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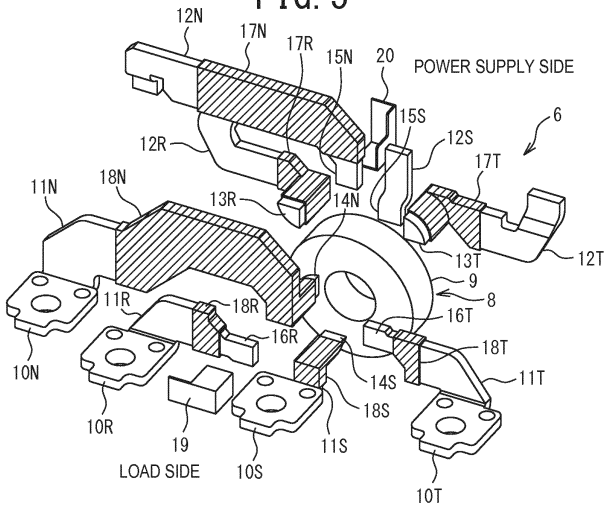
(54) LEAKAGE CURRENT DETECTION UNIT AND LEAKAGE CURRENT BREAKER

(57) To provide an earth leakage detection unit and an earth leakage breaker that make processing of conductor members easy, enable miniaturization of a device, and, in particular, excel in assemblability. Load side conductors (11T to 11N) and power supply side conductors (12T to 12N) are arranged on the one side and the other side in the axial direction of a zero-phase current transformer (8), respectively, so that through conductor portions (14S, 14N) and through conductor portions (13N, 13R) each of which are continuously fixed penetrate an annular core (9) from the one side and the other side in the axial direction of the zero-phase current transformer (8), respectively. With this configuration, the through conductor portions (13T, 13R, 14S, 14N) are jointed to joining portions (16T, 16R, 15S, 15N), and the power supply side conductors (12T to 12N) and the load side conductors (11T to 11N) are connected for each phase. Insulating coating portions (18S, 18N, 17R) are formed at least on the outsides of portions of the through conductor portions continuously fixed to the load side conductors and the power supply side conductor.

FIG. 5



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Description

Technical Field

[0001] The present invention relates to an earth leakage detection unit that is arranged between a power source and a load to detect an earth leakage on the load side and an earth leakage breaker that breaks a circuit when an earth leakage occurs, and in particular to an earth leakage detection unit and an earth leakage breaker that are suitable for a case in which a zero-phase current transformer is used for earth leakage detection.

Background Art

[0002] A zero-phase current transformer is, as is well known, a device to send currents of all phases through the inner hole of an annular core and, when a so-called secondary current is produced on the annular core, judge that an earth leakage (earth fault) has occurred, and what sends a current between a power supply and a load through the inner hole of the annular core is an earth leakage breaker. The earth leakage breaker is, in general, equipped with an over-current tripping device to break a circuit when an over-current (short circuit) is produced on the load side, together with a leakage tripping device to break a circuit when an earth leakage is detected by an earth leakage detection unit including an earth leakage detection circuit. When an earth leakage or an over-current is produced, the leakage tripping device or the over-current tripping device breaks circuits by opening contacts for a power supply side circuit in an open-close mechanism. Such earth leakage breakers and earth leakage detection units include, for example, earth leakage detection units disclosed in PTL 1 and PTL 2, which will be described below. In the earth leakage detection unit disclosed in PTL 1 among the earth leakage detection units, plate-like power supply side conductors corresponding to respective phases of a power supply side circuit are arranged on the one side in the axial direction of a zero-phase current transformer. On the other side in the axial direction of the zero-phase current transformer, plate-like load side conductors corresponding to respective phases of load side terminals are arranged. Round rod-like through conductors for all phases are disposed so as to penetrate an annular core of the zero-phase current transformer and pushed against the corresponding power supply side conductors and load side conductors. With this configuration, the power supply side conductors and the load side conductors are connected to each other with respect to each phase with the through conductors penetrating the zero-phase current transformer, and insulation between respective phases is maintained by filling interspaces between the conductors of respective phases with insulating resin, such as silicon and epoxy, and curing the insulating resin. In the earth leakage detection unit disclosed in PTL 2, each plate-like power supply side conductor and each plate-like load side conductor are interconnected by a plate-like through conductor in one body in a bifurcated manner in advance, and insulation portions are formed through coating processing with respect to each phase. Then, the conductor members are inserted into an annular core of a zero-phase current transformer in such a way as to stride over the annular core to be assembled into a circuit.

