



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
03.10.2018 Bulletin 2018/40

(51) Int Cl.:
H01F 30/16 ^(2006.01) **H01F 27/28** ^(2006.01)
H01F 17/06 ^(2006.01) **H01F 27/32** ^(2006.01)
H01F 27/29 ^(2006.01)

(21) Application number: **18162449.5**

(22) Date of filing: **19.03.2018**

(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:
KH MA MD TN

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(30) Priority: **30.03.2017 JP 2017066589**

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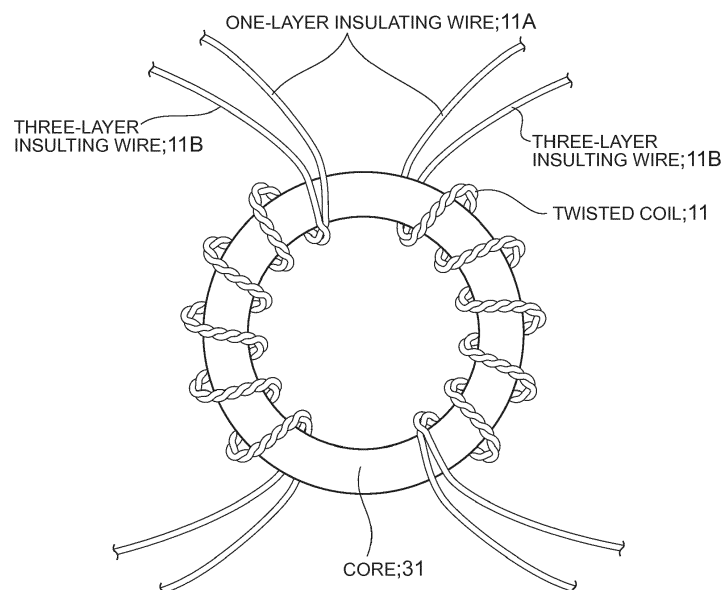
(54) **TRANSFORMER DEVICE**

(57) Two wire materials for coils can be efficiently processed into the same winding state and a configuration in which various characteristics and a cost thereof fall within a predetermined range is formed.

Provided is a transformer device to be mounted in a LAN for networking, in which a wire material 11A for a primary coil and a wire material 11B for a secondary coil are wound around an annular core 31 to allow a signal component to pass from the wire material 11A for the

primary coil to the wire material 11B for the secondary coil, wherein the wire material 11A for the primary coil is formed of a one-layer insulating wire material, and the wire material 11B for the secondary coil is formed of a three-layer insulating wire material, respectively, and the wire materials are wound around the core 31 in the form of a twisted wire (11) formed by intertwisting two insulating wire materials 11A and 11B.

FIG. 1



Description

RELATED APPLICATION

[0001] This application claims the priority of Japanese Patent Application No. 2017-066589 filed on March 30, 2017, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a transformer device used in a LAN for networking or the like, and more specifically, to a transformer device formed by winding a wire material for a primary coil and a wire material for a secondary coil around an annular core such as a toroidal core.

Description of the Prior Art

[0003] In recent years, size reduction of a transformer device used in a LAN for networking or the like has been strongly demanded, and a material formed by winding a wire material for a primary coil and a wire material for a secondary coil around a small core has been known.

[0004] As one of such technologies, a technology is known, in which a transformer device is formed, upon winding a wire material for a primary coil and a wire material for a secondary coil around a toric core such as a toroidal core, by winding a bifilar coil 211 formed by adjoining a primary coil 211A and a secondary coil 211B therearound (see FIG. 15) to reduce leakage flux (Patent Document 1 described below).

[0005] This Patent Document 1 discloses a material in which a three-layer insulating coil is used as a wire material for a bifilar wound coil.

[0006] Such a three-layer insulating coil has a high withstand voltage, and when the coil is used as the wire material, the wire material for the primary coil and the wire material for the secondary coil can also be wound around the core by allowing both into close contact with each other even without interposing a separate insulating tape or the like between the wire material for the primary coil and the wire material for the secondary coil.

Related Prior Art

[0007] Patent Document 1: Japanese Laid-Open Patent Publication No. H7-029755(A)

SUMMARY OF THE INVENTION

[0008] However, according to the Patent Document 1 described above, upon simultaneously winding a plurality of wire materials for coils around a core by bifilar winding, a difference in holding force is unavoidably produced among the wire materials for the coils, resulting in diffi-

culty in processing the wire materials for the coils into a winding state, and characteristics have been liable to be degraded.

[0009] Further, when a three-layer insulating wire is used as the wire material, while the use has an advantage of capability of increasing a withstand voltage, the use may cause a problem of excessive increase of a cost to be over the range which can be allowed by a user in a cost aspect.

[0010] When such a coil is selected, the best coil is not necessarily required in terms of characteristics, and the coil is required to satisfy characteristics according to an application and a purpose thereof and to be formed into a balanced configuration in such a manner that the coil falls within a predetermined range according to the application and the purpose also in terms of cost.

[0011] The present invention has been made in view of the circumstances described above, and an object of the present invention is to provide a transformer device in which two wire materials for coils can be efficiently processed into the same winding state and a configuration in which various characteristics and a cost thereof fall within a predetermined range is formed.

[0012] In order to solve the problems described above, a transformer device according to the present invention has features described below.

[0013] More specifically, the transformer device according to the present invention includes a transformer device to be mounted in a LAN for networking, in which a wire material for a primary coil and a wire material for a secondary coil are wound around an annular core to allow a signal component to pass from the wire material for the primary coil to the wire material for the secondary coil,

wherein the primary coil wire is formed of a one-layer insulating wire material, and the secondary coil wire is formed of a three-layer insulating wire material, respectively, and a twisted wire formed by intertwisting the two insulating wire materials is wound around the core.

[0014] In this case, the annular core is preferably formed into a toroidal core.

[0015] The annular core may be processed into a material in which a closed magnetic path is formed by combining a pair of U-shaped cores or a pair of E-shaped cores.

[0016] Moreover, the twisted wire is preferably split into a first split wire to be wound around a part on one side of the core and a second split wire to be wound around a part on the other side of the core, and the first split wire and the second split wire are electrically bonded thereto in a first terminal pin in the wire material for the primary coil and in a second terminal pin in the wire material for the secondary coil, respectively.

[0017] A twisting pitch of the twisted wire between the one-layer insulating wire material and the three-layer insulating wire material is preferably adjusted to 3 mm or more and 10 mm or less.

[0018] A wire diameter of each of a conducting wire of

the one-layer insulating wire material and the three-layer insulating wire material which constitute the twisted wire is further preferably adjusted to 0.2 mm or more and 0.45 mm or less.

[0019] Moreover, a total thickness of a coating member of the one-layer insulating wire material and a coating member of the three-layer insulating wire material interposed between individual conducting wires of the wire material for the primary coil and the wire material for the secondary coil is preferably adjusted to 0.1155 mm or more and 0.1430 mm or less.

[0020] According to a transformer device of the present invention, a primary coil and a secondary coil are each formed as a twisted wire formed by intertwisting a one-layer insulating wire material and a three-layer insulating wire material into a spiral form, and wire materials can be wound therearound in a state in which two wire materials for coils are intertwisted, and therefore a plurality of wire materials for coils can be processed into the same winding state in each of the wire materials for the coils. Moreover, the wire materials can be formed into a closer contact state with each other in comparison with a case where coils are wound therearound by bifilar winding, and characteristics can be improved such that impedance can be adjusted to a stabilized value in a high-frequency band. Moreover, workability during winding the wire material for the coil around the core is also improved.

[0021] In the transformer device of the present invention, either the primary coil or the secondary coil is applied as the one-layer insulating wire material and the other is applied as the three-layer insulating wire material. Therefore, upon intertwisting the primary coil and the secondary coil, a certain degree of withstand voltage can be secured to maintain the characteristics, and simultaneously a significant rise of a production cost can be suppressed.

[0022] In addition, such a technology is known, in which a material formed by intertwisting a wire material for a primary coil and a wire material for a secondary coil into a twisted form is used as an air-core coil without using a core to improve conversion efficiency and to achieve size reduction of a device (Japanese Laid-Open Patent Publication No. H4-328812(A)). However, the technology described above is completely different from the invention of the present application in a direction of a technical idea in a point of using no core. Moreover, because the material has no core, leakage of magnetic flux is unable to be prevented, and reduction of inductance is unable to be avoided, and therefore the technology is different from the present invention in the direction of the technology also in these points described above.

[0023] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the in-

vention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The present invention will become more fully understood from the detailed description given herein below and the accompanying drawings which are given by way of illustration only and thus are not limitative of the present invention.

FIG. 1 is a schematic view showing a main part of a transformer device according to an embodiment of the present invention.

FIG. 2 is a schematic view showing a form of a coil before winding a wire in the embodiment shown in FIG. 1.

FIG. 3 is a perspective view showing an overall configuration of a transformer device according to the embodiment of the present invention.

FIG. 4 is a conceptual diagram showing a connection relationship between pins and wire materials for coils of the transformer device shown in FIG. 3 when viewed from a back side of the transformer device.

FIG. 5 is a conceptual diagram showing a winding wire relationship between a core and two kinds of wire materials for coils.

FIG. 6 is a graph showing a change in frequency characteristics of passage loss (insertion loss) when a coil twisting pitch is changed with regard to the present embodiment.

FIG. 7 is a graph showing a change in frequency characteristics (primary side) of reflection loss (return loss) when a coil twisting pitch is changed with regard to the present embodiment.

FIG. 8 is a graph showing a change in frequency characteristics (secondary side) of reflection loss (return loss) when a coil twisting pitch is changed in the embodiment.

FIG. 9 is a graph showing a change in frequency characteristics of passage loss (insertion loss) when a coil diameter is changed with regard to the present embodiment.

FIG. 10 is a graph showing a change in frequency characteristics (primary side) of reflection loss (return loss) when a coil diameter is changed with regard to the present embodiment.

FIG. 11 is a graph showing a change in frequency characteristics (secondary side) of reflection loss (return loss) when a coil diameter is changed with regard to the present embodiment.

FIG. 12 is a graph showing a change in frequency characteristics of passage loss (insertion loss) when a coil coating thickness is changed with regard to the present embodiment.

FIG. 13 is a graph showing a change in frequency characteristics (primary side) of reflection loss (return loss) when a coil coating thickness is changed

with regard to the present embodiment.

