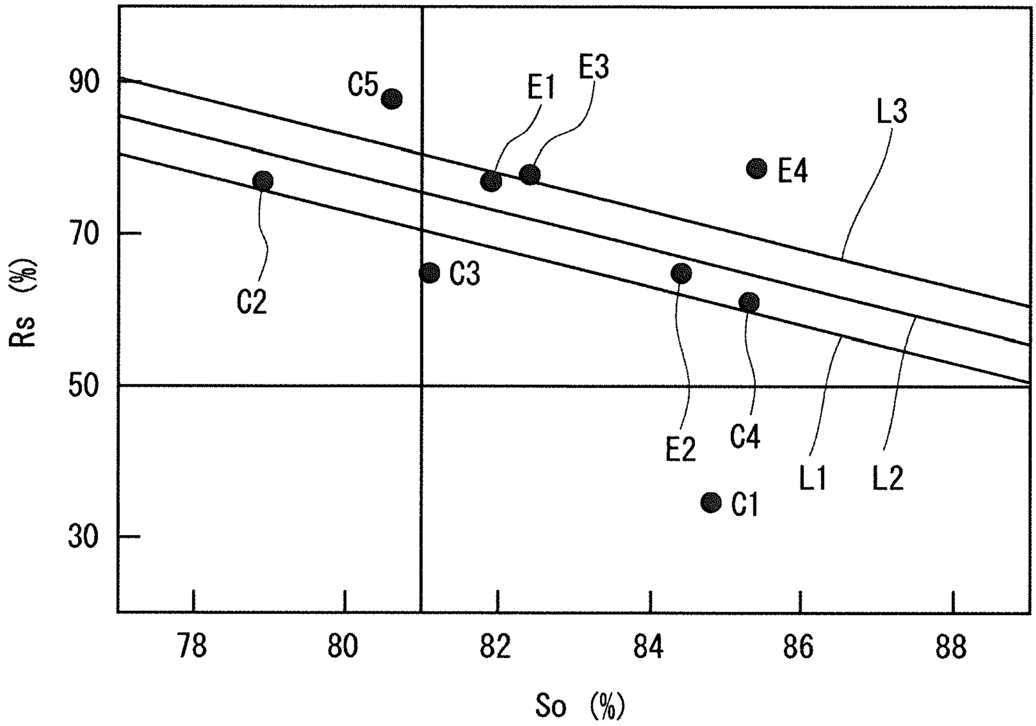


FIG. 5

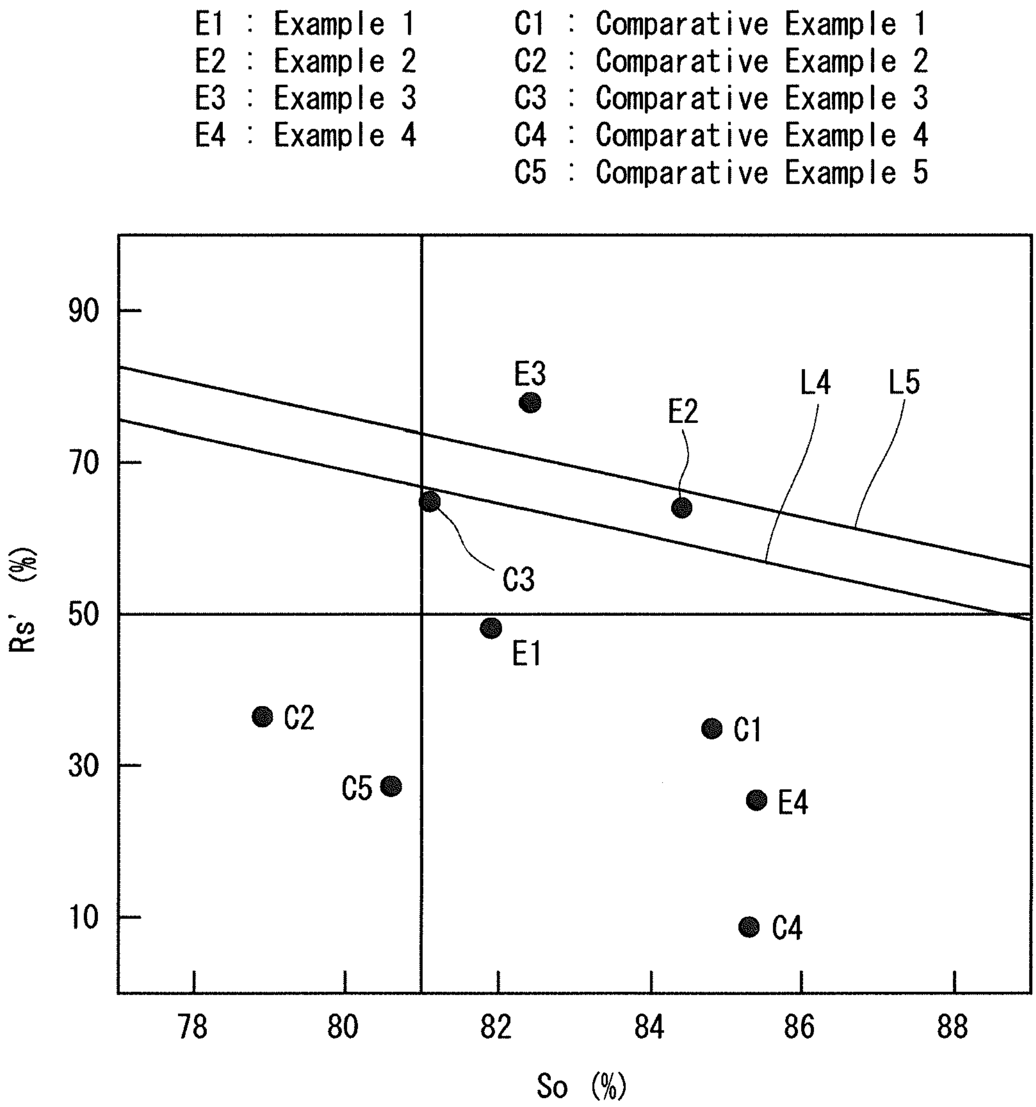

E1 : Example 1
E2 : Example 2
E3 : Example 3
E4 : Example 4
C1 : Comparative Example 1
C2 : Comparative Example 2
C3 : Comparative Example 3
C4 : Comparative Example 4
C5 : Comparative Example 5
Rs' (%)
90
70
50
30
10
78
80
82
84
86
88
So (%)
E3
E2
L4
L5
C3
E1
C2
C1
C5
E4
C4