Citation List

Patent Literature

[0003]

PTL 1: JP 3704885 B2
PTL 2: JP 4736949 B2

Summary of Invention

Technical Problem

[0004] However, both the earth leakage detection unit disclosed in the afore-described PTL 1 and the earth leakage detection unit disclosed in the afore-described PTL 2 have room for improvement in assemblability. For example, in the earth leakage detection unit disclosed in the afore-described PTL 1, since interspaces are required to be filled with insulating resin with the power supply side conductors and the load side conductors being connected by the through conductors with respect to each phase, all conductors are required to be positioned accurately. Since bubbles and cracks developing in the insulating resin with which interspaces are filled cause a degradation in the insulation, it is also required to prevent such bubbles and cracks from developing. In the earth leakage detection unit disclosed in the afore-described PTL 2, since it is required to insert conductor members formed in a bifurcated shape through the annular core of the zero-phase current transformer in such a way that the conductor members stride over the annular core, not only assembling itself is troublesome, but also processing and forming of the conductor members are complicated. Moreover, it is required to enlarge the inner hole of the annular core to insert the conductor members formed in a bifurcated shape into the annular core, which results in a possibility that the zero-phase current transformer and the earth leakage detection unit also become large.

[0005] The present invention is made to solve the above-described problems, and an object of the present invention is to provide an earth leakage detection unit and an earth leakage breaker that make processing of conductor members easy, enable miniaturization of a device, and, in particular, excel in assemblability.

Solution to Problem

[0006] In order to solve the above-described problems,

according to one aspect of the present invention, there is provided an earth leakage detection unit in which load side conductors are arranged on either one side in an axial direction of a zero-phase current transformer, corresponding to respective phases of load side terminals. Power supply side conductors are arranged on the other side in the axial direction of the zero-phase current transformer, corresponding to respective phases of a power supply side circuit. A through conductor portion(s) corresponding to one phase or two phase is/are continuously fixed to either one(s) of a load side conductor(s) among the load side conductors and a power supply side conductor(s) among the power supply side conductors. Through conductor portions corresponding to the other phases are continuously fixed to the other ones of the other load side conductors and the other power supply side conductors. Each of through conductor portions penetrates the annular core of the zero-phase current transformer to be joined to a joining portion of one of the load side conductors and the power supply side conductors that has a corresponding phase and to which any one of the through conductor portions is not continuously fixed. Each of insulating coating portions is formed at least on the outside of a portion of the through conductor portion continuously fixed to one of the load side conductors and the power supply side conductors at which one of the through conductor portions is continuously fixed.

[0007] In the earth leakage detection unit, the annular core of the zero-phase current transformer may be perfectly circular, and shapes of cross-sections of the through conductor portions orthogonal to the axis of the zero-phase current transformer may be sectors.

[0008] In the earth leakage detection unit, the annular core of the zero-phase current transformer may be oval, shapes of cross-sections of the through conductor portions orthogonal to the axis of the zero-phase current transformer may be a combination of sectors and quadrilaterals.

[0009] In the earth leakage detection unit, on either side or each of both sides in the axial direction of the zero-phase current transformer, an insulating plate member may be interposed between a joining portion of one of the load side conductors and a joining portion of one of the power supply side conductors in proximity to each other.

[0010] According to another aspect of the present invention, there is provided an earth leakage breaker comprising: an open-close mechanism for contacts of a power supply side circuit mounted in a main-body case; an over-current tripping device mounted in the main-body case; and a leakage tripping device mounted in the main-body case. The leakage tripping device includes a combination of an earth leakage detection unit and a trip coil unit. In the earth leakage detection unit, load side conductors are arranged on either one side in an axial direction of a zero-phase current transformer, corresponding to respective phases of load side terminals. Power supply side conductors are arranged on the other side in the axial direction of the zero-phase current transformer, corresponding to respective phases of a power supply side circuit. A through conductor portion(s) corresponding to one phase or two phase is/are continuously fixed to either one(s) of a load side conductor(s) among the load side conductors and a power supply side conductor(s) among the power supply side conductors. Through conductor portions corresponding to the other phases are continuously fixed to the other ones of the other load side conductors and the other power supply side conductors. Each of through conductor portions penetrates the annular core of the zero-phase current transformer to be joined to a joining portion of one of the load side conductors and the power supply side conductors that has a corresponding phase and to which any one of the through conductor portions is not continuously fixed. Each of insulating coating portions is formed at least on the outside of a portion of the through conductor portion continuously fixed to one of the load side conductors and the power supply side conductors at which one of the through conductor portions is continuously fixed.

Advantageous Effects of Invention

[0011] In consequence, according to an earth leakage detection unit and an earth leakage breaker of the present invention, load side conductors and power supply side conductors are arranged on the one side and the other side in the axial direction of a zero-phase current transformer, respectively, in such a way that continuously fixed through conductor portions penetrate an annular core from the one side or the other side in the axial direction of the zero-phase current transformer. With this configuration, since each through conductor portion is joined to a joining portion of one of the load side conductors and the power supply side conductors that has a corresponding phase and to which the through conductor portion is not continuously fixed, the load side conductors and the power supply side conductors are connected to each other with respect to each phase. At this time, insulating coating portions are formed on the outsides of portions of the through conductor portions continuously fixed to the load side conductors and the power supply side conductors, which makes it possible to maintain insulation between the load side conductors and between the power supply side conductors that are mutually adjacent to one of the joining portions. Therefore, it becomes possible to achieve not only an excellence in assemblability but also a miniaturization of a device because it is not required to make the annular core of the zero-phase current transformer have a large inner hole. Furthermore, since each load side conductor or power supply side conductor and a through conductor portion are configured with, for example, a plate-like load side conductor or power supply side conductor and a rod-like through conductor portion in combination, the conductor members are easily processed.