FIG. 14 is a graph showing a change in frequency characteristics (secondary side) of reflection loss (return loss) when a coil coating thickness is changed with regard to the present embodiment.

FIG. 15 is a schematic view showing a form of a coil before winding a wire in a conventional technology.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] Hereinafter, an embodiment of a transformer device according to the present invention will be described with reference to the drawings described above.

[0026] FIG. 1 is a schematic view showing a configuration of a transformer device according to the present embodiment, and FIG. 2 shows a twisted coil 11 related to FIG. 1 in a state before winding a wire around a core 31.

[0027] As shown in FIG. 2, the twisted coil 11 is formed of a twisted wire formed by intertwisting, into a spiral form, a one-layer insulating wire (for example, a polyurethane enameled wire (such as UEW), ordinarily also referred to as an insulating wire) 11A formed by performing one-layer insulation coating on a conducting wire by a copper material or the like, and a three-layer insulating wire (such as TEX and TIW) 11B formed by performing three-layer insulation coating on the conducting wire by the copper material or the like.

[0028] Thus, the twisted coil 11 is configured in such a manner that individual insulating wires 11A and 11B are intertwisted into the spiral form. Thus, upon winding the twisted coil around the core 31, the individual insulating wires 11A and 11B can be uniformly crossed with magnetic flux. Moreover, two insulating wires 11A and 11B can be processed into almost the same winding state relative to the core 31 in a closer contact state to reduce magnetic leakage flux, and simultaneously impedance in a high-frequency band can be adjusted to a stabilized value.

[0029] The twisted coil 11 is wound around the annular core 31 at a substantially uniform pitch in a state of a twisted wire in which two kinds of insulating wires are intertwisted.

[0030] As the annular core 31, a material ordinarily referred to as a toroidal core (including not only a circular shape, but also an elliptical shape, a barrel shape, a rectangular shape or the like in an annular cross section) is preferably used, but is not necessarily limited to the toroidal core. For example, the core may be a material in which a closed magnetic path is formed by butting a pair of U-shaped cores or a pair of E-shaped cores with each other. In addition, the shape is not limited to a toric shape, and may be formed into a polygonal annular shape.

[0031] A main material of the core include ferrite, permalloy, a silicon steel plate and the like, and a magnetic material other than the material described above can also be used, and a dust core can also be used.

[0032] FIG. 3 is a perspective view showing an overall configuration of a transformer device according to the

present embodiment.

[0033] More specifically, as described above, the transformer device has a transformer body 1 formed by winding a twisted coil 11 formed by intertwisting two kinds of insulating wires around a toroidal core (formed into almost a rectangular shape in a cross section having an annular shape) 31 in a circumferential direction at almost the same pitch, and a bobbin 41 for housing the transformer body 1, and six terminal pins 51(1) to 51(6) which extend from the bobbin 41 in a downward direction in the figure, and are electrically connected hereto in end parts of predetermined insulating wires 11A and 11B of the twisted coil 11.

[0034] The bobbin 41 has left and right step parts (the step part on a deep side (right side in the figure) is hidden by a front wall part 42) 44 formed between the front wall part 42 and a rear wall part 43, a recessed part 46 surrounded on four sides by the front and rear wall parts 42 and 43 and the left and right step parts 44, and a pair of circuit board butting parts 45A and 45B projecting from a bottom part of the recessed part 46 toward a downward direction in the figure.

[0035] Moreover, the transformer device has primary side terminal pins 51(1) to 51(3) which extend from a lower surface of the step part 44 on a left side in the figure in the bobbin 41 to a downward direction in the figure, and are arranged in parallel to each other, and secondary side terminal pins 51(4) to 51(6) which extend from the lower surface of the step part (not shown) 44 on a right side in the figure in the bobbin 41 to the downward direction in the figure, and are arranged in parallel to each other.

[0036] The transformer body 1 is stored therein in such a manner that, in a state in which a central axis extends in a direction of the front and rear wall parts 42 and 43, a part thereof is fitted into the recessed part 46 described above. Moreover, among parts of the twisted coil 11 wound therearound, the end parts of the one-layer insulating wire (such as UEW) 11A being a primary side coil are electrically connected to the terminal pins 51(1) to 51(3), and meanwhile, the end parts of the three-layer insulating wire (such as TEX and TIW) 11B being a secondary side coil are electrically connected to the terminal pins 51(4) to 51(6).

[0037] Moreover, the pair of circuit board butting parts 45A and 45B each are a columnar member long in a front-rear direction and having a bottom surface formed into a planar form, and are formed into almost the same shape. When the transformer device is mounted on a circuit board (not shown), operation of bringing the transformer device to relatively close toward the circuit board is performed by placing the transformer device in a predetermined position. Upon the operation, the terminal pins 51(1) to 51(6) are first passed through through-holes of the circuit board (not shown), and then the bottom surfaces of the circuit board butting parts 45A and 45B are butted on a surface of the circuit board. Thus, relative movement of the transformer device is stopped. More

specifically, a distance between a bottom surface of the bobbin 42 and the surface of the circuit board is regulated by the circuit board butting parts 45A and 45B, and the terminal pins 51(1) to 51(6) are exposed above the surface of the circuit board over a predetermined length from root parts thereof.

[0038] More specifically, a spacing in which the primary side coil and the secondary side coil are to be connected can be secured in the root parts of the terminal pins.

[0039] FIG. 4 shows an arrangement of individual terminal pins 51(1) to 51(6), and a connection state of coils to the terminal pins 51(1) to 51(6) when the terminal pins 51(1) to 51(6) are viewed from a back side of the transformer device shown in FIG. 3. Moreover, FIG. 5 shows a winding state of primary side coils (UEW) 11A1 and 11A2 and secondary side coils (TEX) 11B1 and 11B2 wound around a core 31A.

[0040] In addition, as shown in FIG. 5, the twisted coil 11 to be wound around the core 31A is split into a first twisted coil 111A to be wound around a part on a left side of the core 31A in the figure, and a second twisted coil 111B to be wound around a part on a right side of the core 31A in the figure, and both coils are configured to be electrically coupled to the terminal pin 51(1) in the primary side coil, and to the terminal pin 51(4) in the secondary side coil, respectively.

[0041] The end parts of the one-layer insulating wire (UEW) 11A being the primary side coil are configured to be electrically connected to the terminal pins 51(1) to 51(3), and meanwhile, the end parts of the three-layer insulating wire (TEX) 11B being the secondary side coil are configured to be electrically connected to the terminal pins 51(4) to 51(6).

[0042] More specifically, as shown in FIG. 5 (see FIG. 4), the primary side coil (UEW) 11A1 (first twisted coil 111A) which extends from the terminal pin 51(2) (a symbol S standing for START is provided), and is started in winding the wire around the core 31A is wound around the part on the right side of the core 31A, in the figure, and then connected to the terminal pin 51(1). Meanwhile, the primary side coil (UEW) 11A2 (second twisted coil 111B) is connected to the terminal pin 51(1), in the figure, and wound around the part on the left side of the core 31A, and then connected to the terminal pin 51(3) (a symbol F standing for FINISH is provided).

[0043] Meanwhile, the secondary side coil (TEX) 11B1 (first twisted coil 111A) which extends from the terminal pin 51(6) (a symbol S standing for START is provided), and is started in winding the wire around the core 31A is wound around the part on the left side of the core 31A, in the figure, and then connected to the terminal pin 51(4). Meanwhile, the secondary side coil (TEX) 11B2 (second twisted coil 111B) is connected to the terminal pin 51(4), in the figure, and wound around the part on the right side of the core 31A, and then connected to the terminal pin 51(5) (a symbol F standing for FINISH is provided).

[0044] Incidentally, regarding to what degree a twisting pitch P of the twisted coil 11 should be adjusted, what is

important is whether or not a shape as the twisted coil can be actually kept and whether or not winding work can be efficiently performed.

[0045] If the twisting pitch P of the twisted coil 11 is adjusted to a level less than 3 mm, it becomes hard to maintain a linear shape of the twisted wire, resulting in difficulty in satisfactorily winding the wire around the core 31. On the other hand, if the twisting pitch P of the twisted coil 11 is over 10 mm, it becomes hard to suppress loosening or untwisting of twist during winding the wire for the twisted coil 11, and efficiency of the winding work is significantly reduced.

[0046] Accordingly, from the viewpoints described above, it is preferably to set the twisting pitch P of the twisted coil 11 to the range:

$$3 \text{ mm} \leq P \leq 10 \text{ mm}$$

in efficiently winding the twisted coil 11 around the core 31 in an original shape.

[0047] It is further preferably to set the twisting pitch P to the range:

$$4 \text{ mm} \leq P \leq 9 \text{ mm}$$

[0048] Thus, the working effect described above can be further secured.

[0049] However, in the case where the twisting pitch P of the twisted coil 11 is set in the range of 3 mm or more and 10 mm or less, it is hard to use such a material unless the material can maintain a satisfactory state also in view of the characteristics. Then, in the range in which the twisting pitch P of the twisted coil 11 is 3 mm or more and 10 mm or less, verification has been made on whether or not a satisfactory value can be obtained in view of the characteristics (frequency characteristics of passage loss (insertion loss), frequency characteristics of reflection loss (return loss) (primary side: between terminal pins 51(2) and 51(3)) and frequency characteristics of reflection loss (return loss) (secondary side: between terminal pins 51(5) and 51(6))).

[0050] FIG. 6 represents each graph showing frequency characteristics of passage loss (insertion loss) when a coil twisting pitch P is changed with regard to the present embodiment.

[0051] In the twisted coil 11 being an evaluation object upon obtaining the graph shown in FIG. 6, the twisting pitch P is changed from 3 mm to 10 mm at an increment of 1 mm, and each graph in FIG. 6 to FIG. 8 shows a change in the characteristics for a material having each pitch. In addition, a primary side coil of the twisted coil 11 at this time is a one-layer insulating wire (2UEW: 0.0155 mm-thick) 11A, and a secondary side coil of the twisted coil 11 is a three-layer insulating wire (TEX-E: 0.1 mm-thick) 11B. A coil diameter D is 0.23 mm (the

same in the graphs shown in FIG. 7 and FIG. 8).

