



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.06.2017 Bulletin 2017/25

(51) Int Cl.:
A63B 37/00 (2006.01)

(21) Application number: **16193917.8**

(22) Date of filing: **14.10.2016**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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(30) Priority: **14.12.2015 JP 2015242909**

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(54) **TWO-PIECE GOLF BALL**

(57) A golf ball (2) includes a core (4) and a cover (6). A value V calculated by the following mathematical formula is equal to or less than 1080 Hz.

$$V = NF(2)2 - 2/3 * NF(2)1$$

In the mathematical formula, NF(2)1 represents a secondary natural frequency of the core (4), and NF(2)2 represents a secondary natural frequency of the golf ball (2). A difference (H1s-H1o) between a Shore C hardness (H1s) at a surface of the core (4) and a Shore C hardness (H1o) at a central point of the core (4) is equal to or greater than 10. An amount of compressive deformation (Df1) of the core (4) is equal to or greater than 4,1 mm.

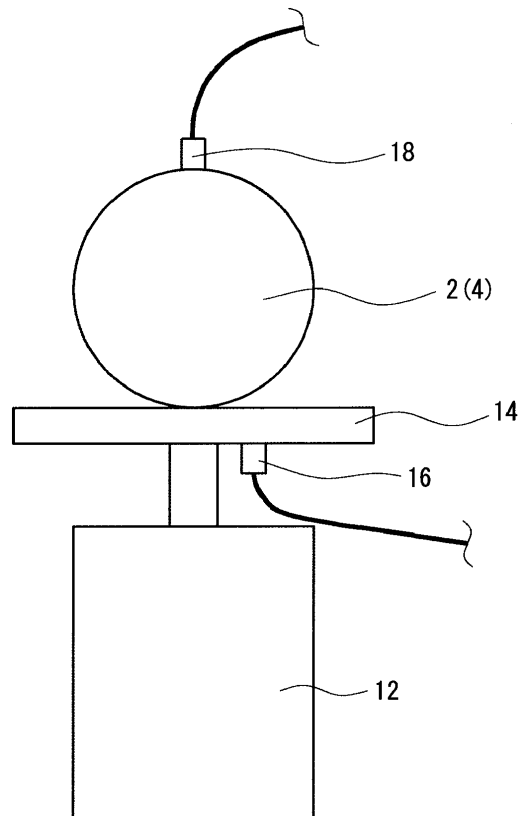


FIG. 2

Description

[0001] This application claims priority on Patent Application No. 2015-242909 filed in JAPAN on December 14, 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 so-called two-piece golf balls including a core and a cover.

Description of the Related Art

[0003] In golf, golf balls are hit with a wood type club, an iron type club, a hybrid type club (utility), and a putter, etc. Feel at impact upon hitting is of interest to golf players. In general, golf players desire golf balls having soft feel at impact.

[0004] In play by beginners, the frequency of a mishit is high. Therefore, beginners are insensitive to feel at impact when hitting a golf ball with a wood type club, an iron type club, or a hybrid type club.

[0005] Meanwhile, in putting, even beginners often hit golf balls at the sweet spots of putters. Even beginners are sensitive to feel at impact upon putting. Beginners desire golf balls with which soft feel at impact is obtained upon putting.

[0006] So-called thread-wound balls used to be mainstream golf balls. At present, thread-wound balls are almost not available commercially. In recent golf, two-piece balls, three-piece balls, four-piece balls, five-piece balls, six-piece balls, and the like are used.

[0007] A two-piece ball includes a core and a cover. The structure of the two-piece ball is simple. The two-piece ball can be manufactured at low cost. Proposals concerning two-piece balls are disclosed in JPH11-76461 (USP6,123,629) and US Patent No. 5971870.

[0008] Upon shots by beginners, golf balls often fly in an unintended direction. Golf balls often fall into a pond or fly into woods. Beginners often lose golf balls. Therefore, beginners do not prefer expensive golf balls. Two-piece balls are suitable for beginners, since two-piece balls can be manufactured at low cost. As described above, beginners prefer soft feel at impact upon putting. Improvement of feel at impact of two-piece balls upon putting is desired.

[0009] An object of the present invention is to provide a two-piece golf ball having excellent feel at impact upon putting.

SUMMARY OF THE INVENTION

[0010] A two-piece golf ball according to the present invention includes a core and a cover positioned outside the core. In the golf ball, a value V calculated by the following mathematical formula is equal to or less than 1080 Hz.

$$V = \text{NF}(2)2 - 2/3 * \text{NF}(2)1$$

In the mathematical formula, NF(2)1 represents a secondary natural frequency of the core, and NF(2)2 represents a secondary natural frequency of the golf ball.

[0011] The two-piece golf ball according to the present invention has a simple structure. The golf ball can be manufactured at low cost. Since the value V is equal to or less than 1080 Hz, the feel at impact of the golf ball upon putting is soft. The golf ball can achieve both a low price and desired feel at impact.

[0012] Preferably, a difference (H1s-H1o) between a Shore C hardness H1s at a surface of the core and a Shore C hardness H1o at a central point of the core is equal to or greater than 10.

[0013] Preferably, the value V is equal to or less than 1040 Hz. Further preferably, the value V is equal to or less than 1000 Hz.

[0014] Preferably, an amount of compressive deformation Df1 of the core is equal to or greater than 4.1 mm.

[0015] Preferably, an amount of compressive deformation Df2 of the two-piece golf ball is equal to or greater than 3.5 mm.

[0016] Preferably, a thickness T2 of the cover is equal to or greater than 0.80 mm but equal to or less than 2.00 mm. Preferably, a Shore D hardness H2 of the cover is equal to or greater than 50 but equal to or less than 65.

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 conceptual diagram showing a device for measuring a natural frequency of the golf ball in FIG. 1; and
 FIG. 3 is a graph showing a relationship between a secondary natural frequency NF(2)1 of a core and a secondary natural frequency NF(2)2 of the golf ball.