[0012] When the annular core of the zero-phase cur-

rent transformer is perfectly circular, using through conductor portions the cross-sections of which orthogonal to the axis of the zero-phase current transformer have sectorial shapes enables the inner hole portion of the annular core to be used effectively as a through hole portion for the through conductor portions.

[0013] Further, when the annular core of the zero-phase current transformer is oval, using through conductor portions the cross-sections of which orthogonal to the axis of the zero-phase current transformer have a combination of sectorial shapes and quadrilateral shapes enables the inner hole portion of the annular core to be used effectively as a through hole portion for the through conductor portions.

[0014] Furthermore, interposing an insulating plate member(s) between the joining portions, which are in proximity to each other, on either side or both sides in the axial direction of the zero-phase current transformer enables the joining portions, which are in proximity to each other, to be insulated easily and securely.

Brief Description of Drawings

[0015]

FIG. 1 is a schematic configuration diagram illustrating an embodiment of an earth leakage breaker in which an earth leakage detection unit of the present invention is used;

FIG. 2 is a perspective view of the earth leakage detection unit of the earth leakage breaker in FIG. 1;

FIG. 3 is a front view of the earth leakage detection unit in FIG. 2;

FIG. 4 is a plan view of the earth leakage detection unit in FIG. 2;

FIG. 5 is an assembly diagram of the earth leakage detection unit in FIG. 2;

FIG. 6 is an explanatory diagram of a portion of the through conductor portion continuously fixed to a power supply side conductor or a load side conductor;

FIG. 7 is an explanatory diagram of a joining state between a T-phase power supply side conductor and a T-phase load side conductor;

FIG. 8 is an explanatory diagram of a joining state between an S-phase power supply side conductor and an S-phase load side conductor;

FIG. 9 is an explanatory diagram of a joining state between an R-phase power supply side conductor and an R-phase load side conductor;

FIG. 10 is an explanatory diagram between an N-phase power supply side conductor and an N-phase load side conductor;

FIG. 11 is an assembly diagram of insulating plate members that are inserted between joining portions;

FIG. 12 is an assembly diagram of the insulating plate members that are inserted between the joining portions;

FIG. 13 is an explanatory diagram of an effect of the insulating plate member between the load side conductors;

FIG. 14 is an explanatory diagram of an effect of the insulating plate member between the power supply side conductors;

FIG. 15 is an explanatory diagram of an insulation length of the through conductor portions inside an annular core;

FIG. 16 is a cross-sectional view illustrating an example of the through conductor portions; and

FIG. 17 is a cross-sectional view illustrating another example of the through conductor portions.

Description of Embodiments

[0016] Next, an embodiment of an earth leakage detection unit and an earth leakage breaker of the present invention will be described in detail with reference to the drawings. FIG. 1 is a perspective view illustrating an overall configuration of the earth leakage breaker of the embodiment. The earth leakage breaker includes a main-body case 1, which is made of a molded resin case, and a cover, which covers the main-body case 1, and, in FIG. 1, illustration of the cover is omitted. The earth leakage breaker has an open-close mechanism 3 for contacts of a power supply side circuit 2, an over-current tripping device 4, and a leakage tripping device 5 mounted on the inside of the main-body case 1, and also has an arc extinction unit 21 and an operating handle 22 of a well-known circuit breaker mounted thereon. In particular, the over-current tripping device 4 is an over-current tripping device in which a well-known current transformer is used. The leakage tripping device 5 is configured including an earth leakage detection unit 6 and a trip coil unit 7. As with a conventional tripping device, when a leakage is detected by the earth leakage detection unit 6, the leakage tripping device 5 opens the contacts of the open-close mechanism 3 using the trip coil unit 7 to break the circuit.

[0017] FIG. 2 is a perspective view of the earth leakage detection unit 6 of the earth leakage breaker in FIG. 1, and FIGs. 3, 4, and 5 are a front view, a plan view, and an assembly diagram of the earth leakage detection unit 6 in FIG. 2, respectively. The earth leakage detection unit 6 of the embodiment, as conventionally configured, includes a zero-phase current transformer 8, the annular core 9 of which is perfectly circular. Thus, the inner hole of the annular core 9 is also perfectly circular. Illustration of secondary wiring of the zero-phase current transformer 8 is omitted. The power supply side circuit 2 of the embodiment is a 4-pole circuit that has N-phase in addition to three commonly-used poles, namely T-phase, S-phase, and R-phase. Thus, load side terminals of the earth leakage detection unit 6 also includes terminals for four poles, namely a T-phase load side terminal 10T, an S-phase load side terminal 10S, an R-phase load side terminal 10R, and an N-phase load side terminal 10N.