[0052] As shown in FIG. 6, verification has been made in such a manner that the frequency characteristics of passage loss (insertion loss) become more satisfactory accordingly as the twisting pitch P is reduced, and are within an allowable range at least in the region from 3 mm to 10 mm in P.

[0053] FIG. 7 represents each graph showing frequency characteristics of reflection loss (return loss) (primary side: between terminal pins 51(2) and 51(3)) when a coil twisting pitch P is changed with regard to the present embodiment.

[0054] As shown in FIG. 7, verification has been made in such a manner that the frequency characteristics of reflection loss (return loss) (primary side) become more satisfactory accordingly as the twisting pitch P is reduced, and are within an allowable range at least in the region from 3 mm to 10 mm.

[0055] FIG. 8 represents each graph showing frequency characteristics of reflection loss (return loss) (secondary side: between terminal pins 51(5) and 51(6)) when a coil twisting pitch P is changed with regard to the present embodiment.

[0056] As shown in FIG. 8, verification has been made in such a manner that the frequency characteristics of reflection loss (return loss) (secondary side) become more satisfactory accordingly as the twisting pitch P is reduced, and are within an allowable range at least in the region from 3 mm to 10 mm.

[0057] Next, verification has been made on a coil diameter D of a conducting wire of insulating wires 11A and 11B of a twisted coil 11 as to whether or not a satisfactory value can be obtained in view of characteristics (frequency characteristics of passage loss (insertion loss), frequency characteristics of reflection loss (return loss) (primary side: between terminal pins 51(2) and 51(3)) and frequency characteristics of reflection loss (return loss) (secondary side: between terminal pins 51(5) and 51(6)), when the diameter is adjusted to an ordinarily used range of 0.20 mm or more and 0.45 mm or less.

[0058] In addition, referring to as the coil diameter in the description of the present application represents a cross sectional diameter of the conducting wire, excluding the insulation coating.

[0059] FIG. 9 represents each graph showing frequency characteristics of passage loss (insertion loss) when a coil diameter D is changed with regard to the present embodiment.

[0060] In a twisted coil 11 being an evaluation object upon obtaining the graph shown in FIG. 9, a coil diameter D is sequentially changed from 0.2 mm to 0.45 mm, and each graph in FIG. 9 to FIG. 11 shows a change in the characteristics for a material having each diameter.

[0061] In addition, a primary side coil of the twisted coil 11 at this time is a one-layer insulating wire (2UEW: 0.0155 mm-thick), and a secondary side coil of the twisted coil 11 is a three-layer insulating wire (TEX-E: 0.1000 mm-thick), and a twisting pitch P of the twisted coil 11 is

5 mm (the same in the graphs shown in FIG. 10 and FIG. 11).

[0062] As shown in FIG. 9, verification has been made in such a manner that the frequency characteristics of passage loss (insertion loss) become more satisfactory accordingly as the coil diameter D is increased, and are within an allowable range at the coil diameter D at least in the region from 0.2 mm to 0.45 mm.

[0063] FIG. 10 represents each graph showing frequency characteristics of reflection loss (return loss) (primary side: between terminal pins 51(2) and 51(3)) when a coil diameter D is changed with regard to the present embodiment.

[0064] As shown in FIG. 10, verification has been made in such a manner that the frequency characteristics of reflection loss (return loss) (primary side) become more satisfactory accordingly as the coil diameter D is increased, and are within an allowable range at least in the region from 0.2 mm to 0.45 mm.

[0065] FIG. 11 represents each graph showing frequency characteristics of reflection loss (return loss) (secondary side: between terminal pins 51(5) and 51(6)) when a coil diameter D is changed with regard to the present embodiment.

[0066] As shown in FIG. 11, verification has been made in such a manner that the frequency characteristics of reflection loss (return loss) (secondary side) become more satisfactory accordingly as the coil diameter D is reduced, and are within an allowable range at least in the region from 0.2 mm to 0.45 mm.

[0067] Next, with regard to a coating thickness (thickness of an insulating material coating a circumference of a metal conducting wire) T of the twisted coil 11, either 1UEW (0.0230 mm-thick) or 2UEW (0.0155 mm-thick) each ordinarily used is selected for a primary side coil, and either TEX-E (0.1000 mm-thick) or TIW-2 (0.1200 mm-thick) each ordinarily used is selected for a secondary side coil, and a total coating thickness T has been set by combining coating thicknesses of individual insulating wires 11A and 11B selected. Thus, with regard to the coating thickness T, a combination of TEX-E (0.1000 mm-thick) and 1UEW (0.0230 mm-thick) results in a thickness of 0.1230 mm, a combination of TEX-E (0.1000 mm-thick) and 2UEW (0.0155 mm-thick) results in a thickness of 0.1155 mm, a combination of TIW-2 (0.1200 mm-thick) and 1UEW (0.0230 mm-thick) results in a thickness of 0.1430 mm, and a combination of TIW-2 (0.1200 mm-thick) and 2UEW (0.0155 mm-thick) results in a thickness of 0.1355 mm.

[0068] More specifically, verification has been made as to whether or not a satisfactory value can be obtained by measuring four twisted coils 11 in which a coating thickness T is changed as an object to be measured in view of characteristics (frequency characteristics of passage loss (insertion loss), frequency characteristics of reflection loss (return loss) (primary side: between terminal pins 51(2) and 51(3)) and frequency characteristics of reflection loss (return loss) (secondary side: between

terminal pins 51(5) and 51(6)), when the coating thickness T is adjusted in the range of 0.1155 mm or more and 0.1430 mm or less.

[0069] FIG. 12 represents each graph showing frequency characteristics of passage loss (insertion loss) when a coil coating thickness T is changed with regard to the present embodiment. In the twisted coil 11 being an evaluation object upon obtaining the graph shown in FIG. 12, a coil coating thickness T is changed from 0.1155 mm to 0.1430 mm in four stages, and the graph in FIG. 12 shows each change in the characteristics for a material having each thickness.

[0070] In addition, a twisting pitch P of the twisted coil 11 at this time is 5 mm and a coil diameter D is 0.20 mm (the same in the graphs shown in FIG. 13 and FIG. 14).

[0071] As shown in FIG. 12, verification has been made in such a manner that the frequency characteristics of passage loss (insertion loss) become more satisfactory accordingly as the coil coating thickness T is reduced, and are within an allowable range at least in the region from 0.1155 mm to 0.1430 mm.

[0072] FIG. 13 represents each graph showing frequency characteristics of reflection loss (return loss) (primary side: between terminal pins 51(2) and 51(3)) when a coil coating thickness T is changed with regard to the present embodiment.

[0073] As shown in FIG. 13, verification has been made in such a manner that the frequency characteristics of reflection loss (return loss) (primary side) become more satisfactory accordingly as the coil coating thickness T is reduced, and are within an allowable range at least in the region from 0.1155 mm to 0.1430 mm.

[0074] FIG. 14 represents each graph showing frequency characteristics of reflection loss (return loss) (secondary side: between terminal pins 51(5) and 51(6)) when a coil coating thickness T is changed with regard to the present embodiment.

[0075] As shown in FIG. 14, verification has been made in such a manner that the frequency characteristics of reflection loss (return loss) (secondary side) become more satisfactory accordingly as the coil coating thickness T is reduced, and are within an allowable range at least in the region from 0.1155 mm to 0.1430 mm.

[0076] As described above, the embodiment of the present invention is described, but the present invention is not limited to the material in the embodiment described above, and the embodiments can be modified in various manners.

[0077] For example, all of the coil twisting pitch P, the coil diameter D and the coil coating thickness T are preferably set to set values verified in the embodiment for the twisted coil 11 described above. However, even if one or two of the elements are out of the verified range, the transformer device can have satisfactory characteristics to a certain degree.

[0078] Moreover, constituent materials of the core, the conducting wire of the coil, the bobbin and the insulation coating are not limited to the materials in the embodiment

described above, and various other materials can be used.

[0079] The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. A transformer device to be mounted in a LAN for networking, in which a wire material for a primary coil and a wire material for a secondary coil are wound around an annular core to allow a signal component to pass from the wire material for the primary coil to the wire material for the secondary coil, wherein the wire material for the primary coil is formed of a one-layer insulating wire material and the wire material for the secondary coil is formed of a three-layer insulating wire material, respectively, and a twisted wire formed by intertwisting the two insulating wire materials is wound around the core.
2. The transformer device according to claim 1, wherein the annular core is formed into a toroidal core.
3. The transformer device according to claim 1, wherein the annular core is processed into a material in which a closed magnetic path is formed by combining a pair of U-shaped cores or a pair of E-shaped cores.
4. The transformer device according to any one of claims 1 to 3, wherein the twisted wire is split into a first split wire to be wound around a part on one side of the core and a second split wire to be wound around a part on the other side of the core, and the first split wire and the second split wire are electrically bonded thereto in a first terminal pin in the wire material for the primary coil and in a second terminal pin in the wire material for the secondary coil, respectively.
5. The transformer device according to any one of claims 1 to 4, wherein a twisting pitch of a twisted wire between the one-layer insulating wire material and the three-layer insulating wire material is adjusted to 3 mm or more and 10 mm or less.
6. The transformer device according to any one of claims 1 to 4, wherein a twisting pitch of the twisted wire between the one-layer insulating wire material and the three-layer insulating wire material is adjusted to 4 mm or more and 9 mm or less.
7. The transformer device according to any one of

claims 1 to 6, wherein a wire diameter of each of a conducting wire of the one-layer insulating wire and the three-layer insulating wire which constitute the twisted wire is adjusted to 0.2 mm or more and 0.45 mm or less.

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8. The transformer device according to any one of claims 1 to 7, wherein a total thickness of a coating member of the one-layer insulating wire material and a coating member of the three-layer insulating wire material each interposed between individual conducting wires of the wire material for the primary coil and the wire material for the secondary coil which constitute the twisted wire is adjusted to 0.1155 mm or more and 0.1430 mm or less.