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 and a cover 6 positioned outside the core 4. In the present embodiment, the cover 6 is joined directly to the core 4. The golf ball 2 is a so-called two-piece ball. The golf ball 2 has a plurality of dimples 8 on the surface thereof. Of the surface of the golf ball 2, a part other than the dimples 8 is a land 10. The golf ball 2 includes a paint layer and a mark layer on the external side of the cover 6 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 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.

[0021] The core 4 is formed by crosslinking a rubber composition. Examples of preferable base rubbers for use in the rubber composition include polybutadienes, polyisoprenes, styrene-butadiene copolymers, ethylenepropylene-diene copolymers, and natural rubbers. In light of resilience performance, polybutadienes are preferable. When a polybutadiene and another rubber are used in combination, it is preferred if the polybutadiene is a principal component. Specifically, the proportion of the polybutadiene to the entire base rubber is preferably equal to or greater than 50% by weight and particularly preferably equal to or greater than 80% by weight. A polybutadiene in which the proportion of cis-1,4 bonds is equal to or greater than 80% is particularly preferable.

[0022] The rubber composition of the core 4 preferably includes a co-crosslinking agent. Preferable co-crosslinking agents in light of resilience performance of the golf ball 2 are monovalent or bivalent metal salts of an α,β -unsaturated carboxylic acid having 2 to 8 carbon atoms. Examples of preferable co-crosslinking agents include zinc acrylate, magnesium acrylate, zinc methacrylate, and magnesium methacrylate. In light of resilience performance of the golf ball 2, zinc acrylate and zinc methacrylate are particularly preferable.

[0023] The rubber composition may include a metal oxide and an α,β -unsaturated carboxylic acid having 2 to 8 carbon atoms. They both react with each other in the rubber composition to obtain a salt. The salt serves as a co-crosslinking agent. Examples of preferable α,β -unsaturated carboxylic acids include acrylic acid and methacrylic acid. Examples of preferable metal oxides include zinc oxide and magnesium oxide.

[0024] The amount of the co-crosslinking agent per 100 parts by weight of the base rubber is preferably equal to or greater than 10 parts by weight. The golf ball 2 that includes the core 4 in which this amount is equal to or greater than 10 parts by weight has excellent resilience performance. In this respect, this amount is more preferably equal to or greater than 15 parts by weight and particularly preferably equal to or greater than 20 parts by weight.

[0025] The amount of the co-crosslinking agent per 100 parts by weight of the base rubber is preferably equal to or less than 40 parts by weight. The golf ball 2 that includes the core 4 in which this amount is equal to or less than 40 parts by weight has soft feel at impact upon putting. In this respect, this amount is more preferably equal to or less than 35 parts by weight and particularly preferably equal to or less than 30 parts by weight.

[0026] Preferably, the rubber composition of the core 4 includes an organic peroxide. The organic peroxide serves as a crosslinking initiator. The organic peroxide contributes to the resilience performance of the golf ball 2. Examples of suitable 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. An organic peroxide with particularly high versatility is dicumyl peroxide.

[0027] The amount of the organic peroxide per 100 parts by weight of the base rubber is preferably equal to or greater than 0.1 parts by weight. The golf ball 2 that includes the core 4 in which this amount is equal to or greater than 0.1 parts by weight has excellent resilience performance. In this respect, this amount is more preferably equal to or greater than

0.3 parts by weight and particularly preferably equal to or greater than 0.5 parts by weight.

[0028] The amount of the organic peroxide per 100 parts by weight of the base rubber is preferably equal to or less than 3.0 parts by weight. The golf ball 2 that includes the core 4 in which this amount is equal to or less than 3.0 parts by weight has soft feel at impact upon putting. In this respect, this amount is more preferably equal to or less than 2.5 parts by weight and particularly preferably equal to or less than 2.0 parts by weight.

[0029] The rubber composition of the core 4 includes an organic sulfur compound. Organic sulfur compounds include naphthalenethiol compounds, benzenethiol compounds, and disulfide compounds.

[0030] Examples of naphthalenethiol compounds include 1-naphthalenethiol, 2-naphthalenethiol, 4-chloro-1-naphthalenethiol, 4-bromo-1-naphthalenethiol, 1-chloro-2-naphthalenethiol, 1-bromo-2-naphthalenethiol, 1-fluoro-2-naphthalenethiol, 1-cyano-2-naphthalenethiol, and 1-acetyl-2-naphthalenethiol.

[0031] Examples of benzenethiol compounds include benzenethiol, 4-chlorobenzenethiol, 3-chlorobenzenethiol, 4-bromobenzenethiol, 3-bromobenzenethiol, 4-fluorobenzenethiol, 4-iodobenzenethiol, 2,5-dichlorobenzenethiol, 3,5-dichlorobenzenethiol, 2,6-dichlorobenzenethiol, 2,5-dibromobenzenethiol, 3,5-dibromobenzenethiol, 2-chloro-5-bromobenzenethiol, 2,4,6-trichlorobenzenethiol, 2,3,4,5,6-pentachlorobenzenethiol, 2,3,4,5,6-pentafluorobenzenethiol, 4-cyanobenzenethiol, 2-cyanobenzenethiol, 4-nitrobenzenethiol, and 2-nitrobenzenethiol.

[0032] Examples of disulfide compounds include diphenyl disulfide, bis(4-chlorophenyl)disulfide, bis(3-chlorophenyl)disulfide, bis(4-bromophenyl)disulfide, bis(3-bromophenyl)disulfide, bis(4-fluorophenyl)disulfide, bis(4-iodophenyl)disulfide, bis(4-cyanophenyl)disulfide, bis(2,5-dichlorophenyl)disulfide, bis(3,5-dichlorophenyl)disulfide, bis(2,6-dichlorophenyl)disulfide, bis(2,5-dibromophenyl)disulfide, bis(3,5-dibromophenyl)disulfide, bis(2-chloro-5-bromophenyl)disulfide, bis(2-cyano-5-bromophenyl)disulfide, bis(2,4,6-trichlorophenyl)disulfide, bis(2-cyano-4-chloro-6-bromophenyl)disulfide, bis(2,3,5,6-tetrachlorophenyl)disulfide, bis(2,3,4,5,6-pentachlorophenyl)disulfide, and bis(2,3,4,5,6-pentabromophenyl)disulfide.