Incidentally, the load side terminals 10T to 10N have square-shaped plate-like forms, and, as illustrated in, for example, FIG. 2, are arranged in line in the orthogonal direction to the axial direction of the zero-phase current transformer 8 on the one side in the axial direction of the zero-phase current transformer 8, that is, on the lower side on the near side in FIG. 2.

[0018] To the load side terminals 10T to 10N, plate-like load side conductors 11T to 11N are continuously fixed, respectively, in the vertical direction in FIG. 2 on the side facing the annular core 9 of the zero-phase current transformer 8. Specifically, each of the load side terminals 10T to 10N and corresponding one of the load side conductors 11T to 11N may be formed in one body by bending a single piece of plate-like conductor. The load side conductors 11T to 11N are arranged on the one side in the axial direction of the zero-phase current transformer 8. The ends on the opposite sides of the load side conductors 11T to 11N to the load side terminals 10T to 10N are arranged in such a way as to converge towards the inner hole portion of the annular core 9. The load side conductors 11T to 11N are arranged in such a way that, as illustrated in, for example, FIG. 3, the T-phase load side conductor 11T, the S-phase load side conductor 11S, the R-phase load side conductor 11R, and the N-phase load side conductor 11N are arranged to the upper right, the lower right, the lower left, and the upper left in the illustration, respectively, with respect to the inner hole of the annular core 9. As a result, the load side conductors 11T to 11N have few overlapping portions with one another in the axial direction of the zero-phase current transformer 8, which makes it possible to reduce dimensions in the axial direction of the zero-phase current transformer 8 in a layout of the load side conductors 11T to 11N.

[0019] On the other hand, power supply side conductors 12T to 12N corresponding to the respective phases of the power supply side circuit 2 are, as illustrated in, for example, FIG. 2, arranged on the other side in the axial direction of the zero-phase current transformer 8, that is, on the far side in FIG. 2. The power supply side conductors 12T to 12N are, for example, configured by bending plate-like conductors, and arranged in such a way that the ends on the one sides of the power supply side conductors 12T to 12N converge towards the inner hole portion of the annular core 9. The ends on the other sides of the power supply side conductors 12T to 12N are connected to the respective phases of the not-illustrated power supply side circuit 2. Among the ends of the power supply side conductors 12T to 12N, each of the ends on the one sides of the power supply side conductors 12T to 12N, which converge towards the inner hole portion of the annular core 9, opposes the end of one of the load side conductors 11T to 11N of a corresponding phase. Thus, as illustrated in, for example, FIG. 14, which illustrates the earth leakage detection unit 6 in FIG. 2 viewed from the rear side, a T-phase power supply side conductor 12T, an S-phase power supply side conductor 12S, an R-phase power supply side conductor 12R, and an N-phase power supply side conductor 12N are arranged to the upper left, the lower left, the lower right, and the upper right in the illustration, respectively, with respect to the inner hole of the annular core 9. As a result, the power supply side conductors 12T to 12N have few overlapping portions with one another in the axial direction of the zero-phase current transformer 8, which makes it possible to reduce dimensions in the axial direction of the zero-phase current transformer 8 in a layout of the power supply side conductors 12T to 12N.

[0020] Among the power supply side conductors 12T to 12N, to the T-phase power supply side conductor 12T and the R-phase power supply side conductor 12R, which are disposed at diagonal positions with respect to the inner hole of the annular core 9, a T-phase power supply side through conductor portion 13T and an R-phase power supply side through conductor portion 13R are continuously fixed, respectively. Among the load side conductors 11T to 11N, to the S-phase load side conductor 11S and the N-phase load side conductor 11N, which are disposed at diagonal positions with respect to the inner hole of the annular core 9, an S-phase load side through conductor portion 14S and an N-phase load side through conductor portion 14N are continuously fixed, respectively. Among the through conductor portions, the T-phase power supply side through conductor portion 13T and the R-phase power supply side through conductor portion 13R are continuously fixed in a projecting manner from the ends on the annular core 9 sides of the T-phase power supply side conductor 12T and the R-phase power supply side conductor 12R, respectively, in such a way as to penetrate the annular core 9. The S-phase load side through conductor portion 14S and the N-phase load side through conductor portion 14N are continuously fixed in a projecting manner from the ends on the annular core 9 sides of the S-phase load side conductor 11S and the N-phase load side conductor 11N, respectively, in such a way as to penetrate the annular core 9.