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FIG. 1

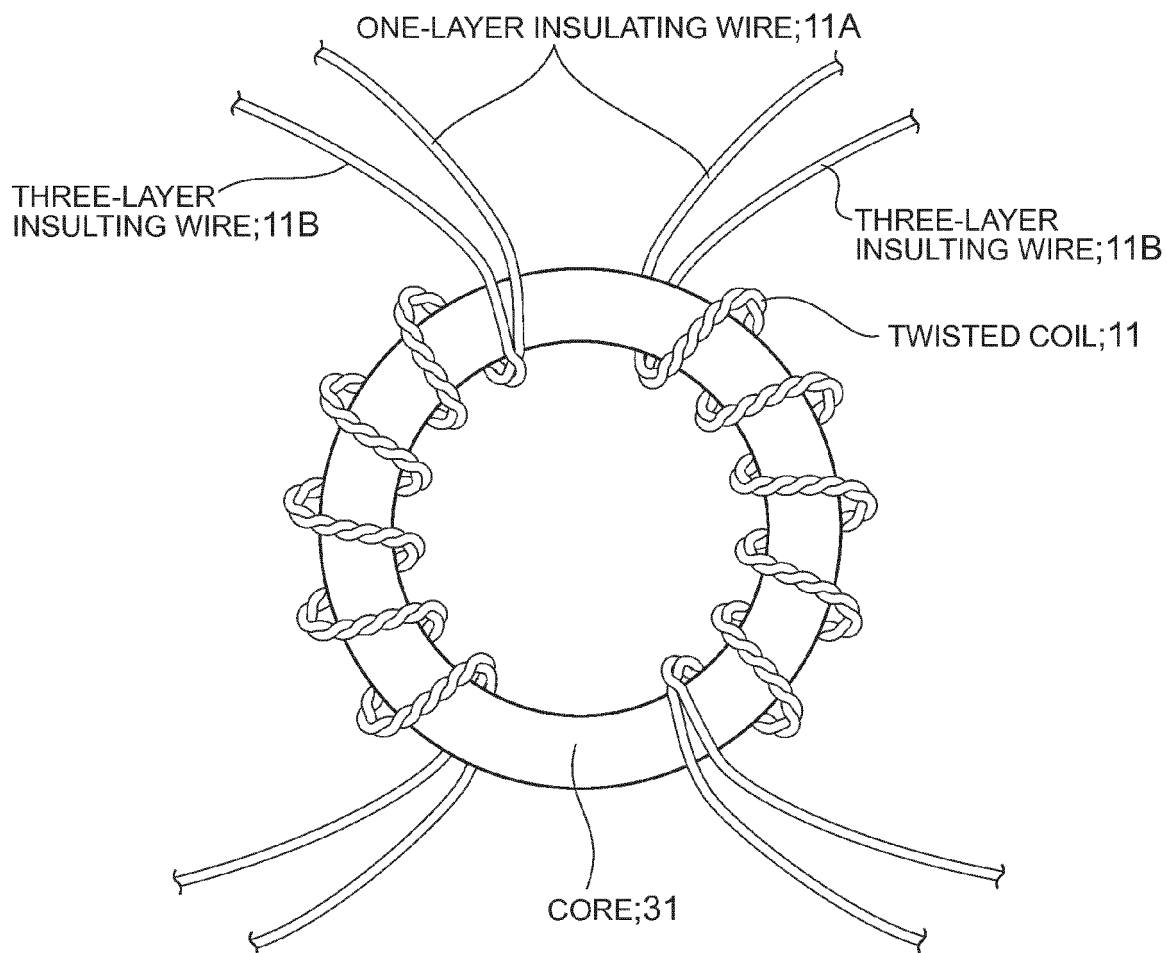


FIG. 2

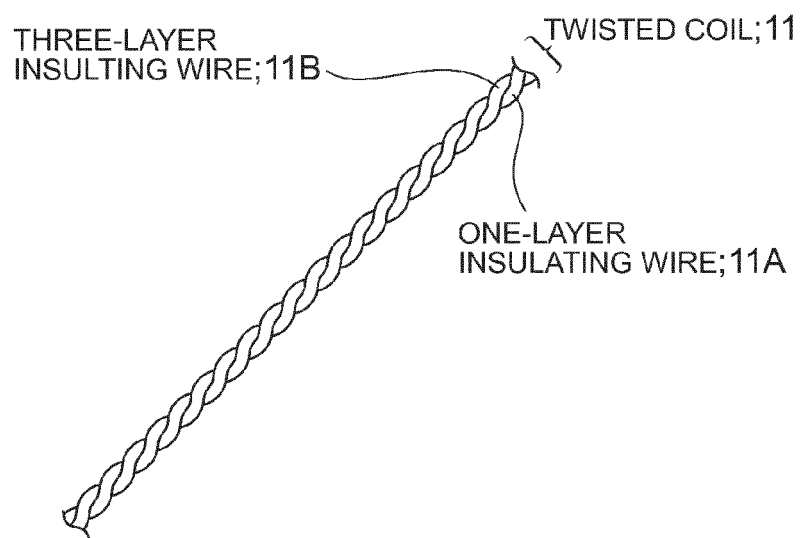


FIG. 3

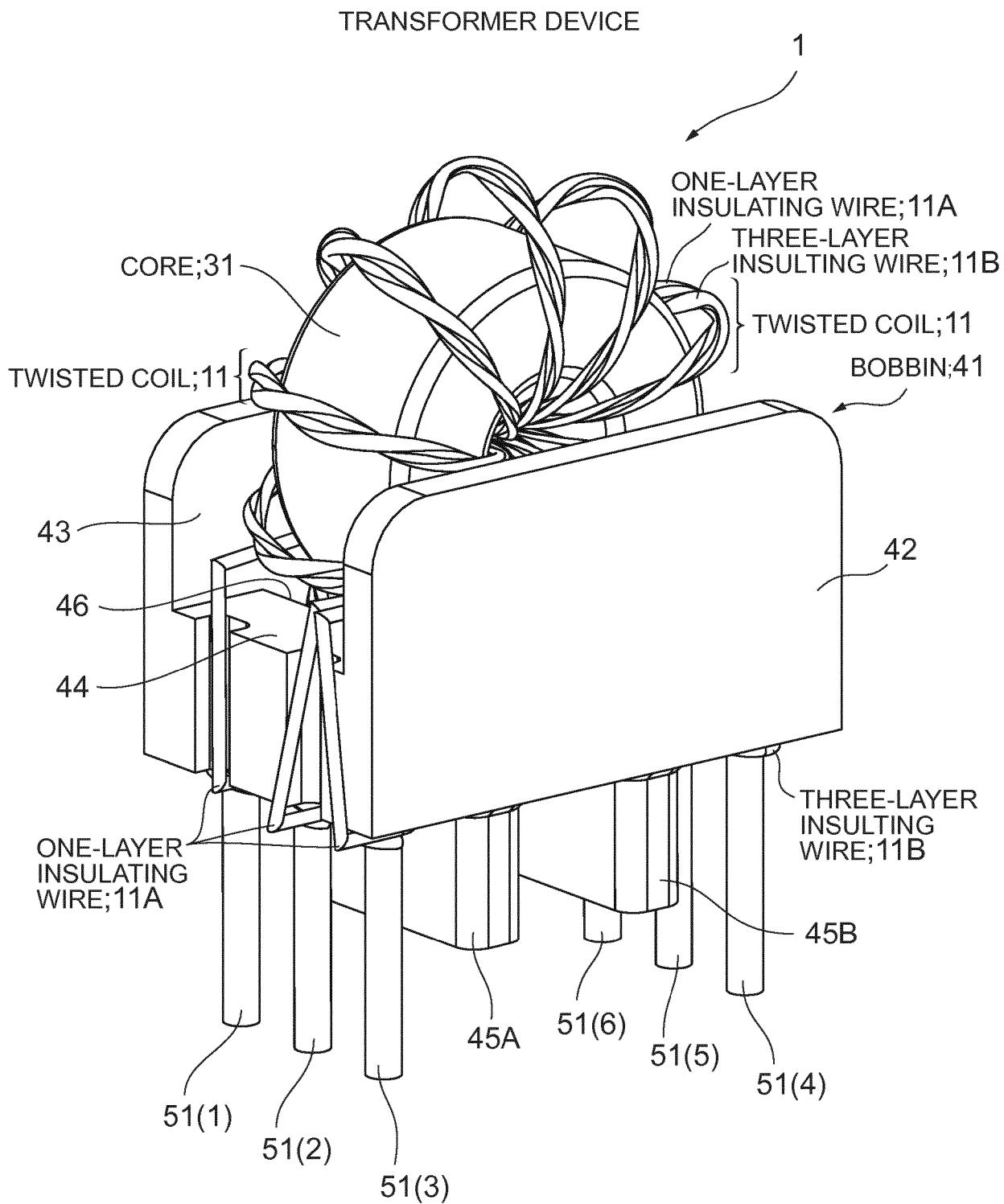


FIG. 4

CONNECTION DIAGRAM (BACK SIDE)