[0033] In light of resilience performance of the golf ball 2, the amount of the organic sulfur compound per 100 parts by weight of the base rubber is preferably equal to or greater than 0.1 parts by weight and particularly preferably equal to or greater than 0.2 parts by weight. In light of feel at impact upon putting, the amount is preferably equal to or less than 1.5 parts by weight, more preferably equal to or less than 1.0 parts by weight, and particularly preferably equal to or less than 0.8 parts by weight. Two or more organic sulfur compounds may be used in combination.

[0034] The rubber composition of the core 4 may include a filler for the purpose of specific gravity adjustment and the like. Examples of suitable fillers include zinc oxide, barium sulfate, calcium carbonate, and magnesium carbonate. The amount of the filler is determined as appropriate so that the intended specific gravity of the core 4 is accomplished.

[0035] The rubber composition may include various additives, such as sulfur, a carboxylic acid, a carboxylate, an anti-aging agent, a coloring agent, a plasticizer, a dispersant, and the like, in an adequate amount. The rubber composition may include crosslinked rubber powder or synthetic resin powder.

[0036] The core 4 preferably has a diameter of equal to or greater than 39.0 mm. In the golf ball 2 that includes the core 4 having a diameter of equal to or greater than 39.0 mm, the cover 6 is thin. Therefore, with the golf ball 2, the feel at impact upon putting is soft. Furthermore, the golf ball 2 has excellent resilience performance. In these respects, the diameter is more preferably equal to or greater than 39.3 mm and particularly preferably equal to or greater than 39.5 mm. In light of durability of the golf ball 2, the diameter is preferably equal to or less than 41.0 mm, more preferably equal to or less than 40.6 mm, and particularly preferably equal to or less than 40.2 mm.

[0037] The core 4 preferably has an amount of compressive deformation Df1 of equal to or greater than 4.1 mm. With the core 4 having an amount of compressive deformation Df1 of equal to or greater than 4.1 mm, the feel at impact upon putting is soft. In this respect, the amount of compressive deformation Df1 is more preferably equal to or greater than 4.2 mm and particularly preferably equal to or greater than 4.4 mm. In light of resilience performance of the golf ball 2, the amount of compressive deformation Df1 is preferably equal to or less than 6.5 mm, more preferably equal to or less than 6.0 mm, and particularly preferably equal to or less than 5.5 mm.

[0038] For measurement of the amount of compressive deformation, a YAMADA type compression tester is used. In the tester, a sphere (the core 4 or the golf ball 2) is placed on a hard plate made of metal. Next, a cylinder made of metal gradually descends toward the sphere. The sphere, squeezed between the bottom face of the cylinder and the hard plate, becomes deformed. A migration distance of the cylinder, starting from the state in which an initial load of 98 N is applied to the sphere up to the state in which a final load of 1274 N is applied thereto, is measured. A moving speed of the cylinder until the initial load is applied is 0.83 mm/s. A moving speed of the cylinder after the initial load is applied until the final load is applied is 1.67 mm/s.

[0039] The difference (H1s-H1o) between a Shore C hardness H1s at the surface of the core 4 and a Shore C hardness H1o at the central point of the core 4 is preferably equal to or greater than 10. The core 4 having a difference (H1s-H1o) of equal to or greater than 10 has a so-called outer-hard/inner-soft structure. When the golf ball 2 including the core 4 is hit with a driver, the spin is suppressed. When the golf ball 2 including the core 4 is hit with a driver, a high launch angle is obtained.

[0040] Upon a shot with a driver, an appropriate trajectory height and appropriate flight duration are required. With

the golf ball 2 that achieves a desired trajectory height and desired flight duration at a high spin rate, the run after landing is short. With the golf ball 2 that achieves a desired trajectory height and desired flight duration at a high launch angle, the run after landing is long. In light of flight distance, the golf ball 2 that achieves a desired trajectory height and desired flight duration at a high launch angle is preferable. The core 4 having an outer-hard/inner-soft structure can contribute to a high launch angle and a low spin rate as described above. Although the amount of compressive deformation Df1 is small, the core 4 can contribute to the flight performance of the golf ball 2.

[0041] In light of flight performance, the difference (H1s-H1o) is more preferably equal to or greater than 11 and particularly preferably equal to or greater than 12. In light of durability of the golf ball 2, the difference (H1s-H1o) is preferably equal to or less than 30, more preferably equal to or less than 28, and particularly preferably equal to or less than 25.

[0042] In light of durability and resilience performance, the central hardness H1o is preferably equal to or greater than 40, more preferably equal to or greater than 45, and particularly preferably equal to or greater than 50. In light of spin suppression, the hardness H1o is preferably equal to or less than 70, more preferably equal to or less than 65, and particularly preferably equal to or less than 60.

[0043] The hardness H1o is measured with a Shore C type hardness scale mounted to an automated hardness meter (trade name "digi test II" manufactured by Heinrich Bareiss Prüfgerätebau GmbH). The hardness scale is pressed against the central point of the cross-section of a hemisphere obtained by cutting the golf ball 2. The measurement is conducted in the environment of 23°C.

[0044] In light of spin suppression, the surface hardness H1s is preferably equal to or greater than 64, more preferably equal to or greater than 66, and particularly preferably equal to or greater than 68. In light of durability of the golf ball 2, the hardness H1s is preferably equal to or less than 85, more preferably equal to or less than 83, and particularly preferably equal to or less than 80.

[0045] The hardness H1s is measured with a Shore C type hardness scale mounted to an automated hardness meter (trade name "digi test II" manufactured by Heinrich Bareiss Prüfgerätebau GmbH). The hardness scale is pressed against the surface of the core 4. The measurement is conducted in the environment of 23°C.

[0046] The core 4 preferably has a weight of equal to or greater than 10 g but equal to or less than 42 g. The temperature for crosslinking the core 4 is equal to or higher than 140°C but equal to or lower than 180°C. The time period for crosslinking the core 4 is equal to or longer than 10 minutes but equal to or shorter than 60 minutes.