FIG. 6

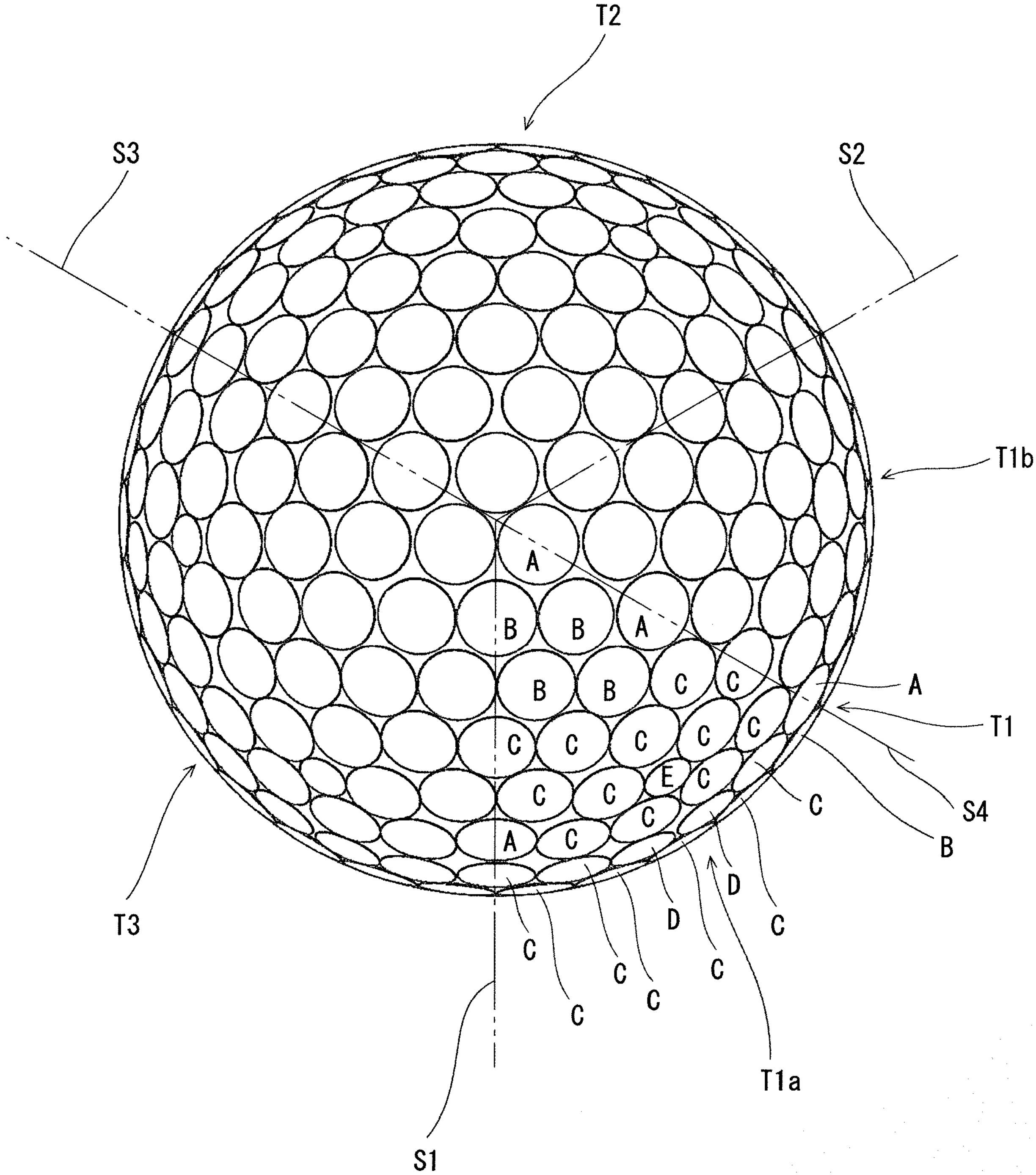

T2
S3
S2
T1b
A
B
B
A
B
B
C
C
A
C
C
C
C
C
T1
C
C
E
C
S4
C
B
A
C
C
T3
D
C
D
D
C
C
C
C
C
C
T1a
S1

FIG. 7

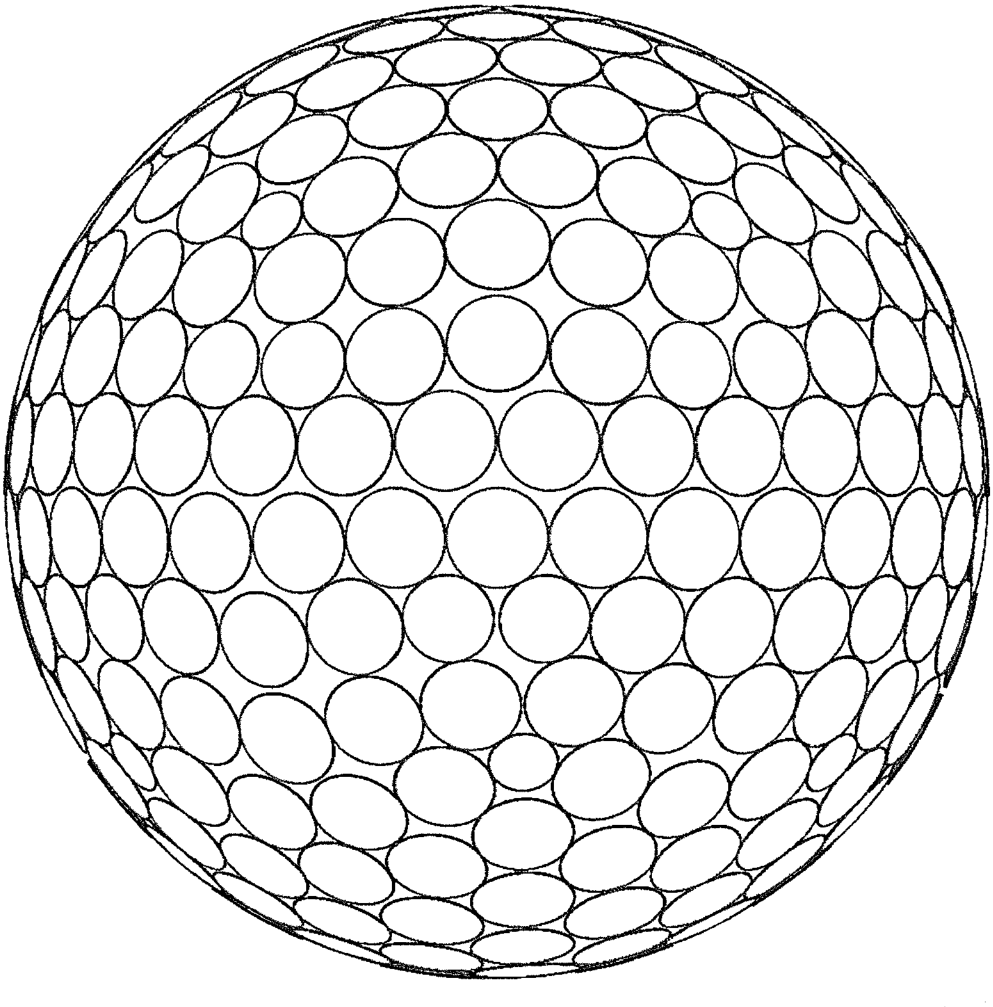
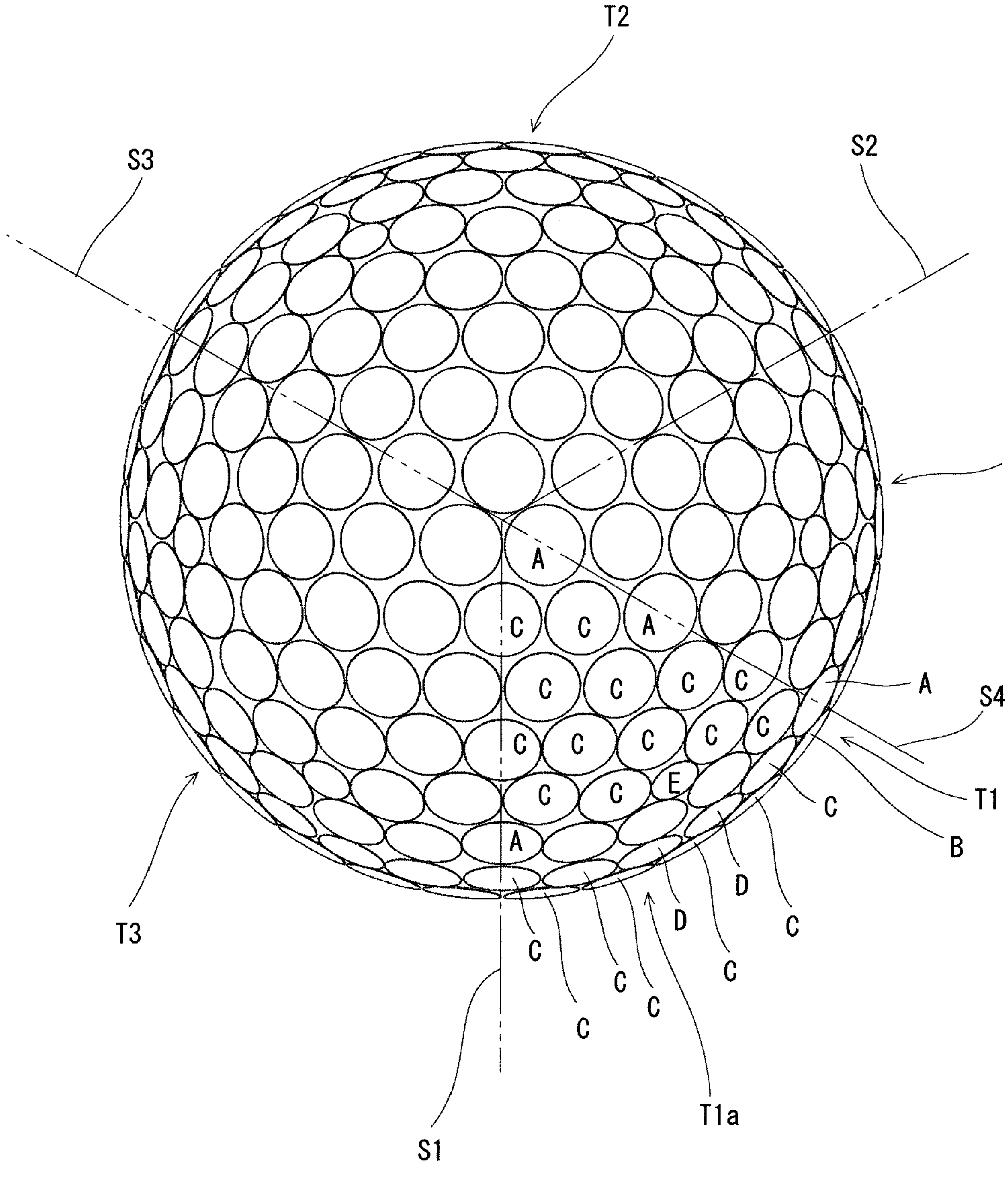


FIG. 8


T2
S3
S2
T1b
A
A
C
C
A
C
C
C
C
A
S4
C
C
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C
C
T1
C
C
E
C
A
B
T3
D
C
D
C
C
C
C
C
C
S1
T1a