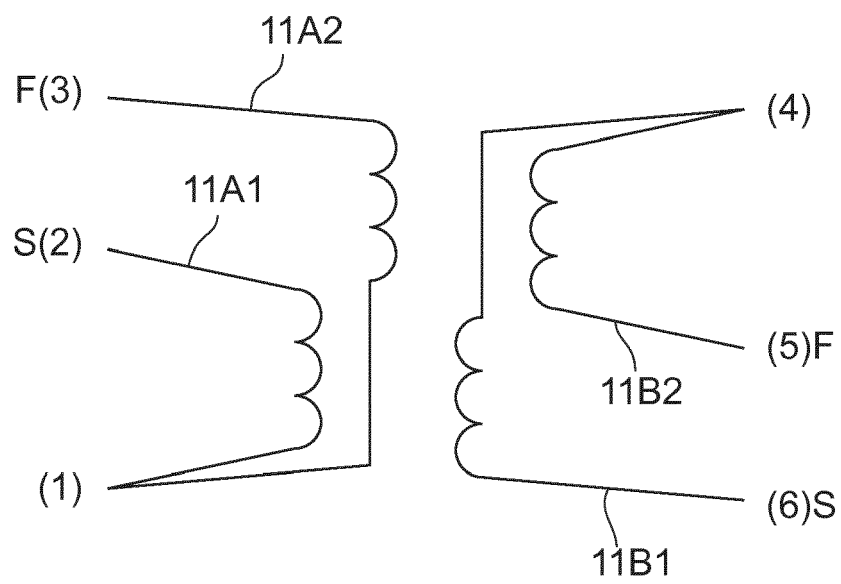


FIG. 5

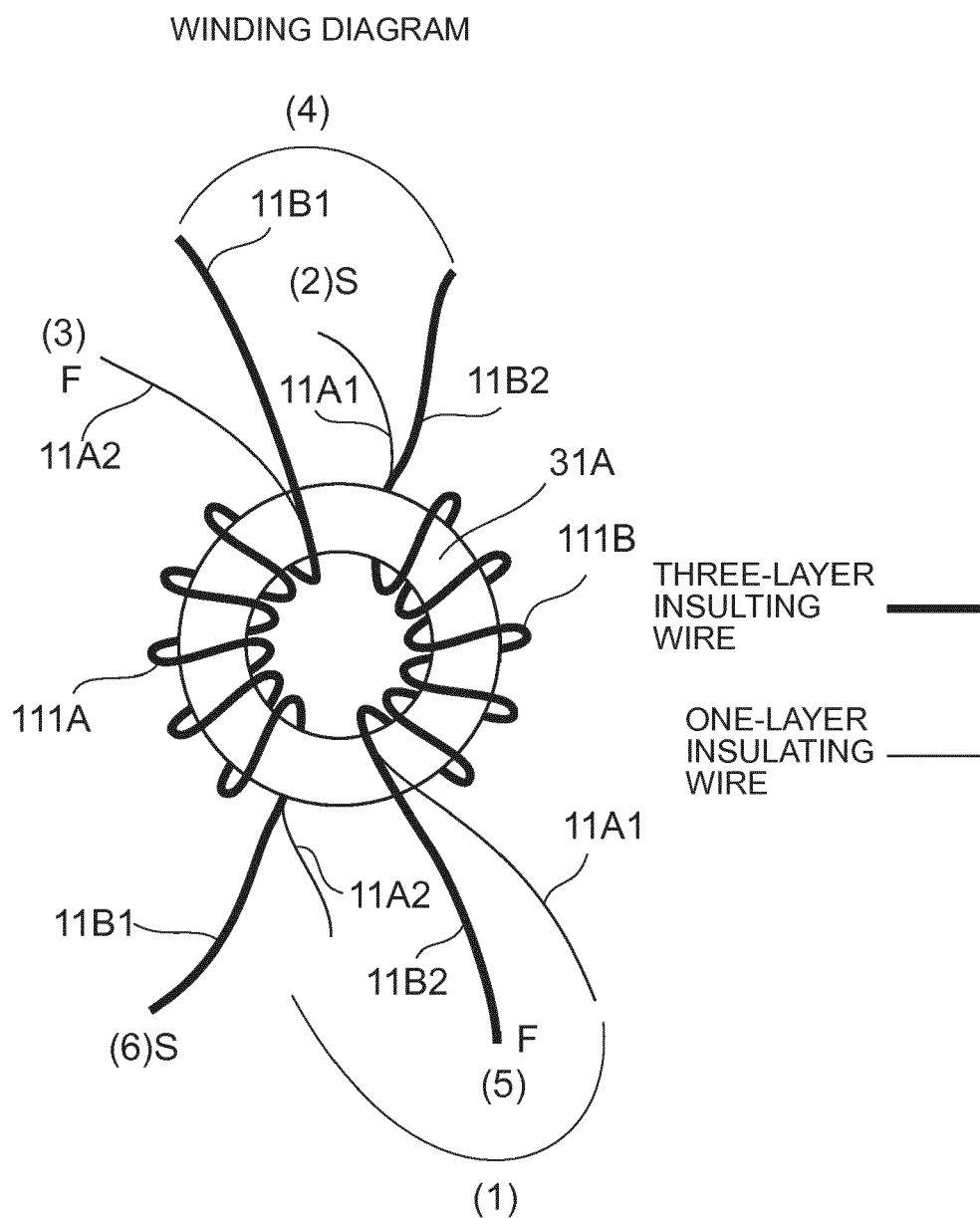


FIG. 6

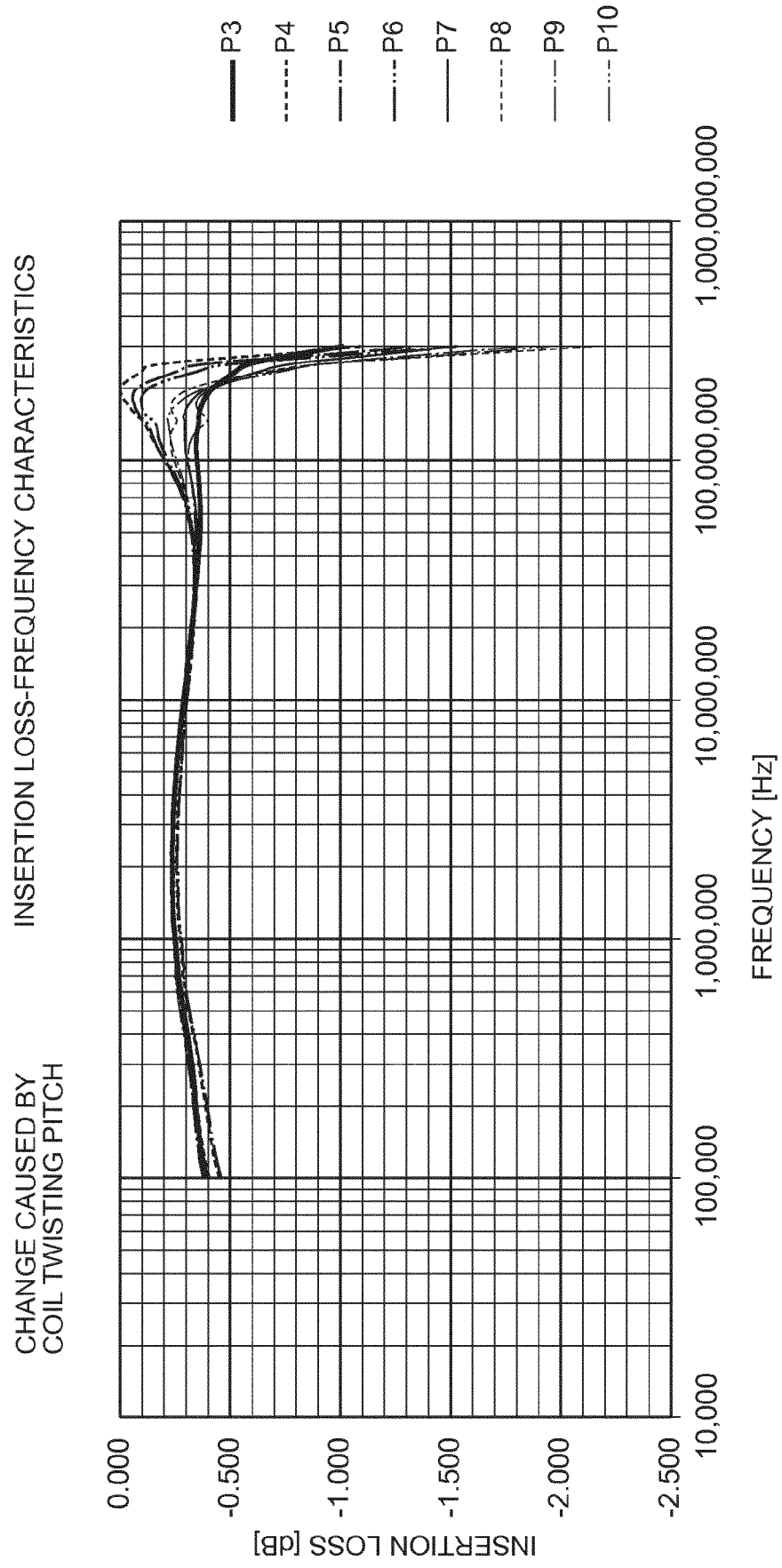


FIG. 7

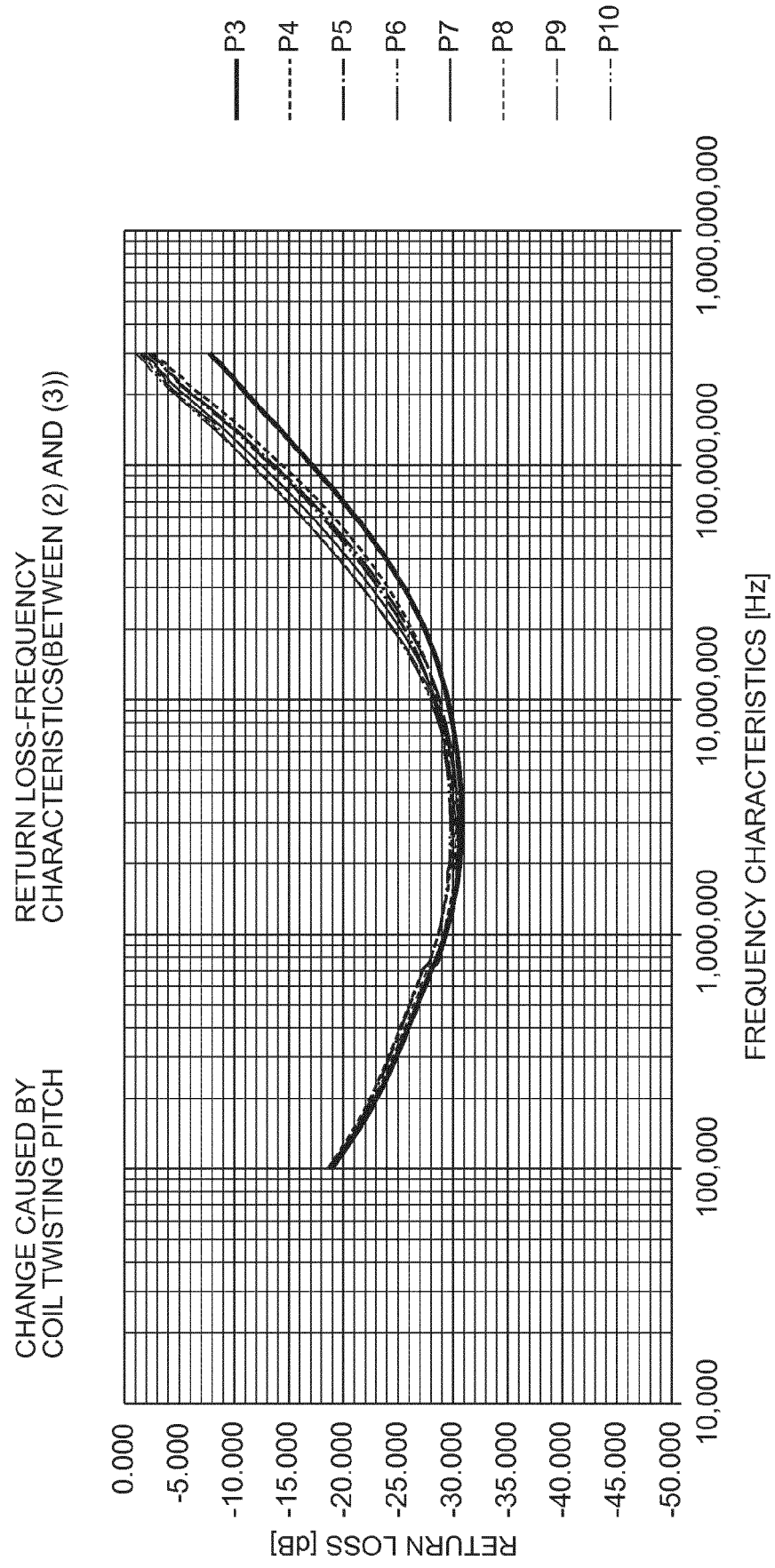


FIG. 8

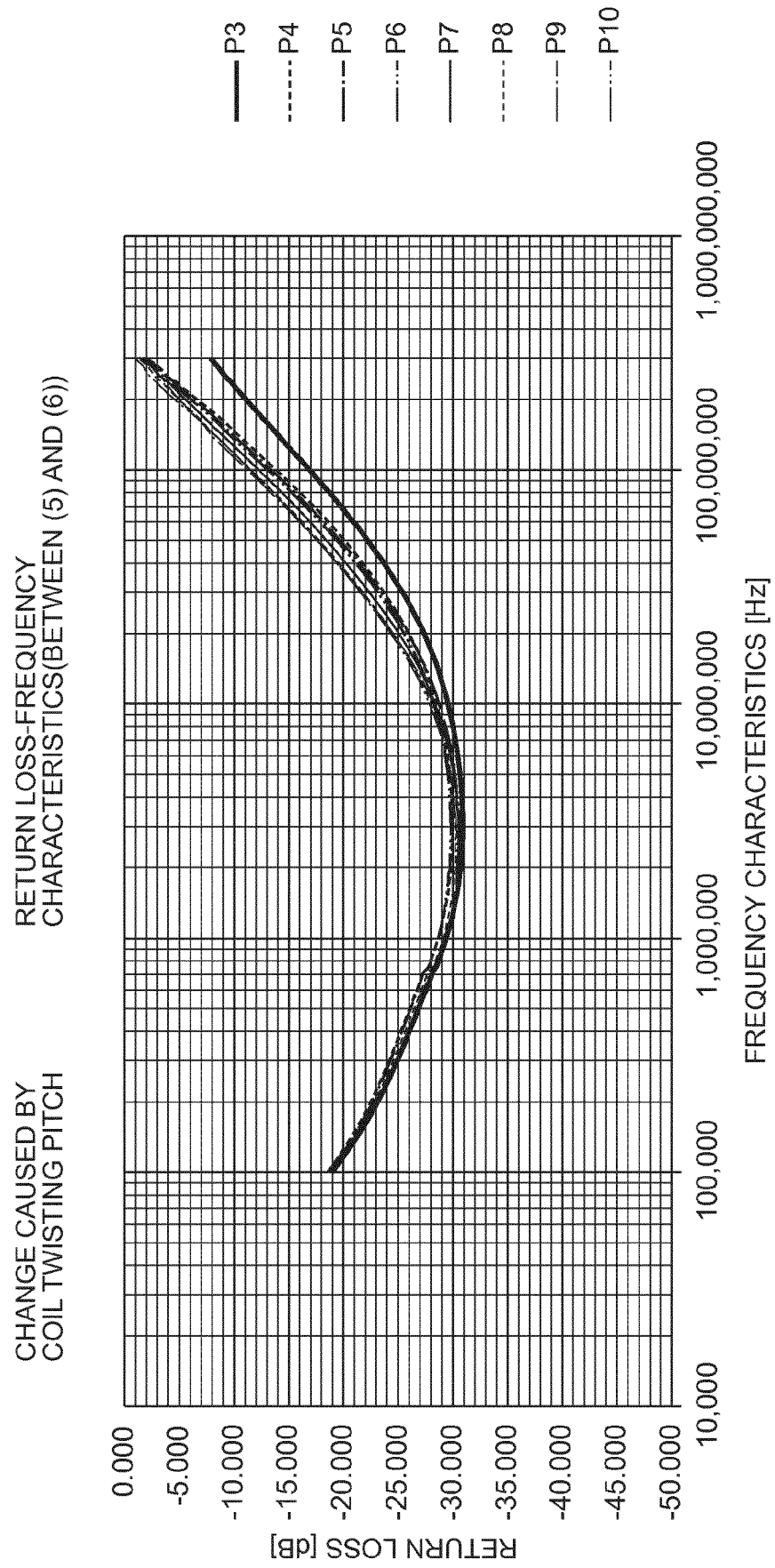