[0047] The cover 6 is positioned outside the core 4. The cover 6 is the outermost layer except the mark layer and the paint layer. The cover 6 is formed from a thermoplastic resin composition. Examples of the base polymer of the resin composition include ionomer resins, thermoplastic polyester elastomers, thermoplastic polyamide elastomers, thermoplastic polyurethane elastomers, thermoplastic polyolefin elastomers, and thermoplastic polystyrene elastomers. Ionomer resins are particularly preferable. Ionomer resins are highly elastic. The golf ball 2 that includes the cover 6 including an ionomer resin has excellent resilience performance. The cover 6 may be formed from a thermosetting resin composition.

[0048] An ionomer resin and another resin may be used in combination. In this case, in light of resilience performance, the ionomer resin is included as the principal component of the base polymer. The proportion of the ionomer resin to the entire base polymer is preferably equal to or greater than 50% by weight, more preferably equal to or greater than 70% by weight, and particularly preferably equal to or greater than 85% by weight.

[0049] 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. A preferable binary copolymer includes 80% by weight or more but 90% by weight or less of an α -olefin, and 10% by weight or more but 20% by weight or less of an α,β -unsaturated carboxylic acid. The binary copolymer has excellent resilience performance. 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. A preferable ternary copolymer includes 70% by weight or more but 85% by weight or less of an α -olefin, 5% by weight or more but 30% by weight or less of an α,β -unsaturated carboxylic acid, and 1% by weight or more but 25% by weight or less of an α,β -unsaturated carboxylate ester. The ternary copolymer has excellent resilience performance. 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. A particularly preferable ionomer resin is a copolymer formed with ethylene and acrylic acid. Another particularly preferable ionomer resin is a copolymer formed with ethylene and methacrylic acid.

[0050] 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. The neutralization may be carried out with two or more types of metal ions. Particularly suitable metal ions in light of resilience performance and durability of the golf ball 2 are sodium ion, zinc ion, lithium ion, and magnesium ion.

[0051] Specific examples of ionomer resins include trade names "Himilan 1555", "Himilan 1557", "Himilan 1605", "Himilan 1706", "Himilan 1707", "Himilan 1856", "Himilan 1855", "Himilan AM7311", "Himilan AM7315", "Himilan

AM7317", "Himilan AM7329", and "Himilan AM7337", manufactured by Du Pont-MITSUI POLYCHEMICALS Co., Ltd.; trade names "Surlyn 6120", "Surlyn 6910", "Surlyn 7930", "Surlyn 7940", "Surlyn 8140", "Surlyn 8150", "Surlyn 8940", "Surlyn 8945", "Surlyn 9120", "Surlyn 9150", "Surlyn 9910", "Surlyn 9945", "Surlyn AD8546", "HPF1000", and "HPF2000", manufactured by E.I. du Pont de Nemours and Company; and trade names "IOTEK 7010", "IOTEK 7030", "IOTEK 7510", "IOTEK 7520", "IOTEK 8000", and "IOTEK 8030", manufactured by ExxonMobil Chemical Corporation. Two or more ionomer resins may be used in combination.

[0052] The resin composition of the cover 6 may include a styrene block-containing thermoplastic elastomer. The styrene block-containing thermoplastic elastomer includes a polystyrene block as a hard segment, and a soft segment. A typical soft segment is a diene block. Examples of compounds for the diene block include butadiene, isoprene, 1,3-pentadiene, and 2,3-dimethyl-1,3-butadiene. Butadiene and isoprene are preferable. Two or more compounds may be used in combination.

[0053] Examples of styrene block-containing thermoplastic elastomers include styrene-butadiene-styrene block copolymers (SBS), styrene-isoprene-styrene block copolymers (SIS), styrene-isoprene-butadiene-styrene block copolymers (SIBS), hydrogenated SBS, hydrogenated SIS, and hydrogenated SIBS. Examples of hydrogenated SBS include styrene-ethylene-butylene-styrene block copolymers (SEBS). Examples of hydrogenated SIS include styrene-ethylene-propylene-styrene block copolymers (SEPS). Examples of hydrogenated SIBS include styrene-ethylene-ethylenepropylene-styrene block copolymers (SEEPS).

[0054] In light of resilience performance of the golf ball 2, the content of the styrene component in the styrene block-containing thermoplastic elastomer is preferably equal to or greater than 10% by weight, more preferably equal to or greater than 12% by weight, and particularly preferably equal to or greater than 15% by weight. In light of feel at impact of the golf ball 2, the content is preferably equal to or less than 50% by weight, more preferably equal to or less than 47% by weight, and particularly preferably equal to or less than 45% by weight.

[0055] In the present invention, styrene block-containing thermoplastic elastomers include an alloy of an olefin and one or more members selected from the group consisting of SBS, SIS, SIBS, SEBS, SEPS, and SEEPS. The olefin component in the alloy is presumed to contribute to improvement of compatibility with another base polymer. The alloy can contribute to the resilience performance of the golf ball 2. An olefin having 2 to 10 carbon atoms is preferable. Examples of suitable olefins include ethylene, propylene, butene, and pentene. Ethylene and propylene are particularly preferable.

[0056] Specific examples of polymer alloys include trade names "RABALON T3221C", "RABALON T3339C", "RABALON SJ4400N", "RABALON SJ5400N", "RABALON SJ6400N", "RABALON SJ7400N", "RABALON SJ8400N", "RABALON SJ9400N", and "RABALON SR04", manufactured by Mitsubishi Chemical Corporation. Other specific examples of styrene block-containing thermoplastic elastomers include trade name "Epofriend A1010" manufactured by Daicel Chemical Industries, Ltd., and trade name "SEPTON HG-252" manufactured by Kuraray Co., Ltd.

[0057] In light of feel at impact upon putting, the proportion of the styrene block-containing thermoplastic elastomer to the entire base polymer is preferably equal to or greater than 2% by weight, more preferably equal to or greater than 4% by weight, and particularly preferably equal to or greater than 6% by weight. In light of spin suppression, the proportion is preferably equal to or less than 30% by weight, more preferably equal to or less than 25% by weight, and particularly preferably equal to or less than 20% by weight.