FIG. 9

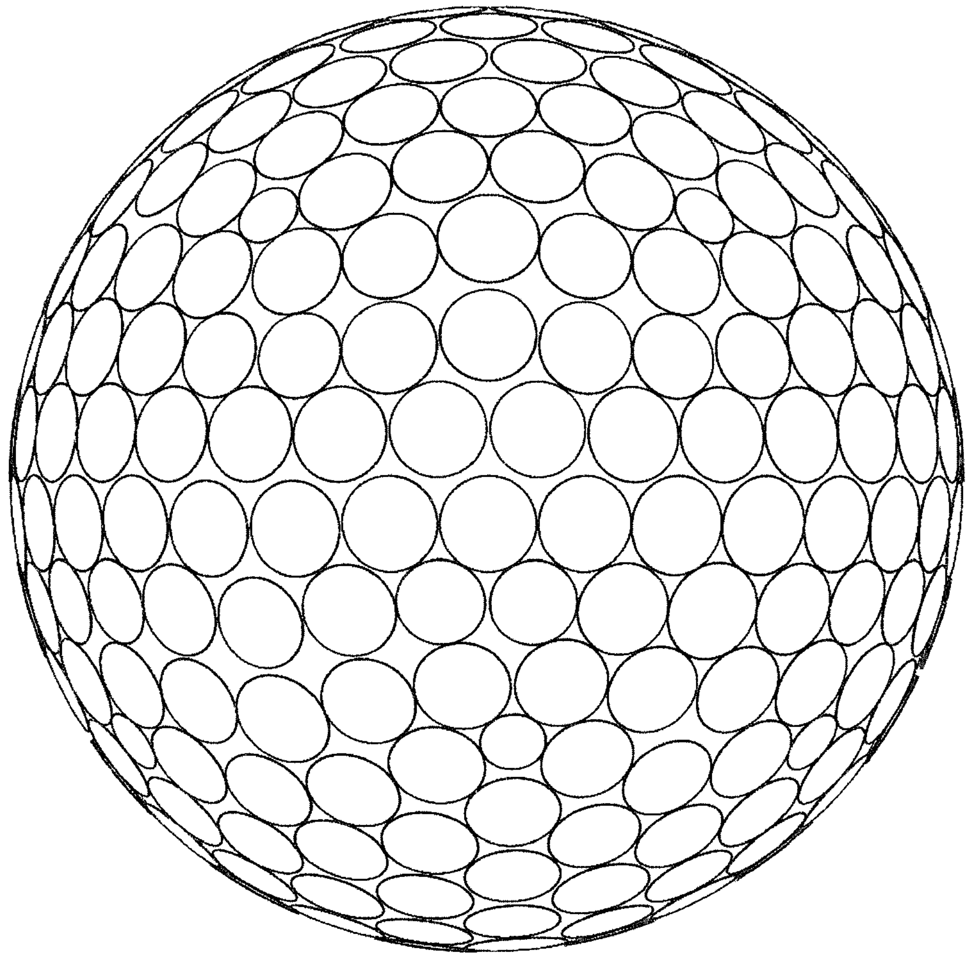


FIG. 10

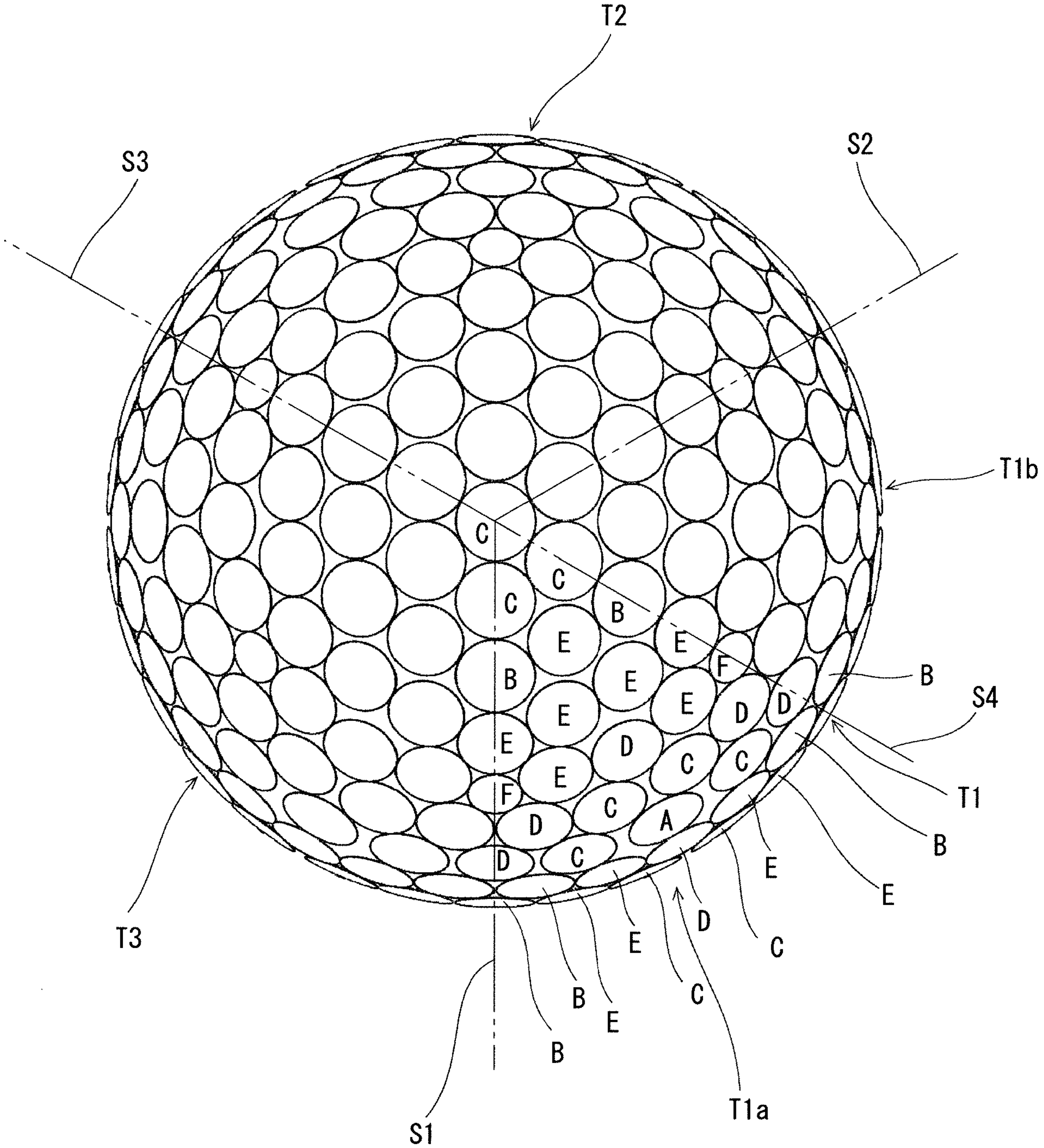


FIG. 11

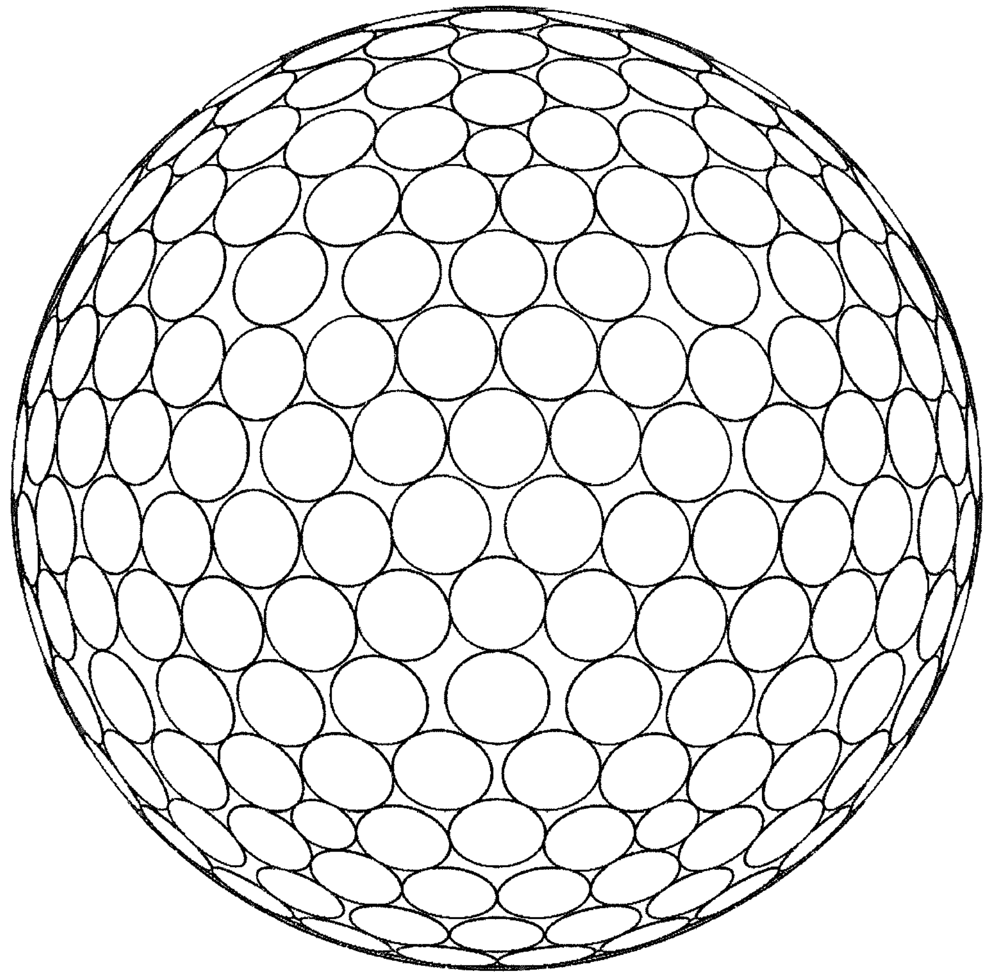


FIG. 12

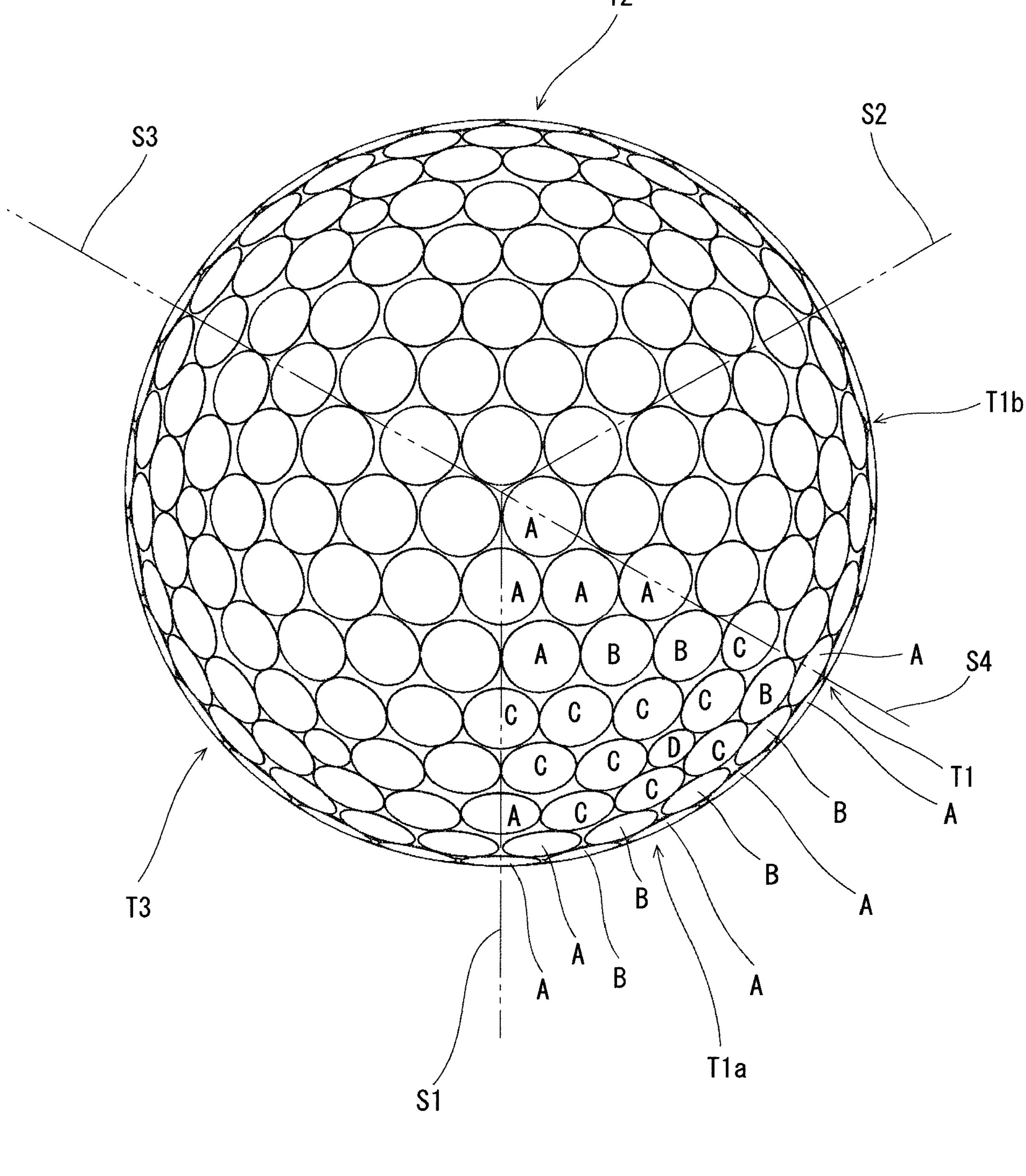

T2
S3
S2
T1b
A
A A A
A B B C
A
S4
C C C C B
T1
C C D C
A
B
A C C