[0021] On the other hand, among the power supply side conductors 12T to 12N, to the ends on the annular core 9 sides of the S-phase power supply side conductor 12S and the N-phase power supply side conductor 12N, which are disposed at diagonal positions with respect to the inner hole of the annular core 9, an S-phase power supply side joining portion 15S and an N-phase power supply side joining portion 15N are formed in one bodies, respectively. Among the load side conductors 11T to 11N, to the ends on the annular core 9 sides of the T-phase load side conductor 11T and the R-phase load side conductor 11R, which are disposed at diagonal positions with respect to the inner hole of the annular core 9, a T-phase load side joining portion 16T and an R-phase load side joining portion 16R are formed in one bodies, respectively.

[0022] A structure to continuously fix the N-phase load side through conductor portion 14N to the N-phase load side conductor 11N is illustrated in FIG. 6, representing the above-described through conductor portions. In the

embodiment, for example, the through conductor portion 14N that has a form obtained by cutting a cylinder vertically into four sections the cross-sections of which are sectors with a central angle of 90°, that is, into quarters, is used and arranged in such a way that the central angle of the sector thereof is positioned around the center of the inner hole of the annular core 9. The outer peripheral surface of the through conductor portion 14N, which is in the form of a quarter cylinder, is joined to the end on the annular core 9 side of the load side conductor 11N, and both are continuously fixed in one body by, for example, soldering or welding. A load side conductor 11N that has been formed in advance with a through conductor portion 14N being continuously fixed thereto in one body may also be used.

[0023] In the embodiment, on the outsides of all power supply side conductors 12T to 12N except the S-phase power supply side conductor 12S, power supply side insulating coating portions 17T to 17N are formed. On the outsides of all load side conductors 11T to 11N, load side insulating coating portions 18T to 18N are formed. The insulating coating portions are formed in one bodies with the respective conductor members by, for example, forming insulating resin on the outsides of the conductor members by injection molding. Among the power supply side insulating coating portions 17T to 17N, an N-phase power supply side insulating coating portion 17N is not formed on the N-phase power supply side joining portion 15N. Among the load side insulating coating portions 18T to 18N, a T-phase load side insulating coating portion 18T and an R-phase load side insulating coating portion 18R are not formed on the T-phase load side joining portion 16T and the R-phase load side joining portion 16R, respectively.

[0024] On the other hand, among the power supply side insulating coating portions 17T to 17N, a T-phase power supply side insulating coating portion 17T and an R-phase power supply side insulating coating portion 17R are formed on portions of the T-phase power supply side through conductor portion 13T and the R-phase power supply side through conductor portion 13R continuously fixed to the corresponding power supply side conductors, respectively. Among the load side insulating coating portions 18T to 18N, an S-phase load side insulating coating portion 18S and an N-phase load side insulating coating portion 18N are formed on portions of the S-phase load side through conductor portion 14S and the N-phase load side through conductor portion 14N continuously fixed to the corresponding load side conductors, respectively. However, the T-phase power supply side insulating coating portion 17T and the R-phase power supply side insulating coating portion 17R are not formed on projection tip portions of the T-phase power supply side through conductor portion 13T and the R-phase power supply side through conductor portion 13R, respectively. The S-phase load side insulating coating portion 18S and the N-phase load side insulating coating portion 18N are not formed on projection tip portions of the S-phase load side through conductor portion 14S and the N-phase load side through conductor portion 14N, respectively.

[0025] FIG. 7 is an explanatory diagram of a joining state between the T-phase power supply side through conductor portion 13T of the T-phase power supply side conductor 12T and the T-phase load side joining portion 16T of the T-phase load side conductor 11T. When the T-phase power supply side through conductor portion 13T is inserted into the inner hole of the annular core 9 from the far side in FIG. 7 (the other side in the axial direction of the zero-phase current transformer 8), that is, the power supply side, the projection tip portion of the T-phase power supply side through conductor portion 13T is joined to the T-phase load side joining portion 16T (FIG. 7 illustrates a state immediately before joining). As described earlier, on the projection tip portion of the T-phase power supply side through conductor portion 13T, the T-phase power supply side insulating coating portion 17T is not formed. On the T-phase load side joining portion 16T, the T-phase load side insulating coating portion 18T is not formed. As a result, when the T-phase power supply side through conductor portion 13T is joined to the T-phase load side joining portion 16T, the T-phase power supply side conductor 12T and the T-phase load side conductor 11T penetrate the annular core 9 of the zero-phase current transformer 8 to be connected electrically.