[0058] The resin composition of the cover 6 may include a coloring agent, a filler, a dispersant, an antioxidant, an ultraviolet absorber, a light stabilizer, a fluorescent material, a fluorescent brightener, and the like in an adequate amount. When the hue of the golf ball 2 is white, a typical coloring agent is titanium dioxide.

[0059] The cover 6 preferably has a thickness T2 of equal to or less than 2.00 mm. The cover 6 having a thickness T2 of equal to or less than 2.00 mm does not impair soft feel at impact upon putting. In this respect, the thickness T2 is more preferably equal to or less than 1.85 mm and particularly preferably equal to or less than 1.70 mm. In light of ease of forming the cover 6 and in light of durability of the golf ball 2, the thickness T2 is preferably equal to or greater than 0.80 mm, more preferably equal to or greater than 0.95 mm, and particularly preferably equal to or greater than 1.05 mm. The thickness T2 is measured at a position immediately below the land 10.

[0060] From the standpoint that the golf ball 2 can have an outer-hard/inner-soft structure as a whole, the cover 6 has a Shore D hardness H2 of preferably equal to or greater than 50, more preferably equal to or greater than 53, and particularly preferably equal to or greater than 55. In light of feel at impact upon putting, the hardness H2 is preferably equal to or less than 65, more preferably equal to or less than 63, and particularly preferably equal to or less than 61.

[0061] The hardness H2 of the cover 6 is measured according to the standards of "ASTM-D 2240-68". The hardness H2 is measured with a Shore D type hardness scale mounted to an automated hardness meter (trade name "digi test II" manufactured by Heinrich Bareiss Prüfgerätebau GmbH). For the measurement, a sheet that is formed by hot press, is formed from the same material as that of the cover 6, and has a thickness of about 2 mm is used. Prior to the measurement, a sheet is kept at 23°C for two weeks. At the measurement, three sheets are stacked.

[0062] The golf ball 2 preferably has an amount of compressive deformation Df2 of equal to or greater than 3.5 mm. With the golf ball 2 having an amount of compressive deformation Df2 of equal to or greater than 3.5 mm, the feel at

impact upon putting is soft. In this respect, the amount of compressive deformation Df2 is more preferably equal to or greater than 3.6 mm and particularly preferably equal to or greater than 3.8 mm. In light of resilience performance of the golf ball 2, the amount of compressive deformation Df2 is preferably equal to or less than 6.0 mm, more preferably equal to or less than 5.5 mm, and particularly preferably equal to or less than 5.0 mm.

[0063] FIG. 2 shows a device for measuring natural frequencies of the core 4 and the golf ball 2. The device includes a vibration exciter 12, a plate 14, a first acceleration pickup 16, and a second acceleration pickup 18. The plate 14 is mounted on the vibration exciter 12. A sphere (the core 4 or the golf ball 2) is placed on the plate 14. The first acceleration pickup 16 is mounted on the plate 14. The second acceleration pickup 18 is mounted on the sphere. Vibration is applied to the sphere by the vibration exciter 12. A signal of acceleration applied to the sphere is outputted from the first acceleration pickup 16. A signal of the acceleration of the sphere is outputted from the second acceleration pickup 18. These signals are inputted into a dynamic signal analyzer. By calculation of the analyzer, a curve is obtained which shows a relationship between frequency and mechanical impedance at the sphere. The frequency at a minimum point of the curve is a natural frequency. The frequency at a minimum point that appears first on the curve is a primary natural frequency. The frequency at a minimum point that appears second on the curve is a secondary natural frequency. The vibration exciter 12 is typically trade name "PET", manufactured by IMV Corporation. The dynamic signal analyzer is typically trade name "HP-5420A", manufactured by Yokokawa Hewlett-Packard, Ltd.

[0064] As a result of thorough research, the present inventors have found that soft feel at impact upon putting is achieved when a secondary natural frequency NF(2)1 of the core 4 and a secondary natural frequency NF(2)2 of the golf ball 2 have a predetermined relationship.

[0065] FIG. 3 is a graph showing a relationship between the secondary natural frequency NF(2)1 of the core 4 and the secondary natural frequency NF(2)2 of the golf ball 2. In this graph, the horizontal axis indicates the secondary natural frequency NF(2)1 of the core, and the vertical axis indicates the secondary natural frequency NF(2)2 of the golf ball. A straight line indicated by reference sign L1 in this graph is represented by the following mathematical formula.

$$NF(2)2 = 2/3 * NF(2)1 + 1080$$

In the zone below the straight line L1 in this graph, a value V calculated by the following mathematical formula is equal to or less than 1080 Hz.

$$V = NF(2)2 - 2/3 * NF(2)1$$

According to the finding by the present inventors, the golf ball 2 having a value V of equal to or less than 1080 Hz has excellent feel at impact upon putting. With the golf ball 2, the feel at impact upon putting is soft.

[0066] A straight line indicated by reference sign L2 in the graph of FIG. 3 is represented by the following mathematical formula.

$$NF(2)2 = 2/3 * NF(2)1 + 1040$$

In the zone below the straight line L2 in this graph, the value V is equal to or less than 1040 Hz. The golf ball 2 having a value V of equal to or less than 1040 Hz has excellent feel at impact upon putting. With the golf ball 2, the feel at impact upon putting is soft.

[0067] A straight line indicated by reference sign L3 in the graph of FIG. 3 is represented by the following mathematical formula.

$$NF(2)2 = 2/3 * NF(2)1 + 1000$$

In the zone below the straight line L3 in this graph, the value V is equal to or less than 1000 Hz. The golf ball 2 having a value V of equal to or less than 1000 Hz has excellent feel at impact upon putting. With the golf ball 2, the feel at impact upon putting is soft.

[0068] In light of durability and resilience performance of the golf ball 2, the value V is preferably equal to or greater than 800 Hz.