B
T3
B
A
B
A
A
B
A
T1a
S1

FIG. 13

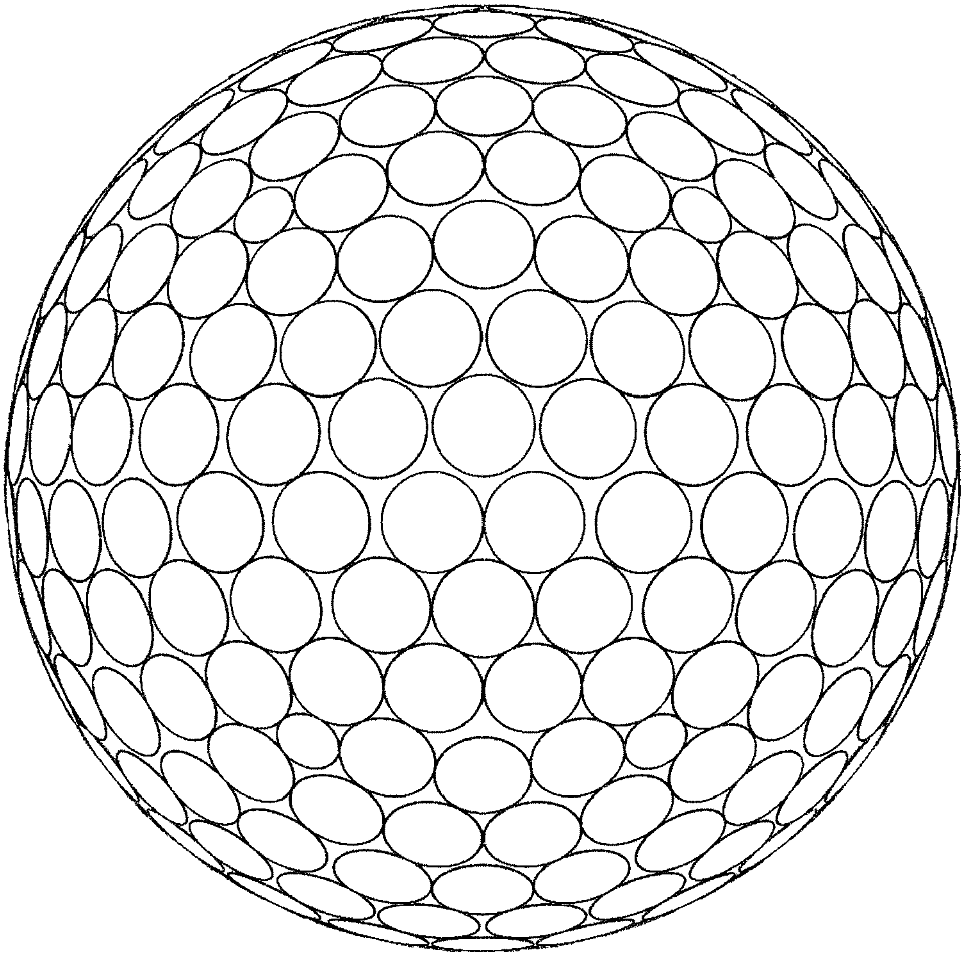
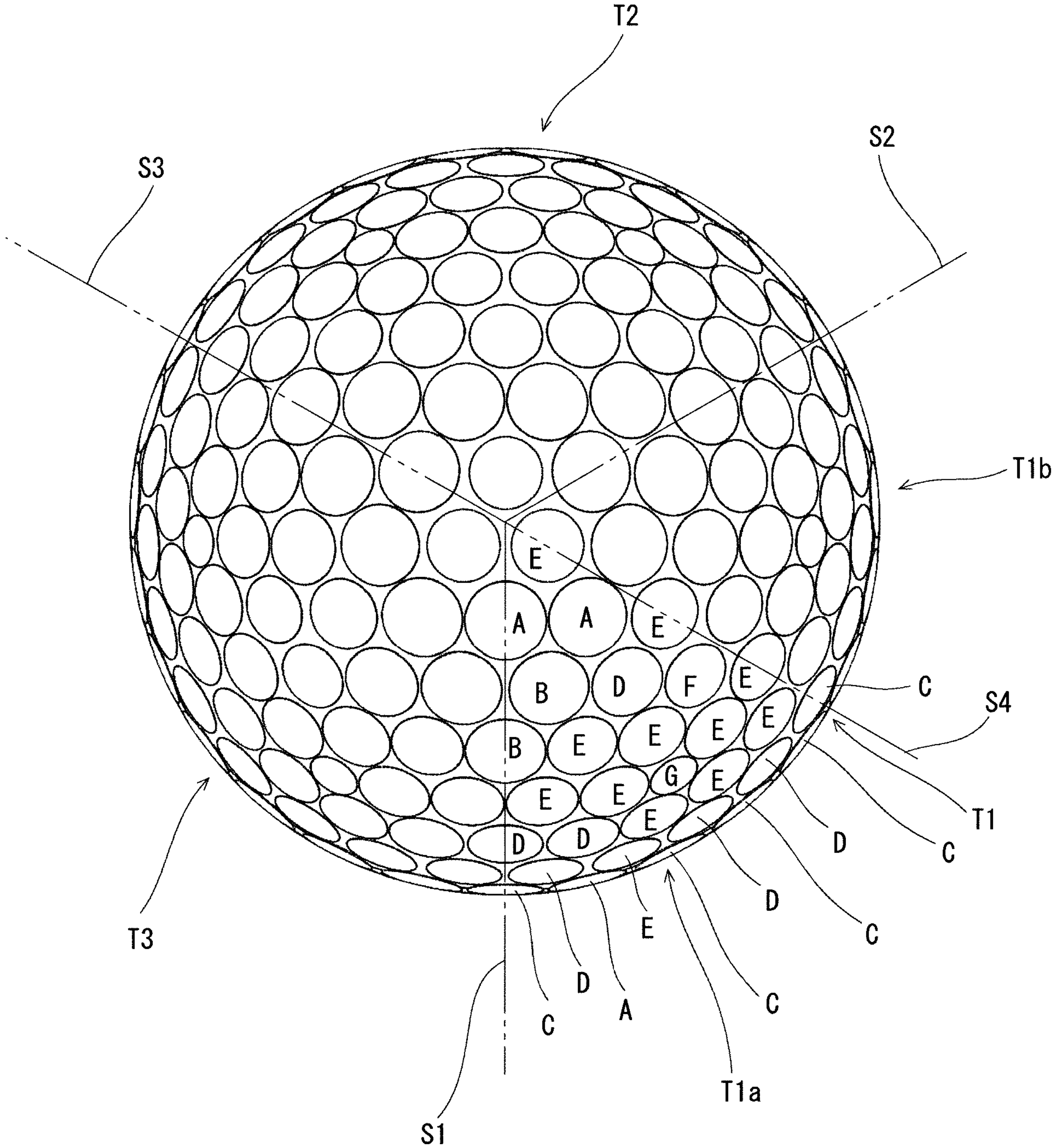


FIG. 14


T2
S3
S2
T1b
E
A
A
E
B
D
F
E
C
S4
B
E
E
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E
G
E
E
E
E
D
D
E
T1
C
D
T3
D
C
E
D
A
C
C
T1a
S1