[0026] FIG. 8 is an explanatory diagram of a joining state between the S-phase load side through conductor portion 14S of the S-phase load side conductor 11S and the S-phase power supply side joining portion 15S of the S-phase power supply side conductor 12S. When the S-phase load side through conductor portion 14S is inserted into the inner hole of the annular core 9 from the near side in FIG. 8 (the one side in the axial direction of the zero-phase current transformer 8), that is, the load side, the projection tip portion of the S-phase load side through conductor portion 14S is joined to the S-phase power supply side joining portion 15S. As described earlier, on the projection tip portion of the S-phase load side through conductor portion 14S, the S-phase load side insulating coating portion 18S is not formed. On the S-phase power supply side conductor 12S, the S-phase power supply side insulating coating portion is not formed at all. As a result, when the S-phase load side through conductor portion 14S is joined to the S-phase power supply side joining portion 15S, the S-phase power supply side conductor 12S and the S-phase load side conductor 11S penetrate the annular core 9 of the zero-phase current transformer 8 to be connected electrically.

[0027] FIG. 9 is an explanatory diagram of a joining state between the R-phase power supply side through conductor portion 13R of the R-phase power supply side conductor 12R and the R-phase load side joining portion 16R of the R-phase load side conductor 11R. When the R-phase power supply side through conductor portion 13R is inserted into the inner hole of the annular core 9

from the far side in FIG. 9 (the other side in the axial direction of the zero-phase current transformer 8), that is, the power supply side, the projection tip portion of the R-phase power supply side through conductor portion 13R is joined to the R-phase load side joining portion 16R (FIG. 9 illustrates a state immediately before joining). As described earlier, on the projection tip portion of the R-phase power supply side through conductor portion 13R, the R-phase power supply side insulating coating portion 17R is not formed. On the R-phase load side joining portion 16R, the R-phase load side insulating coating portion 18R is not formed. As a result, when the R-phase power supply side through conductor portion 13R is joined to the R-phase load side joining portion 16R, the R-phase power supply side conductor 12R and the R-phase load side conductor 11R penetrate the annular core 9 of the zero-phase current transformer 8 to be connected electrically.

[0028] FIG. 10 is an explanatory diagram of a joining state between the N-phase load side through conductor portion 14N of the N-phase load side conductor 11N and the N-phase power supply side joining portion 15N of the N-phase power supply side conductor 12N. When the N-phase load side through conductor portion 14N is inserted into the inner hole of the annular core 9 from the near side in FIG. 10 (the one side in the axial direction of the zero-phase current transformer 8), that is, the load side, the projection tip portion of the N-phase load side through conductor portion 14N is joined to the N-phase power supply side joining portion 15N. As described earlier, on the projection tip portion of the N-phase load side through conductor portion 14N, the N-phase load side insulating coating portion 18N is not formed. On the N-phase power supply side joining portion 15N, the N-phase power supply side insulating coating portion 17N is not formed. As a result, when the N-phase load side through conductor portion 14N is joined to the N-phase power supply side joining portion 15N, the N-phase power supply side conductor 12N and the N-phase load side conductor 11N penetrate the annular core 9 of the zero-phase current transformer 8 to be connected electrically.

[0029] In FIG. 15, a connection state between the T-phase power supply side conductor 12T and the T-phase load side conductor 11T and between the N-phase power supply side conductor 12N and the N-phase load side conductor 11N inside the annular core 9 is illustrated, representing the power supply side conductors 12T to 12N and the load side conductors 11T to 11N that are connected to each other as described above. The T-phase power supply side through conductor portion 13T and the N-phase load side through conductor portion 14N, both of which have a form of a quarter cylinder, are adjacent to each other in the inner hole of the annular core 9, as illustrated in FIG. 15. However, since the T-phase power supply side insulating coating portion 17T and the N-phase load side insulating coating portion 18N are formed at least on the portion of the through conductor portion 13T continuously fixed to the T-phase power supply side conductor 12T and the portion of the through conductor portion 14N continuously fixed to the N-phase load side conductor 11N, respectively, a sufficient insulation length is maintained in the axial direction of the zero-phase current transformer 8.

[0030] However, on the near side of the illustration in FIG. 11, that is, the load side, the T-phase load side joining portion 16T and the R-phase load side joining portion 16R, which are disposed at diagonal positions, are in proximity to each other. On the near side of the illustration in FIG. 12, that is, the power supply side, the S-phase power supply side joining portion 15S and the N-phase power supply side joining portion 15N, which are disposed at diagonal positions, are in proximity to each other. As described earlier, the T-phase load side insulating coating portion 18T and the R-phase load side insulating coating portion 18R are not formed on the T-phase load side joining portion 16T and the R-phase load side joining portion 16R, respectively. The S-phase power supply side insulating coating portion is not formed on the S-phase power supply side conductor 12S at all, and the N-phase power supply side insulating coating portion 17N is not formed on the N-phase power supply side joining portion 15N.