EXAMPLES

[Example 1]

[0069] A rubber composition A was obtained by kneading 100 parts by weight of a high-cis polybutadiene (trade name "BR-730", manufactured by JSR Corporation), 22.0 parts by weight of zinc diacrylate, 5 parts by weight of zinc oxide, an appropriate amount of barium sulfate, 0.5 parts by weight of diphenyl disulfide, and 0.9 parts by weight of dicumyl peroxide. This rubber composition A was placed into a mold including upper and lower mold halves each having a hemispherical cavity, and heated at 160°C for 20 minutes to obtain a core with a diameter of 39.8 mm. The amount of barium sulfate was adjusted such that the weight of a golf ball was appropriate.

[0070] A resin composition a was obtained by kneading 47 parts by weight of an ionomer resin (the aforementioned "Himilan 1555"), 46 parts by weight of another ionomer resin (the aforementioned "Himilan 1557"), 7 parts by weight of a styrene block-containing thermoplastic elastomer (the aforementioned "RABALON T3221C"), 4 parts by weight of titanium dioxide, and 0.2 parts by weight of a light stabilizer (trade name "JF-90", manufactured by Johoku Chemical Co., Ltd.) with a twin-screw kneading extruder. The core was placed into a final mold that includes upper and lower mold halves each having a hemispherical cavity. The final mold has a large number of pimples on the cavity face thereof. By injection molding, the melted resin composition a was injected around the core to form a cover with a thickness T2 of 1.45 mm. Dimples having a shape that is the inverted shape of the pimples were formed on the cover.

[0071] 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.

[Examples 2 to 11 and Comparative Examples 1 to 3]

[0072] Golf balls of Examples 2 to 11 and Comparative Examples 1 to 3 were obtained in the same manner as Example 1, except the specifications of the core and the cover were as shown in Tables 4 to 6 below. The specifications of the core are shown in detail in Tables 1 and 2 below. The specifications of the cover are shown in detail in Table 3 below.

[Flight Test]

[0073] A driver (trade name "XXIO8", manufactured by DUNLOP SPORTS CO. 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 a condition of a head speed of 40 m/sec, and the ball initial speed, the spin rate, and the flight distance were measured. The flight distance is the distance between the point at the hit and the point at which the golf ball stopped. The average value of values obtained by 12 measurements is shown in Tables 4 to 6 below.

[Feel at Impact]

[0074] Twenty golf players hit golf balls with putters and were asked about feeling. The evaluation was categorized as follows on the basis of the number of golf players who answered, "the feeling was favorable".

A: 16 to 20

B: 10 to 15

C: 3 to 9

D: 0 to 2

The results are shown in Tables 4 to 6 below.

Table 1 Specifications of Core (parts by weight)

	A	B	C	D
Polybutadiene	100	100	100	100
Zinc oxide	5	5	5	5
Zinc acrylate	22.0	24.8	21.6	21.2
Barium sulfate	*	*	*	*
Diphenyl disulfide	0.5	0.5	0.5	0.5
Dicumyl peroxide	0.9	0.9	0.9	0.9
2-naphthalenethiol	-	-	-	-

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(continued)

	A	B	C	D
Crosslinking temperature (°C)	160	160	160	160
Crosslinking time period (min)	20	20	20	20
* Appropriate amount				

Table 2 Specifications of Core (parts by weight)

	E	F	G	H
Polybutadiene	100	100	100	100
Zinc oxide	5	5	5	5
Zinc acrylate	20.8	26.0	21.0	27.0
Barium sulfate	*	*	*	*
Diphenyl disulfide	0.5	0.5	0.5	0.5
Dicumyl peroxide	0.9	0.9	0.9	0.8
2-naphthalenethiol	-	-	-	0.1
Crosslinking temperature (°C)	160	160	140	160
Crosslinking time period (min)	20	20	20	20
* Appropriate amount				

Table 3 Specifications of Cover (parts by weight)

	a	b	c	d
Himilan 1555	47		-	-
Himilan AM7329	-	40	40	50
Himilan 1557	46	-	-	-
Himilan 1605	-	52	57	47
RABALON T3221C	7	8	3	3
Titanium dioxide	4	4	4	4
JF-90	0.2	0.2	0.2	0.2
H2 (Shore D)	57	59	61	63

Table 4 Results of Evaluation

	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5
Core					
Composition	A	B	C	D	E
Diameter (mm)	39.8	39.8	39.8	39.8	39.8
Df1 (mm)	4.85	4.15	4.95	5.05	5.15
H1o (shore C)	58	62	57	56	55
H1s (shore C)	72	76	71	70	69
H1s - H1o	14	14	14	14	14

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(continued)

	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5
NF(2)1 (Hz)	1355	1631	1315	1275	1235
Cover					
Composition	a	a	b	c	d
T2 (mm)	1.45	1.45	1.45	1.45	1.45
H2 (Shore D)	57	57	59	61	63
Ball					
NF(2)2 (Hz)	1855	2031	1865	1875	1885
Df2 (mm)	4.25	3.65	4.25	4.25	4.25
V (Hz)	952	944	988	1025	1062
Feel at impact	A	B	A	B	C
Flight test					
Spin (rpm)	2500	2588	2450	2400	2350
Initial speed (m/s)	57.50	57.70	57.63	57.76	57.89
Flight distance (m)	195.9	196.0	196.9	198.0	199.0

Table 5 Results of Evaluation

	Ex. 6	Ex. 7	Ex. 8	Ex. 9	Ex. 10
Core					
Composition	A	B	F	C	G
Diameter (mm)	39.5	39.5	39.5	39.5	40.2
Df1 (mm)	4.85	4.15	3.85	4.95	4.75
H1o (shore C)	58	62	64	57	60
H1s (shore C)	72	76	78	71	68
H1s - H1o	14	14	14	14	8
NF(2)1 (Hz)	1347	1623	1761	1307	1316
Cover					
Composition	a	a	a	b	a
T2 (mm)	1.60	1.60	1.60	1.60	1.25
H2 (Shore D)	57	57	57	59	57
Ball					
NF(2)2 (Hz)	1927	2103	2191	1937	1816
Df2 (mm)	4.23	3.63	3.38	4.23	4.27
V (Hz)	1029	1021	1017	1066	939
Feel at impact	A	B	C	B	A
Flight test					
Spin (rpm)	2520	2608	2683	2470	2650
Initial speed (m/s)	57.52	57.72	57.82	57.65	57.48