FIG. 9

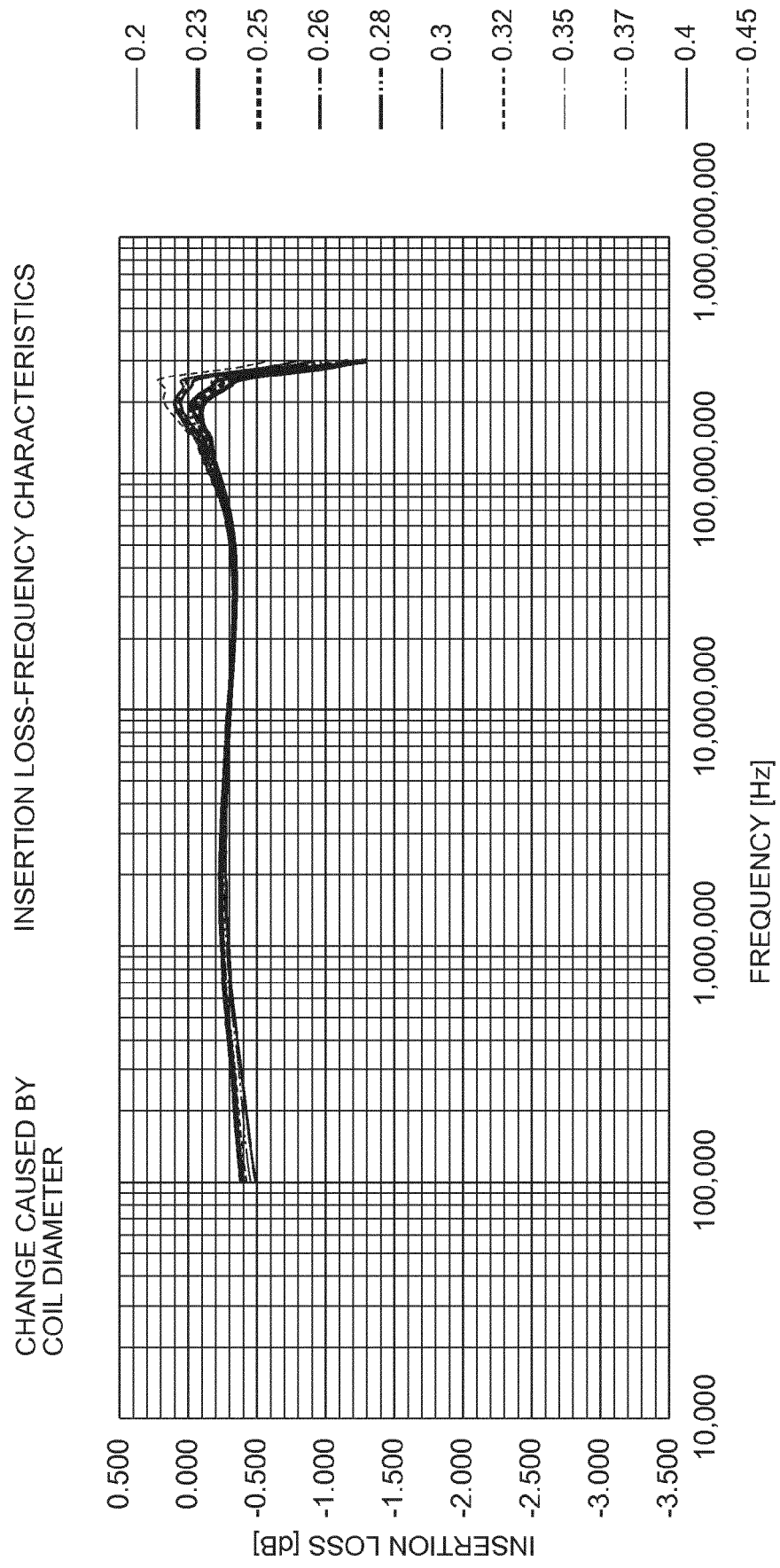


FIG. 10

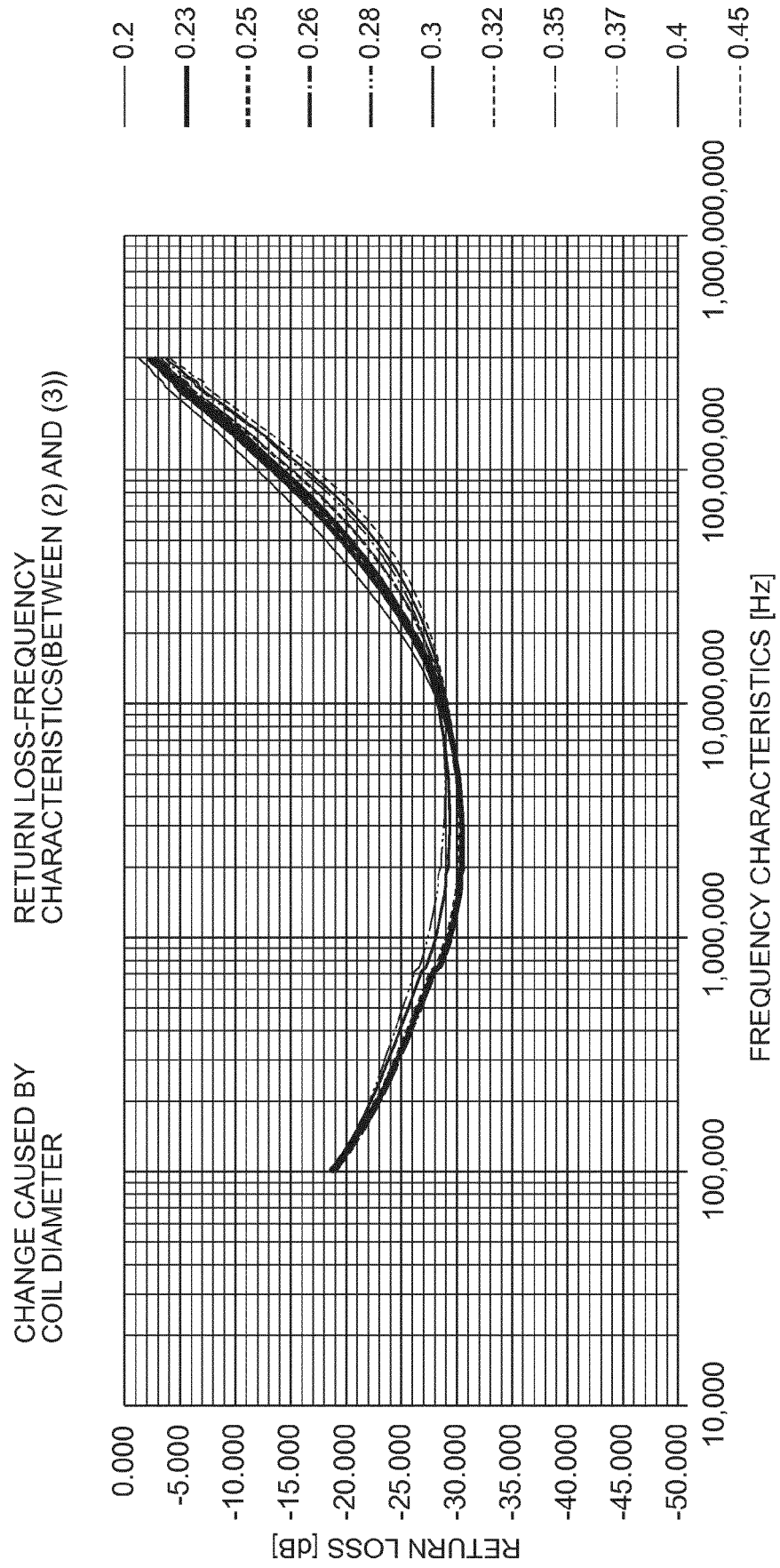


FIG. 11

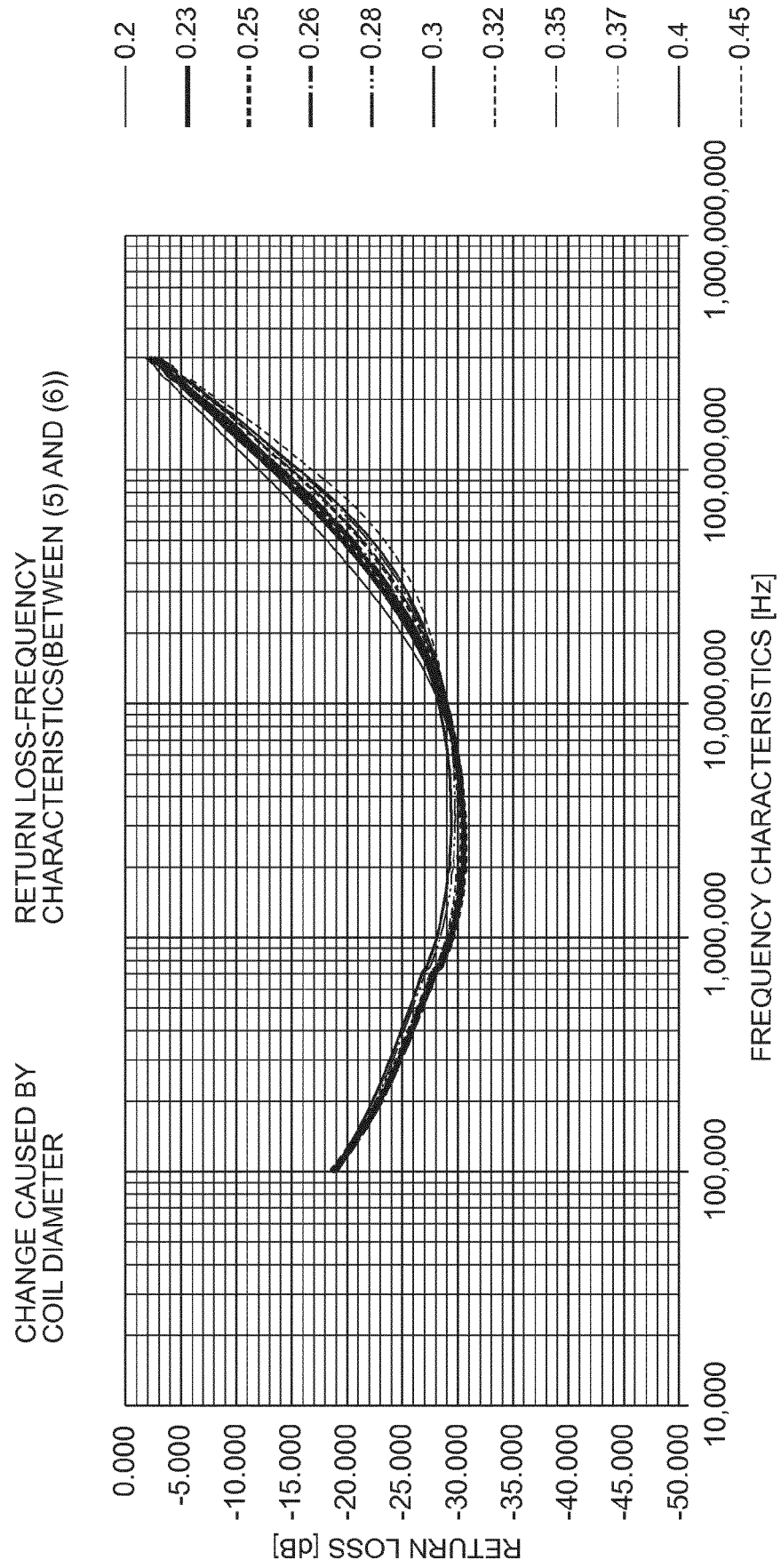


FIG. 12

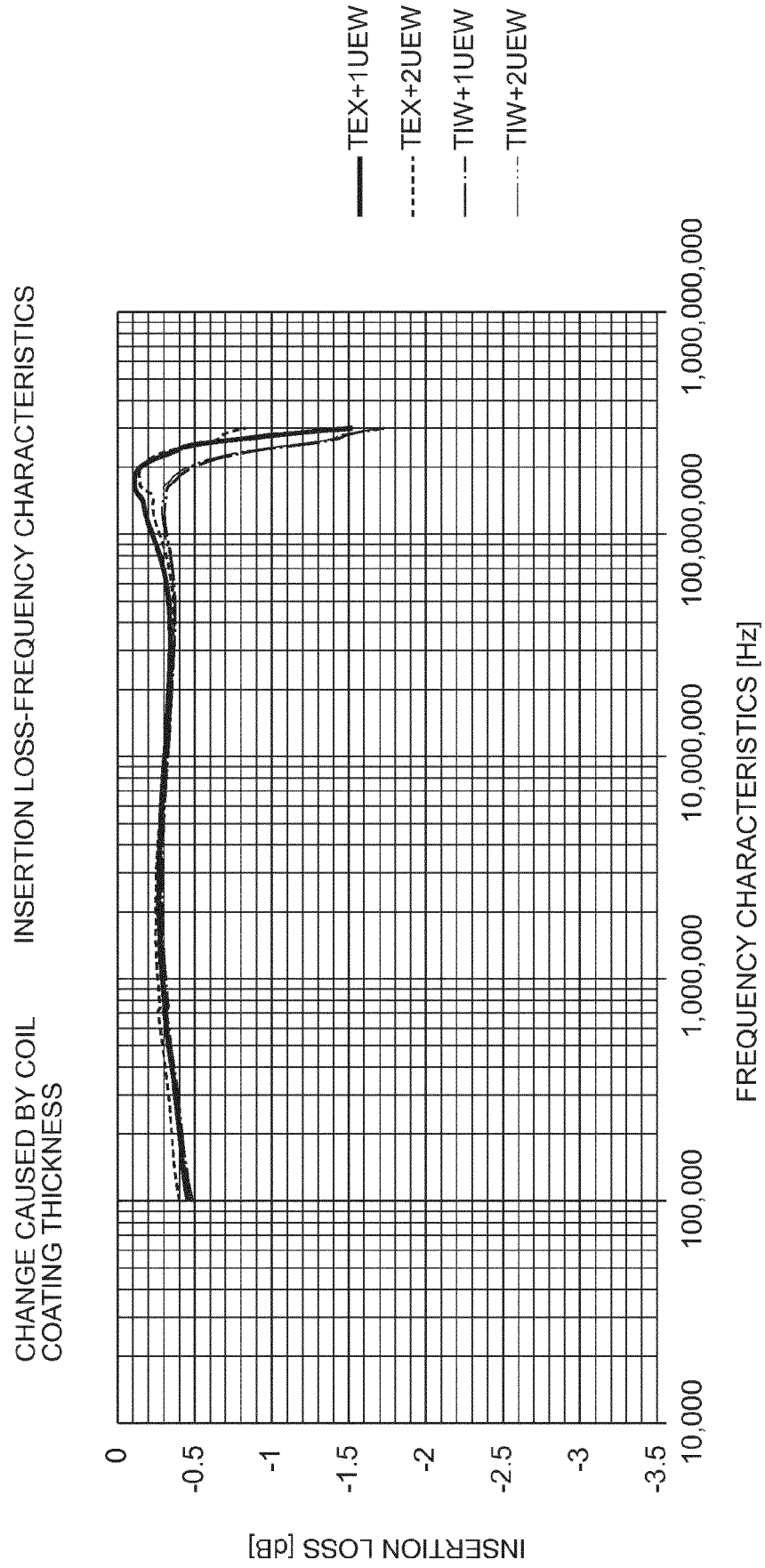


FIG. 13

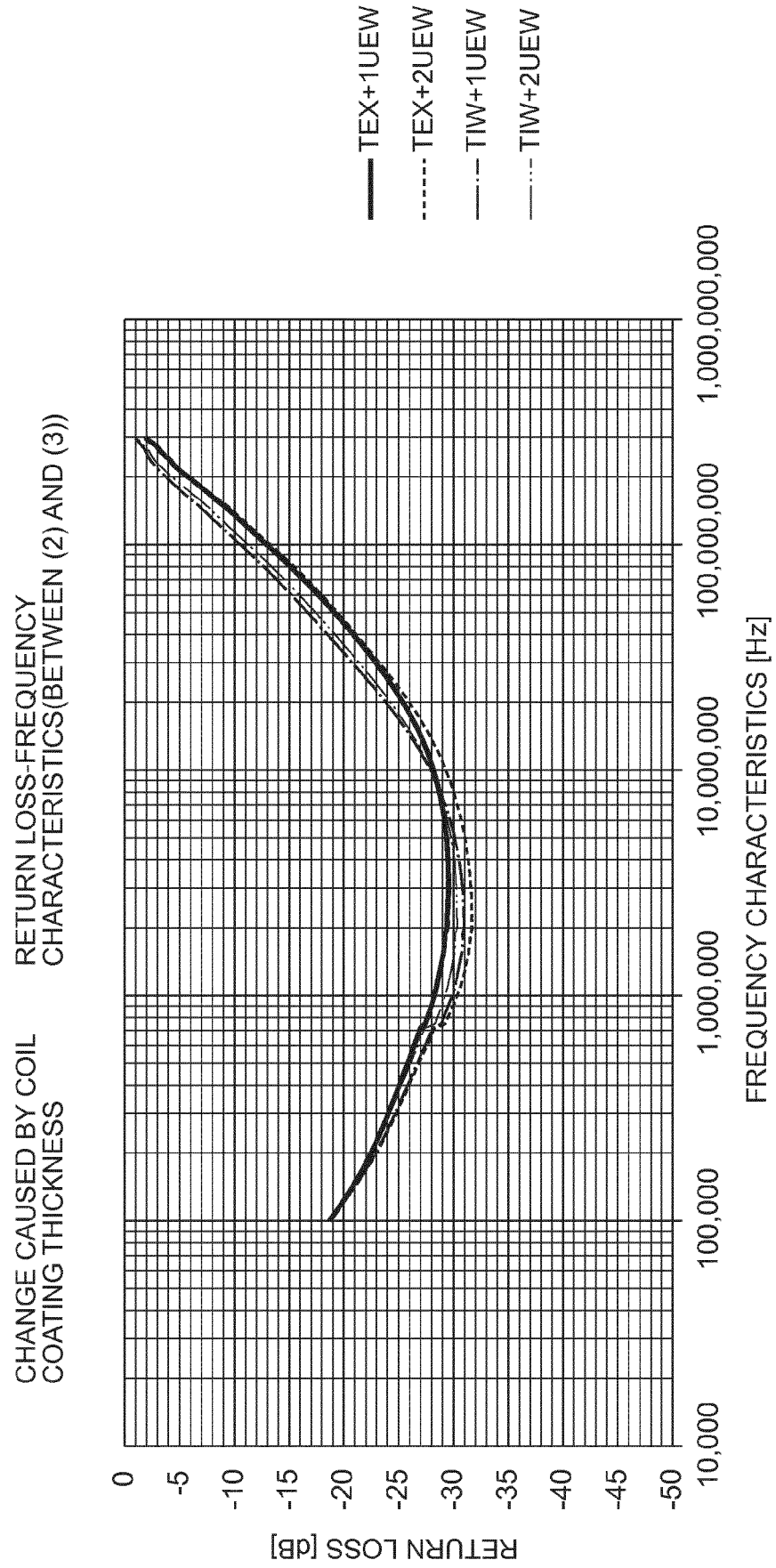