[0031] Therefore, in the embodiment, as clearly illustrated in FIG. 11, a load side insulating plate member 19 is inserted between the T-phase load side joining portion 16T and the R-phase load side joining portion 16R, which are in proximity to each other, from the load side to maintain insulation between the T-phase load side joining portion 16T and the R-phase load side joining portion 16R. The load side insulating plate member 19 is made of, for example, insulating resin or the like, and, in the embodiment, formed into a box shape that covers the R-phase load side joining portion 16R entirely. As a result, as illustrated in FIG. 13, the load side insulating plate member 19 is interposed between the T-phase load side joining portion 16T and the R-phase load side joining portion 16R, which are in proximity to each other, maintaining insulation between the T-phase load side joining portion 16T and the R-phase load side joining portion 16R.

[0032] Similarly, in the embodiment, as clearly illustrated in FIG. 12, a power supply side insulating plate member 20 is inserted between the S-phase power supply side joining portion 15S and the N-phase power supply side joining portion 15N, which are in proximity to each other, from the power supply side to maintain insulation between the S-phase power supply side joining portion 15S and the N-phase power supply side joining portion 15N. The power supply side insulating plate member 20 is made of, for example, insulating resin or the like, and, in the embodiment, formed in a box shape that covers the N-phase power supply side joining portion 15N entirely. As a result, as illustrated in FIG. 14, the power supply side insulating plate member 20 is interposed between the S-phase power supply side joining portion 15S and N-phase power supply side joining portion 15N, which are in proximity to each other, maintaining insula-

tion between the S-phase power supply side joining portion 15S and the N-phase power supply side joining portion 15N.

[0033] FIG. 16 illustrates a state of the power supply side through conductor portions 13T and 13R and the load side through conductor portions 14S and 14N in the annular core 9 of the zero-phase current transformer 8. In the embodiment, since the power supply side through conductor portions 13T and 13R and the load side through conductor portions 14S and 14N each of which has a quarter cylinder shape and a sectorial cross-section with a central angle of 90° are used, the through conductor portions are efficiently contained in the inner hole of the annular core 9 without interfering with one another. Moreover, since, as described earlier, the power supply side insulating coating portions 17T and 17R and the load side insulating coating portions 18S and 18N are formed on the outsides of the power supply side through conductor portions 13T and 13R and the load side through conductor portions 14S and 14N, respectively, insulation is also maintained.

[0034] FIG. 17 illustrates an example of power supply side through conductor portions 13T and 13R and load side through conductor portions 14S and 14N for a case in which the inner hole of the annular core 9 of the zero-phase current transformer 8 is oval. Since, in the embodiment represented by FIG. 16, the inner hole of the annular core 9 is perfectly circular, through conductor portions corresponding to four poles each of which has a quarter cylinder shape and a sectorial cross-section with a central angle of 90° may fit to the inner hole. However, when, as illustrated in FIG. 17, the inner hole of the annular core 9 is oval, simply combining through conductor portions with sectorial cross-sections does not enable the through conductor portions to be efficiently contained in the inner hole of the annular core 9. Therefore, when the inner hole of the annular core 9 is oval as illustrated in FIG. 17, combining, for example, power supply side through conductor portions 13T and 13R with sectorial cross-sections and load side through conductor portions 14S and 14N with quadrilateral cross-sections enables the through conductor portions to be efficiently contained in the inner hole of the annular core 9.

[0035] As described above, in the embodiment, the load side conductors 11T to 11N and the power supply side conductors 12T to 12N are arranged on the one side and the other side in the axial direction of the zero-phase current transformer 8, respectively, in such a way that the through conductor portions 14S and 14N, which are continuously fixed to the load side conductors 11S and 11N, and the through conductor portions 13T and 13R, which are continuously fixed to the supply side conductors 12T and 12R, penetrate the annular core 9 alternately one another from the one side and the other side in the axial direction of the zero-phase current transformer 8, respectively. With this configuration, the through conductor portions 13T, 13R, 14S, and 14N are joined to the joining portions 16T and 16R of the load side conductors 11T and 11R and the joining portions 15S and 15N of the power supply side conductors 12S and 12N, each of which has a corresponding phase and is not continuously fixed, and, as a result, the power supply side conductors 12T to 12N and the load side conductors 11T to 11N are connected to each other with respect to each phase. At this time, the insulating coating portions 18S, 18N, and 17R are formed at least on the outsides of the portions of the through conductor portions continuously fixed to the load side conductors 11S and 11N and the power supply side conductor 12R, which makes it possible to maintain insulation between the load side conductors 11T to 11N or the power supply side conductors 12T to 12N, which are mutually adjacent to one of the joining portions 16T, 16R, 15S, and 15N. Therefore, it becomes possible to achieve not only an excellence in assemblability but also a miniaturization of a device because it is not required to make the annular core 9 of the zero-phase current transformer 8 have a large inner hole. Furthermore, since each of the load side conductors 11S and 11N and the power supply side conductors 12T and 12R, which include the through conductor portions 14S, 14N, 13T, and 13R, respectively, is configured with, for example, a combination of one of the load side conductors 11S and 11N and the power supply side conductors 12T and 12R, which have plate-like shapes, and one of the through conductor portions 14S, 14N, 13T, and 13R, which have rod-like shapes, the conductor members are easily processed.