(continued)

	Ex. 6	Ex. 7	Ex. 8	Ex. 9	Ex. 10
Flight distance (m)	195.8	195.9	195.7	196.8	194.4

Table 6 Results of Evaluation

	Ex. 11	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3
Core				
Composition	G	D	A	H
Diameter (mm)	39.5	39.5	39.1	39.5
Df1 (mm)	4.75	5.05	4.85	4.00
H1o (shore C)	60	56	58	58
H1s (shore C)	68	70	72	78
H1s - H1o	8	14	14	20
NF(2) 1 (Hz)	1304	1267	1507	1779
Cover				
Composition	a	c	a	a
T2 (mm)	1.60	1.60	1.80	1.60
H2 (Shore D)	57	61	57	57
Ball				
NF(2)2 (Hz)	1834	1947	2167	2269
Df2 (mm)	4.23	4.23	4.21	3.66
V (Hz)	965	1102	1162	1083
Feel at impact	A	D	D	D
Flight test				
Spin (rpm)	2685	2420	2540	2618
Initial speed (m/s)	57.52	57.78	57.54	58.29
Flight distance (m)	194.3	197.9	195.7	198.4

[0075] As shown in Tables 4 to 6, the golf ball of each Example has excellent feel at impact upon putting and has excellent flight performance upon a shot with a driver. From the results of evaluation, advantages of the present invention are clear.

[0076] The golf ball according to the present invention is suitable for, for example, playing golf on golf courses and practicing at driving ranges. 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 two-piece golf ball including a core and a cover positioned outside the core, wherein a value V calculated by the following mathematical formula is equal to or less than 1080 Hz,

$$V = \text{NF}(2)2 - 2/3 * \text{NF}(2)1,$$

wherein NF(2)1 represents a secondary natural frequency of the core, and NF(2)2 represents a secondary natural

frequency of the golf ball.

2. The two-piece golf ball according to claim 1, wherein a difference ($H1s-H1o$) between a Shore C hardness $H1s$ at a surface of the core and a Shore C hardness $H1o$ at a central point of the core is equal to or greater than 10.
3. The two-piece golf ball according to claim 1 or 2, wherein the value V is equal to or less than 1040 Hz.
4. The two-piece golf ball according to claim 3, wherein the value V is equal to or less than 1000 Hz.
5. The two-piece golf ball according to any one of claims 1 to 4, wherein an amount of compressive deformation $Df1$ of the core is equal to or greater than 4.1 mm.
6. The two-piece golf ball according to any one of claims 1 to 5, wherein an amount of compressive deformation $Df2$ of the two-piece golf ball is equal to or greater than 3.5 mm.
7. The two-piece golf ball according to any one of claims 1 to 6, wherein a thickness $T2$ of the cover is equal to or greater than 0.80 mm but equal to or less than 2.00 mm.
8. The two-piece golf ball according to any one of claims 1 to 7, wherein a Shore D hardness $H2$ of the cover is equal to or greater than 50 but equal to or less than 65.