FIG. 15

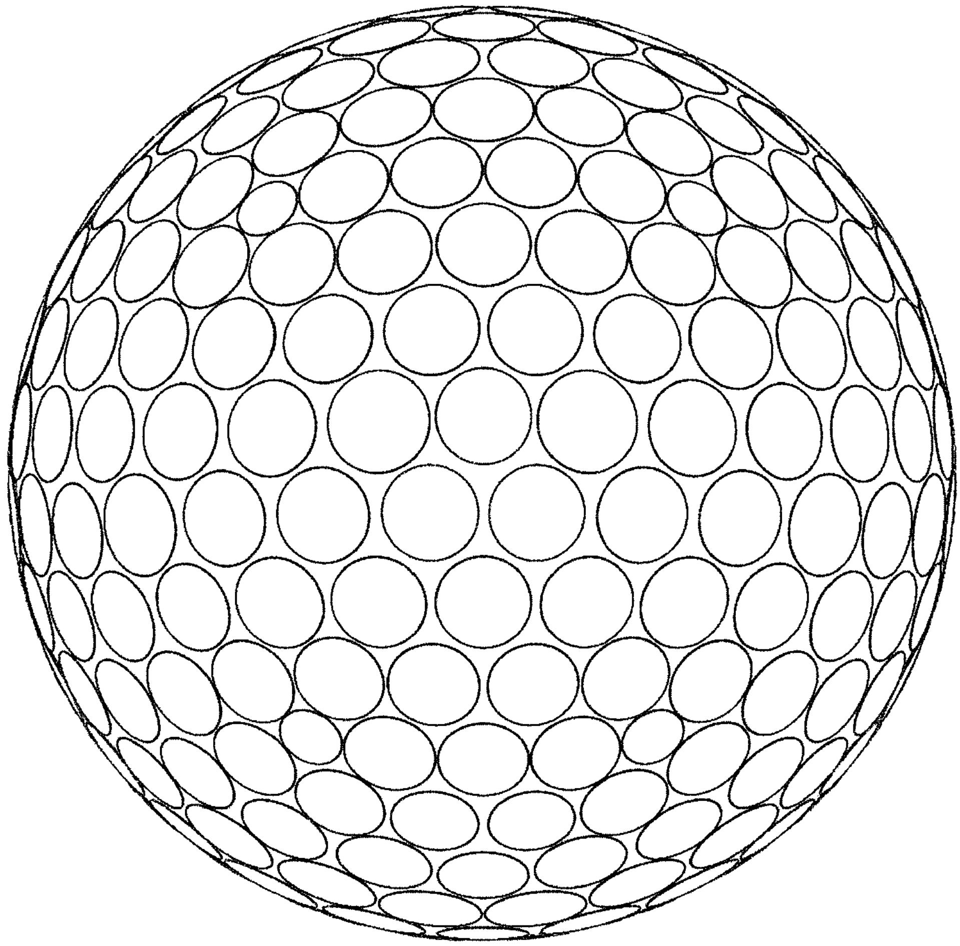
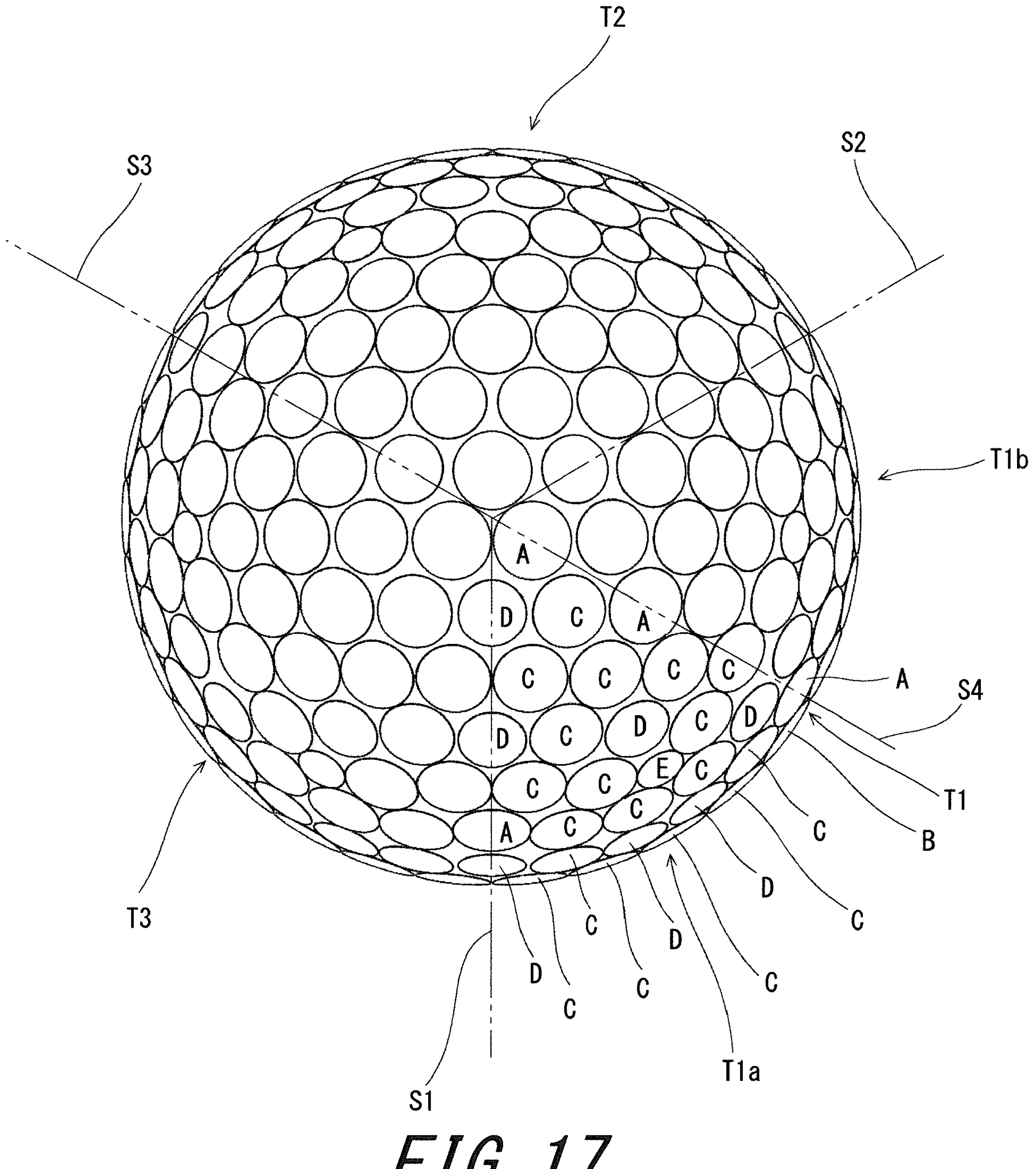


FIG. 16


T2
S3
S2
T1b
A
D
C
A
C
C
C
C
A
S4
D
C
D
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D
C
C
E
C
T1
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D
C
C
T1a
S1