FIG. 14

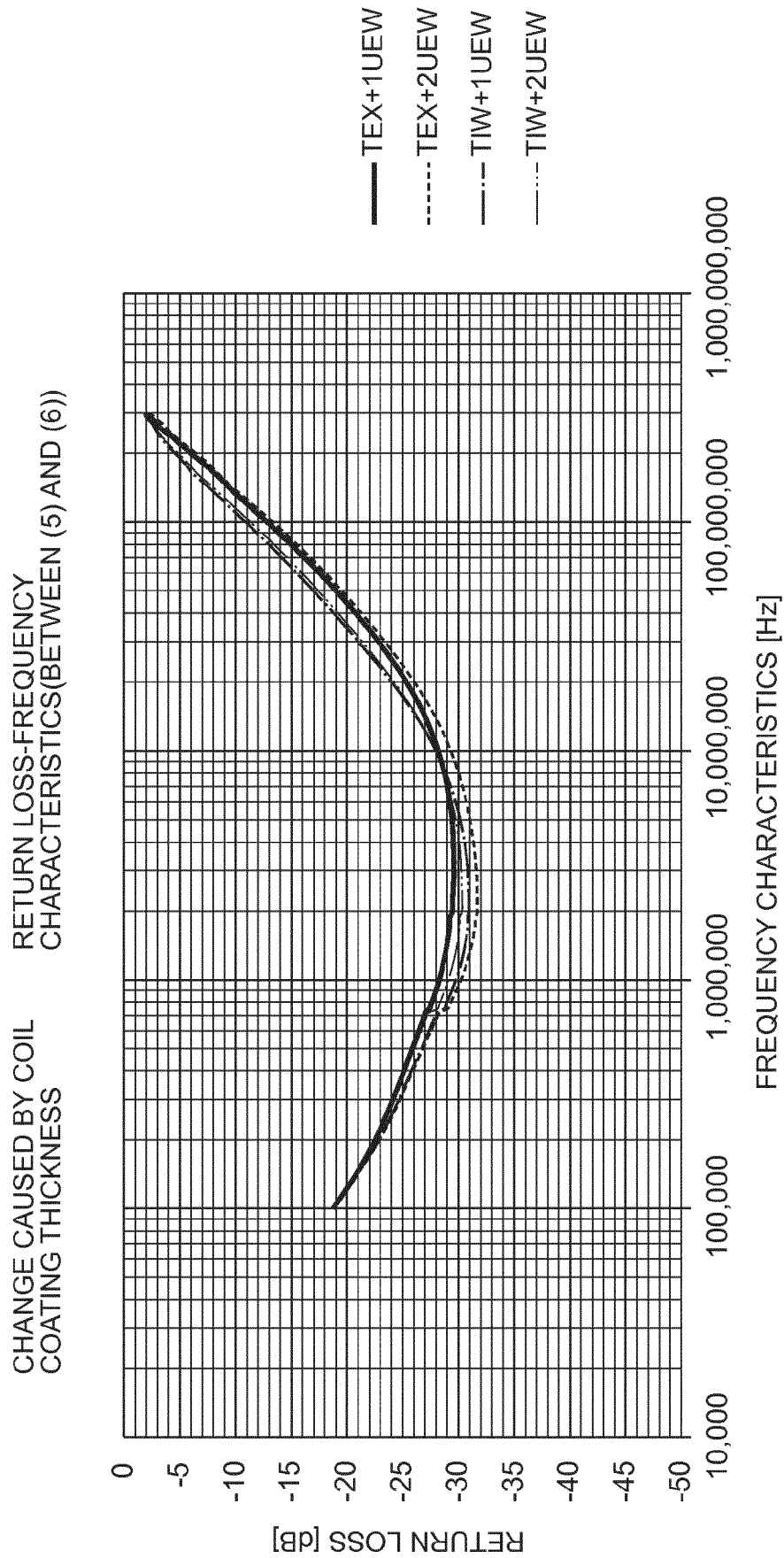
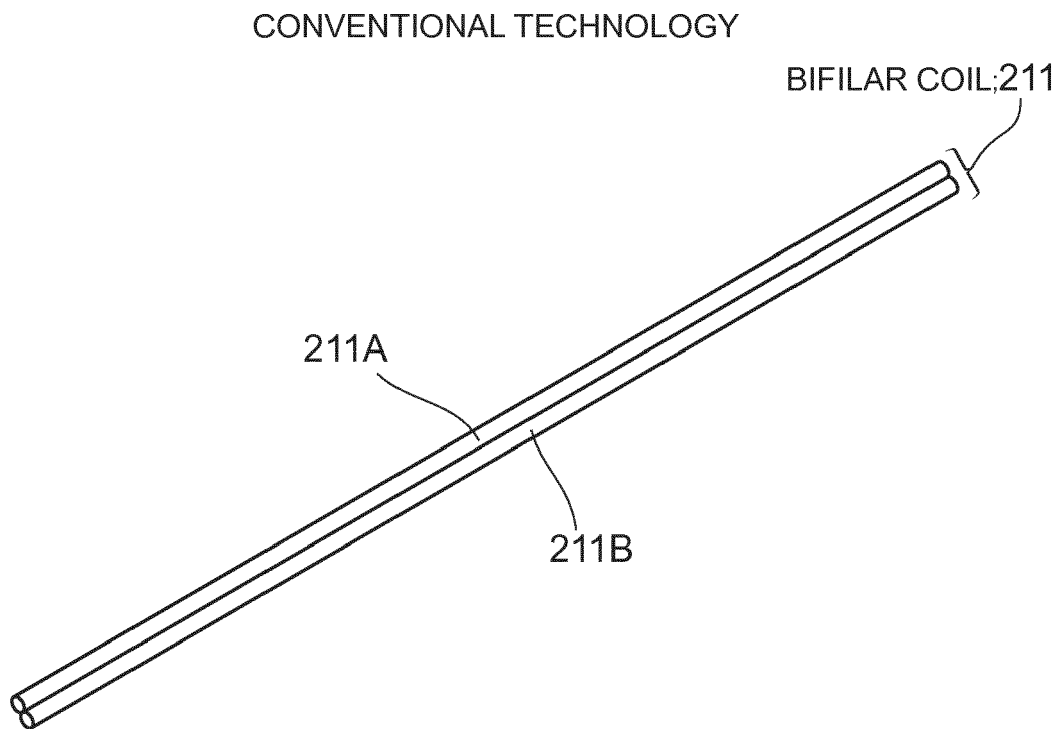


FIG.15





EUROPEAN SEARCH REPORT

Application Number
EP 18 16 2449

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			H01F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 August 2018	Examiner Weisser, Wolfgang
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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

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