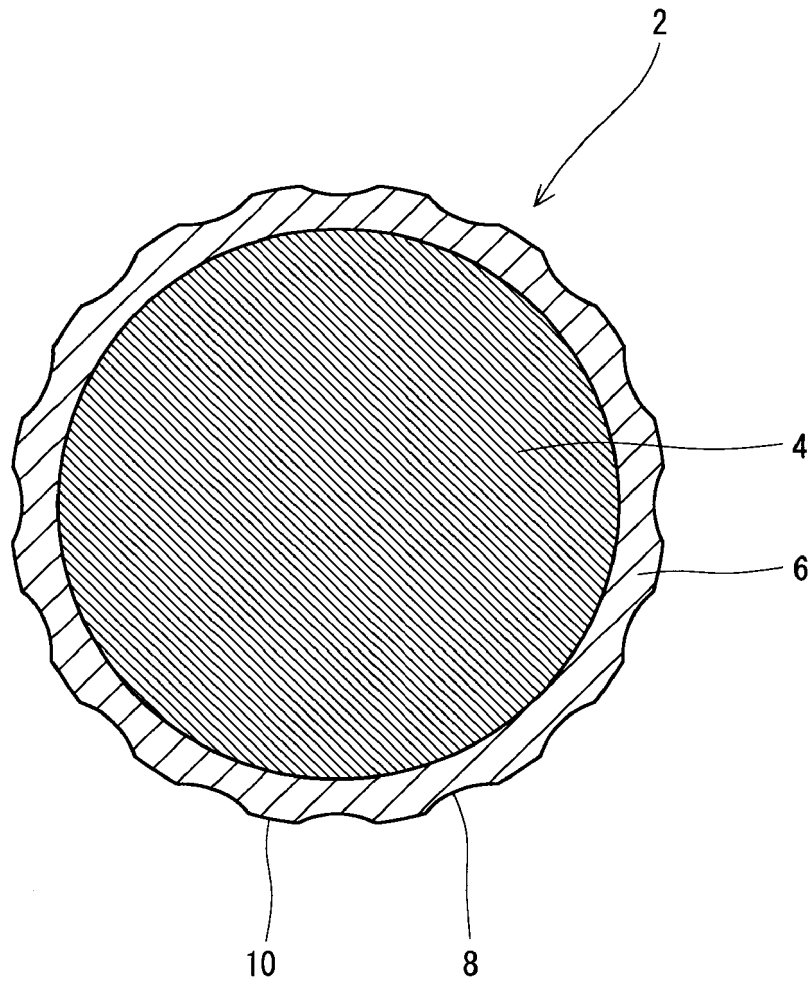


FIG. 1

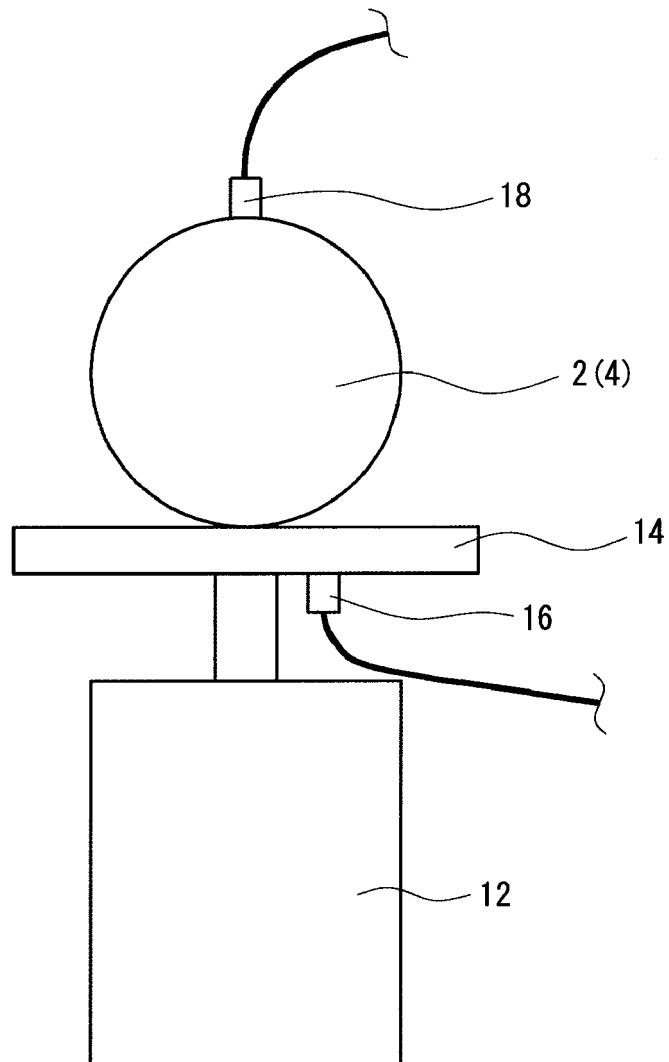


FIG. 2

E1 : Example 1	E8 : Example 8
E2 : Example 2	E9 : Example 9
E3 : Example 3	E10 : Example 10
E4 : Example 4	E11 : Example 11
E5 : Example 5	C1 : Comparative Example 1
E6 : Example 6	C2 : Comparative Example 2
E7 : Example 7	C3 : Comparative Example 3

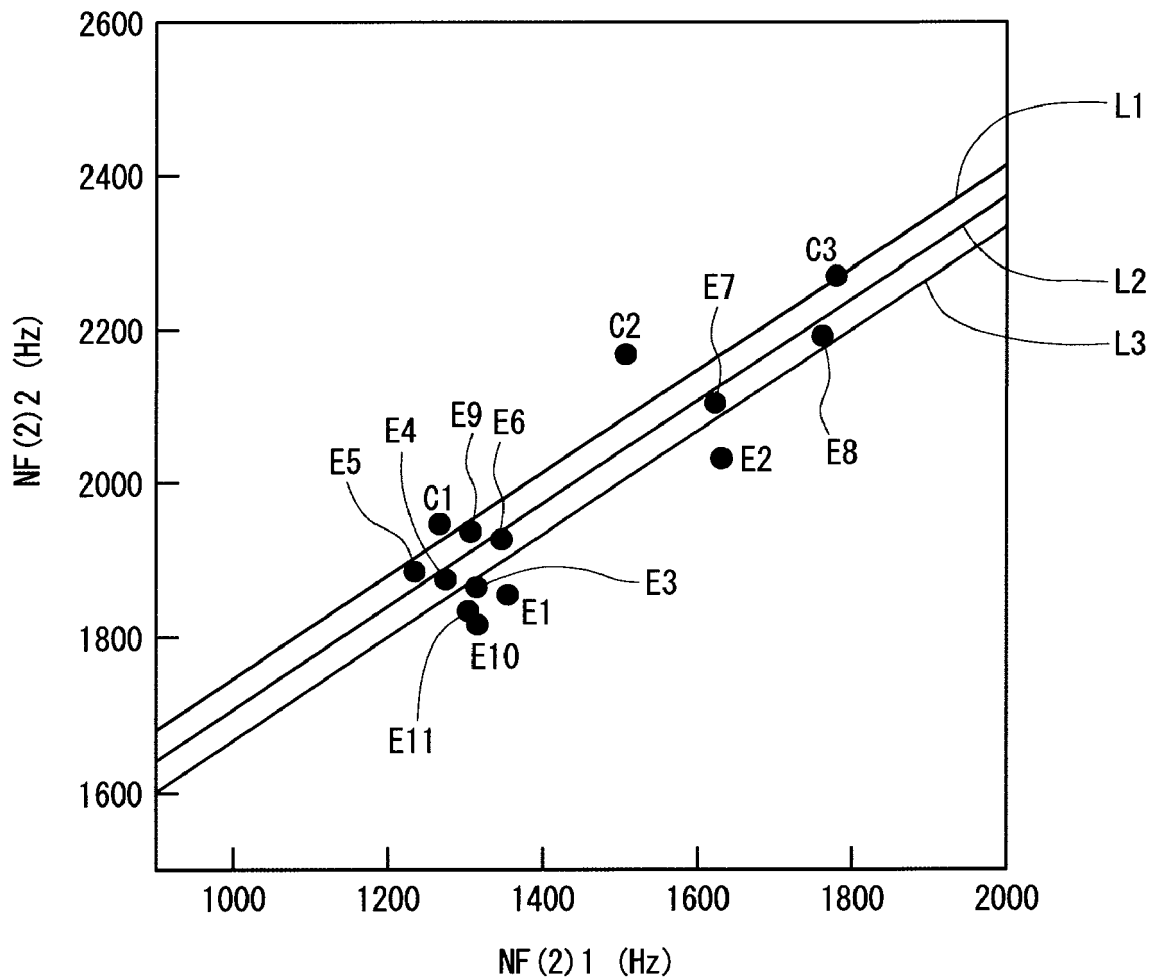


FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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