FIG. 17

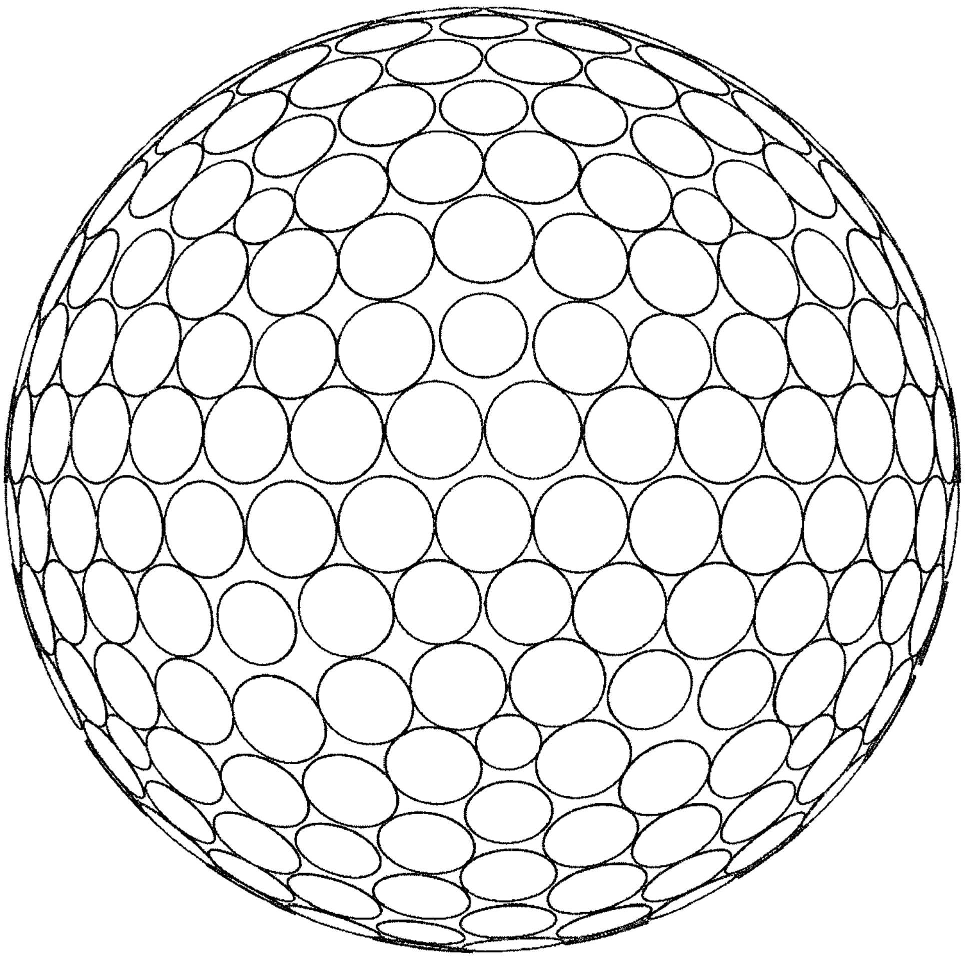

FIG. 18

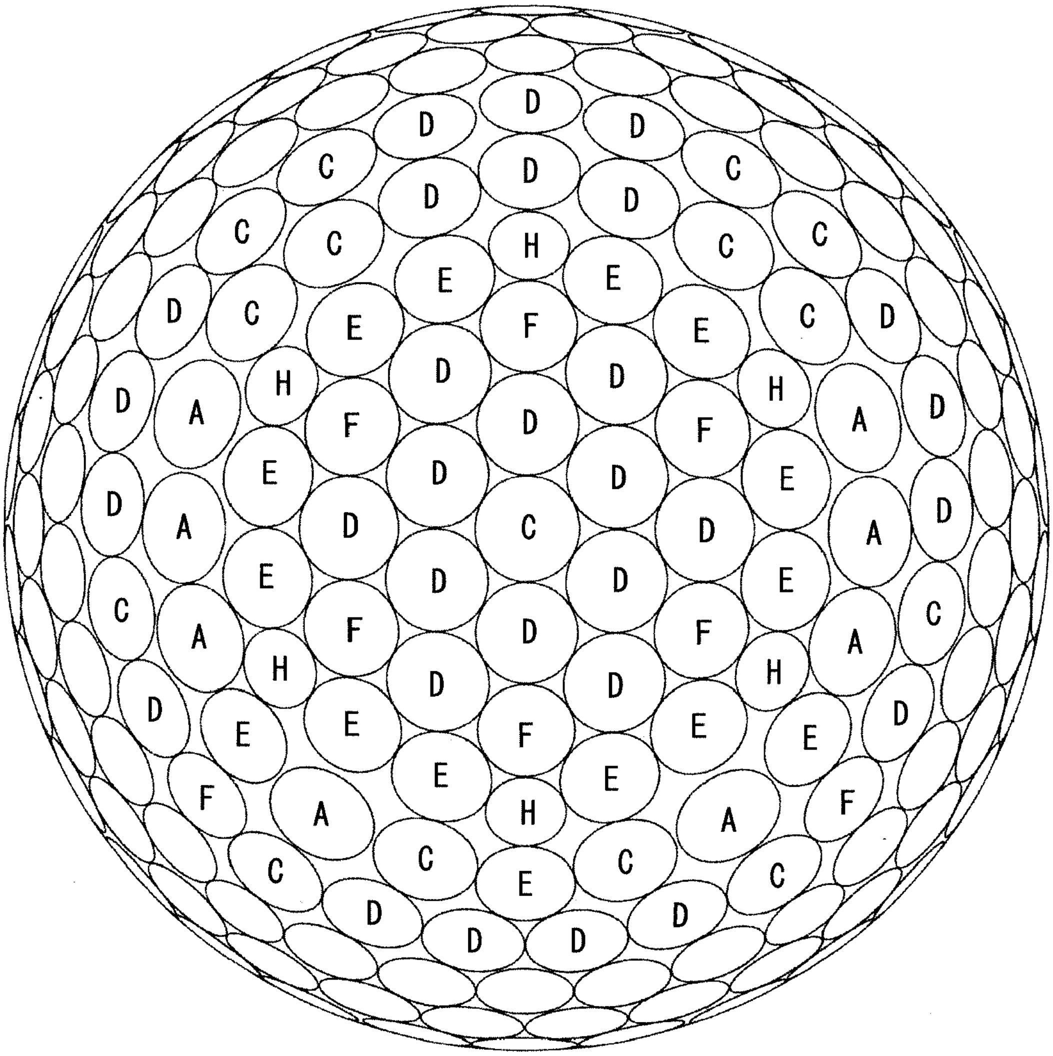

FIG. 19

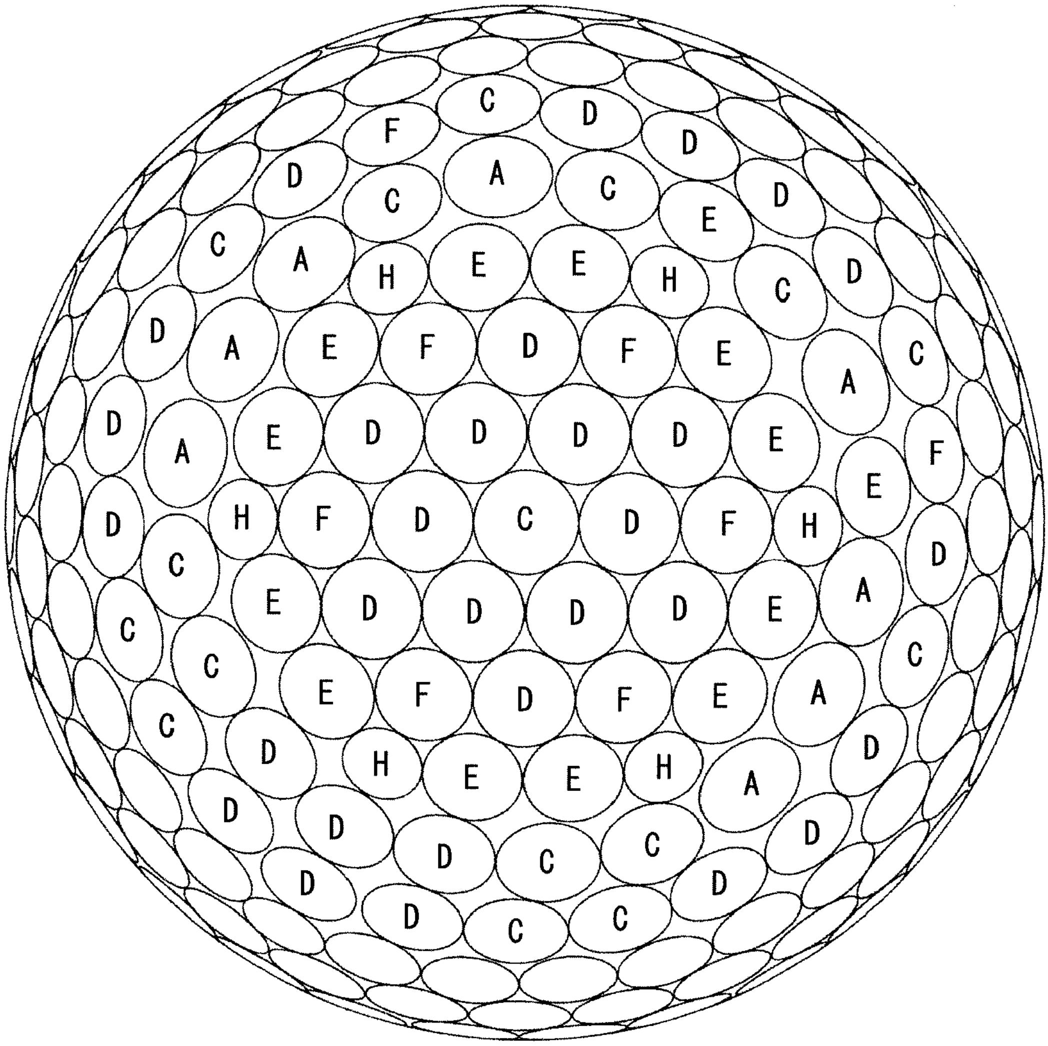

FIG. 20

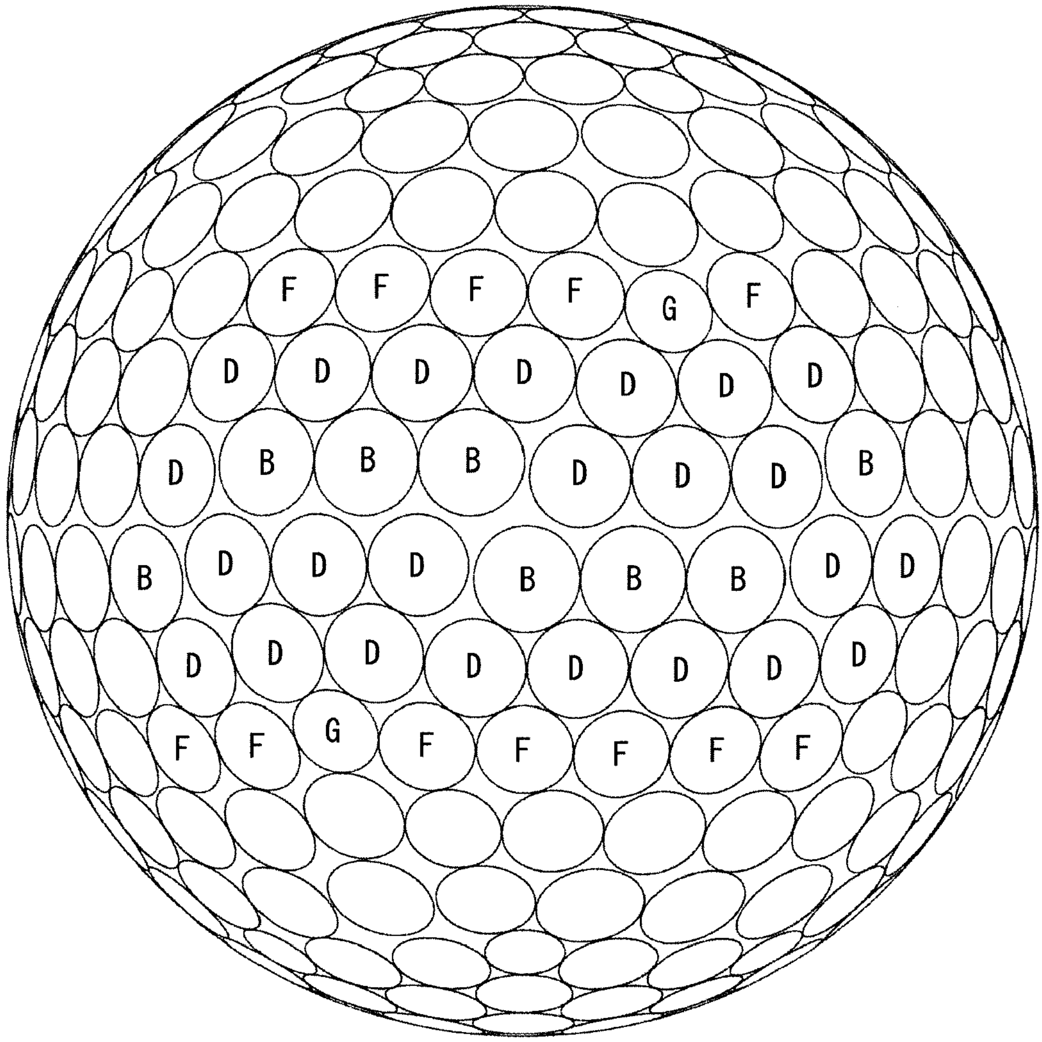

FIG. 21

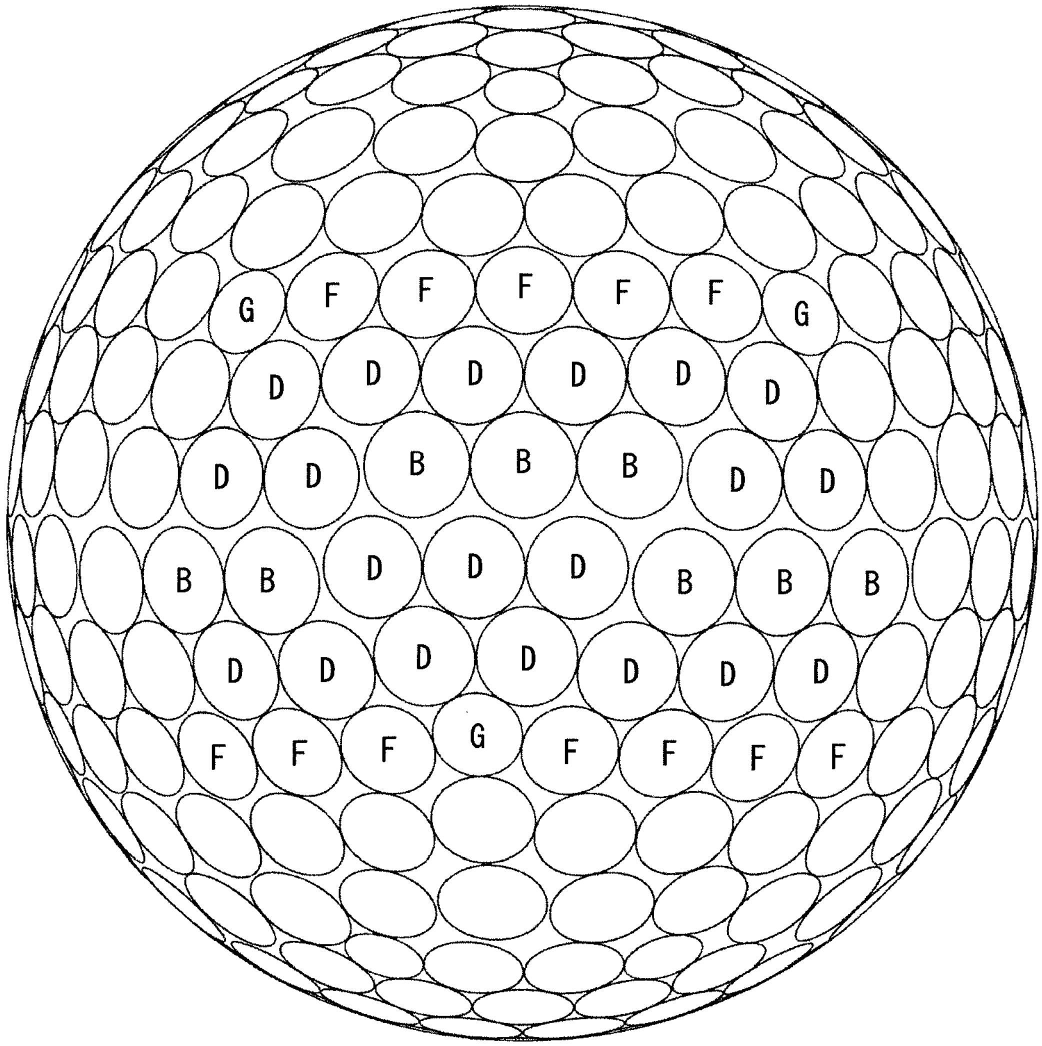

FIG. 22

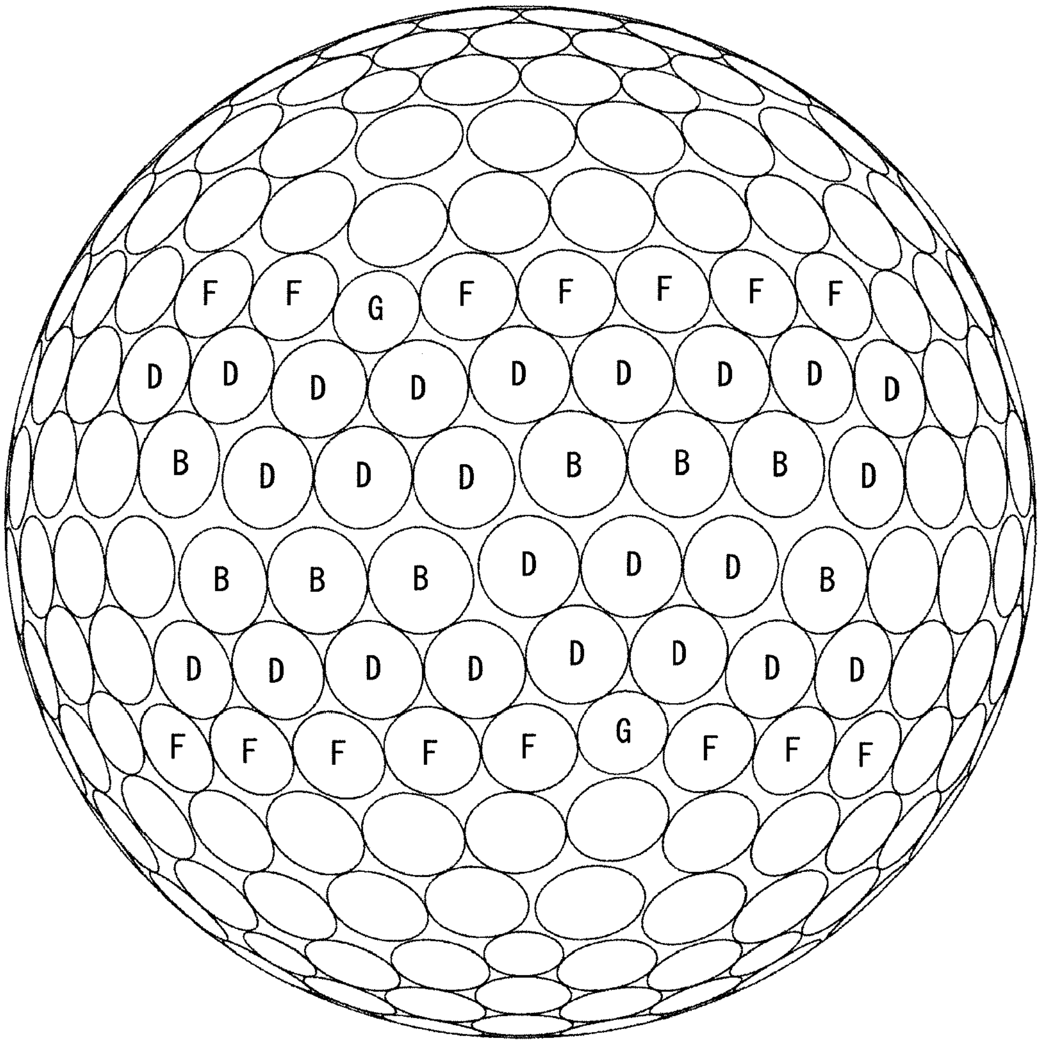

FIG. 23

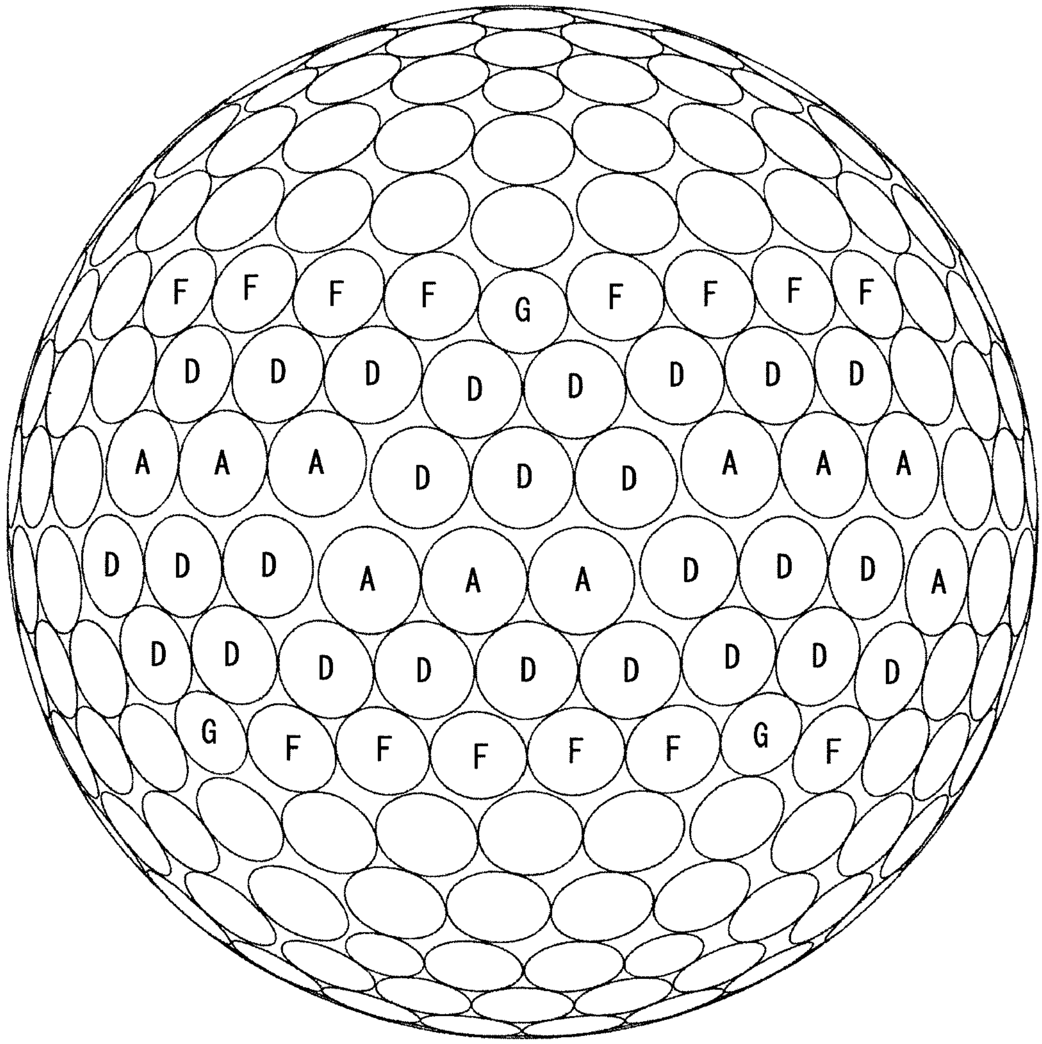
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FIG. 24

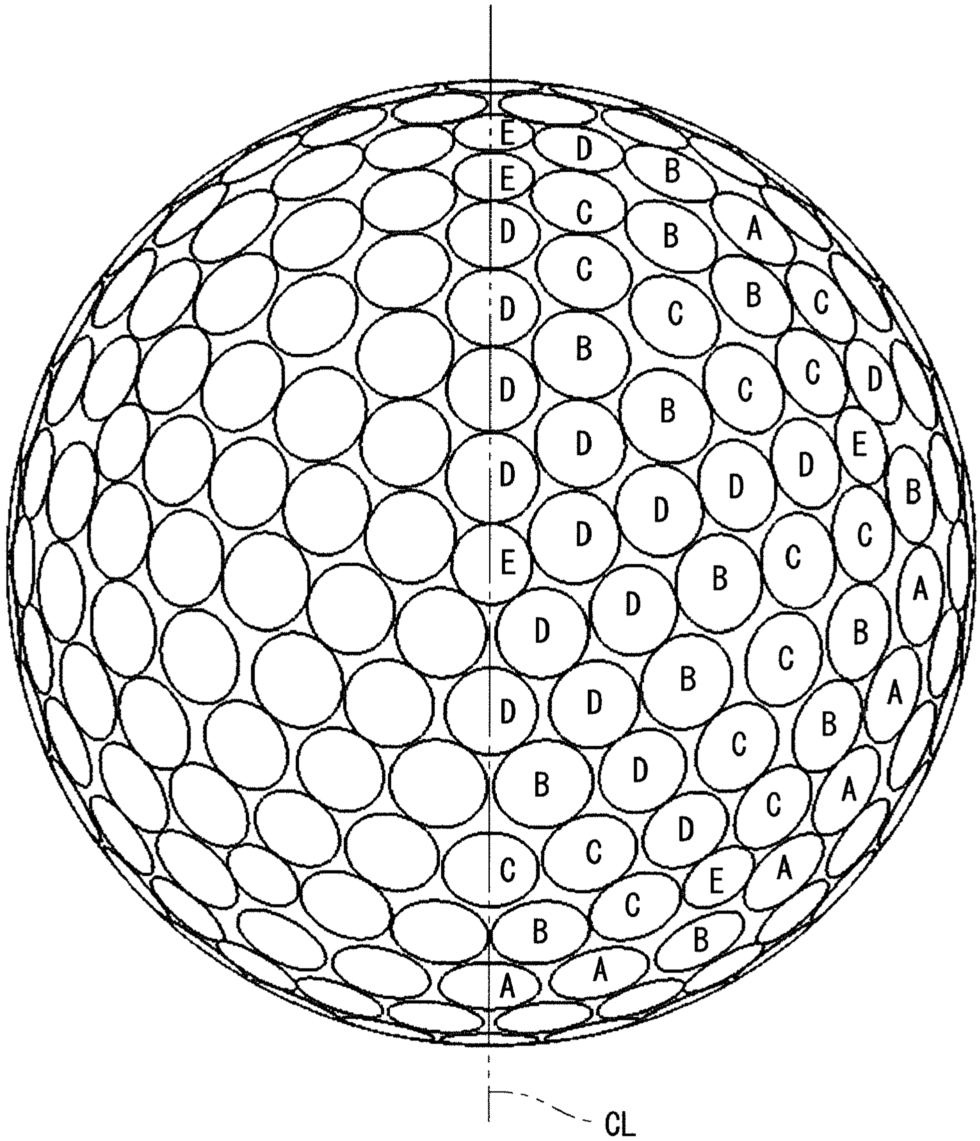
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FIG. 25

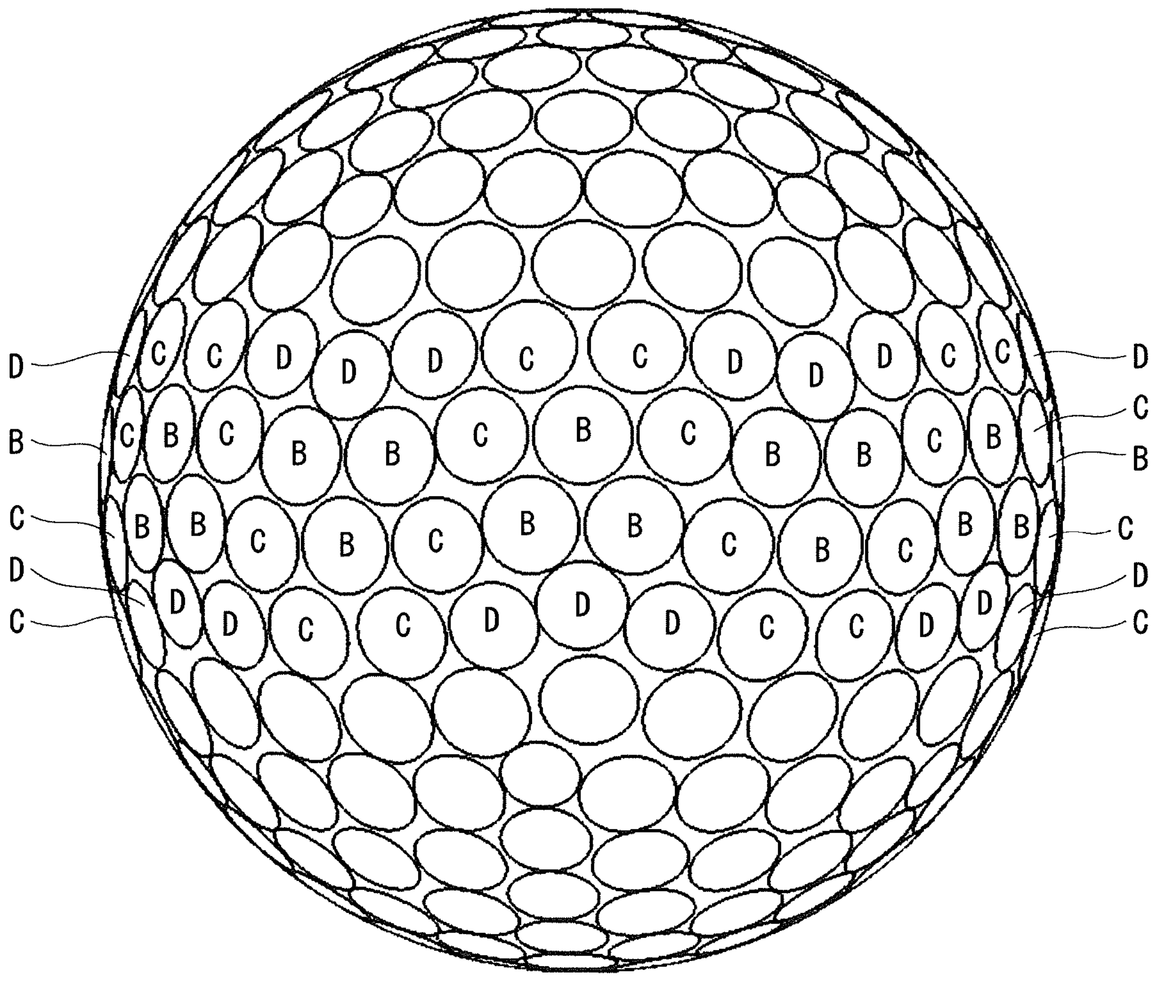

FIG. 26

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EUROPEAN SEARCH REPORT

Application Number
EP 16 20 0870

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X	US 8 651 978 B2 (SAJIMA TAKAHIRO [JP] ET AL) 18 February 2014 (2014-02-18) * column 9, line 10 - column 17, line 44; figure 18 * -----	1-8	INV. A63B37/00
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	14 February 2017	Jekabsons, Armands

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