[0036] When the annular core 9 of the zero-phase current transformer 8 is perfectly circular, using the through conductor portions 145, 14N, 13T, and 13R the cross-sections of which orthogonal to the axis of the zero-phase current transformer have sectorial shapes enables the inner hole portion of the annular core 9 to be used effectively as a through hole portion for the through conductor portions 14S, 14N, 13T, and 13R.

[0037] Further, when the annular core 9 of the zero-phase current transformer 8 is oval, using the through conductor portions 14S, 14N, 13T, and 13R the cross-sections of which orthogonal to the axis of the zero-phase current transformer have a combination of sectorial shapes and quadrilateral shapes enables the inner hole portion of the annular core 9 to be used effectively as a through hole portion for the through conductor portions 14S, 14N, 13T, and 13R.

[0038] Furthermore, interposing the insulating plate members 19 and/or 20 between the joining portions 15S and 15N and/or the joining portions 16T and 16R, each pair of which are in proximity to each other, on either side or both sides in the axial direction of the zero-phase current transformer 8 enables the joining portions 15S and 15N and/or the joining portions 16T and 16R, each pair of which are in proximity to each other, to be insulated easily and securely.

[0039] In the afore-described embodiment, the T-phase, S-phase, R-phase, and N-phase through conductor portions are arranged in such a way as to be inserted

alternately from the power supply side and the load side. With this configuration, it is possible to reduce the area of proximity between joining portions in proximity to each other on the power supply side or the load side. However, the through conductor portions corresponding to four poles do not always have to be inserted alternately. In the case in which the through conductor portions are not inserted alternately, there is a possibility that the area of proximity between joining portions in proximity to each other increases. If such a case materializes, interposing insulating plate members to maintain insulation prevents any difficulty.

[0040] Although, in the afore-described embodiment, the earth leakage detection unit and the earth leakage breaker including a 4-pole circuit that has N-phase in addition to three poles, that is, T-phase, S-phase, and R-phase, was described in detail, a circuit having three poles, namely T-phase, S-phase, and R-phase, may also be acceptable. In that case, a through conductor portion corresponding to any one pole may be inserted into the annular core from either one side of the power supply side and the load side, and through conductor portions corresponding to the other poles may be inserted into the annular core from the other side of the power supply side and the load side.

Reference Signs List

[0041]

1	Main-body case
2	Power supply side circuit
3	Open-close mechanism
4	Over-current tripping device
5	Leakage tripping device
6	Earth leakage detection unit
7	Trip coil unit
8	Zero-phase current transformer
9	Annular core
10T to 10N	Load side terminal
11T to 11N	Load side conductor
12T to 12N	Power supply side conductor
13T, 13R	Power supply side through conductor portion
14S, 14N	Load side through conductor portion
15S, 15N	Power supply side joining portion
16T, 16R	Load side joining portion
17T to 17N	Power supply side insulating coating portion
18T to 18N	Load side insulating coating portion
19	Load side insulating plate member
20	Power supply side insulating plate member

Claims

1. An earth leakage detection unit, comprising:

a zero-phase current transformer that has an annular core;

load side conductors that are arranged on either one side in an axial direction of the zero-phase current transformer, corresponding to respective phases of load side terminals;

power supply side conductors that are arranged on the other side in the axial direction of the zero-phase current transformer, corresponding to respective phases of a power supply side circuit;

through conductor portions among which a through conductor portion (s) corresponding to one phase or two phase is/are continuously fixed to either one(s) of a load side conductor (s) among the load side conductors and a power supply side conductor (s) among the power supply side conductors, and among which through conductor portions corresponding to the other phases are continuously fixed to the other ones of the other load side conductors and the other power supply side conductors, and each of which penetrates the annular core of the zero-phase current transformer to be joined to a joining portion of one of the load side conductors and the power supply side conductors that has a corresponding phase and to which any one of the through conductor portions is not continuously fixed; and

insulating coating portions each of which is formed at least on the outside of a portion of the through conductor portion continuously fixed to one of the load side conductors and the power supply side conductors at which one of the through conductor portions is continuously fixed.

2. The earth leakage detection unit according to claim 1, wherein, the annular core of the zero-phase current transformer is perfectly circular, and shapes of cross-sections of the through conductor portions orthogonal to the axis of the zero-phase current transformer are sectors.

3. The earth leakage detection unit according to claim 1, wherein, the annular core of the zero-phase current transformer is oval, shapes of cross-sections of the through conductor portions orthogonal to the axis of the zero-phase current transformer are a combination of sectors and quadrilaterals.

4. The earth leakage detection unit according to any one of claims 1 to 3, wherein, on either side or each of both sides in the axial direction of the zero-phase current transformer, an insulating plate member is interposed between a joining portion of one of the load side conductors and a joining portion of one of the power supply side conductors in proximity to each other.

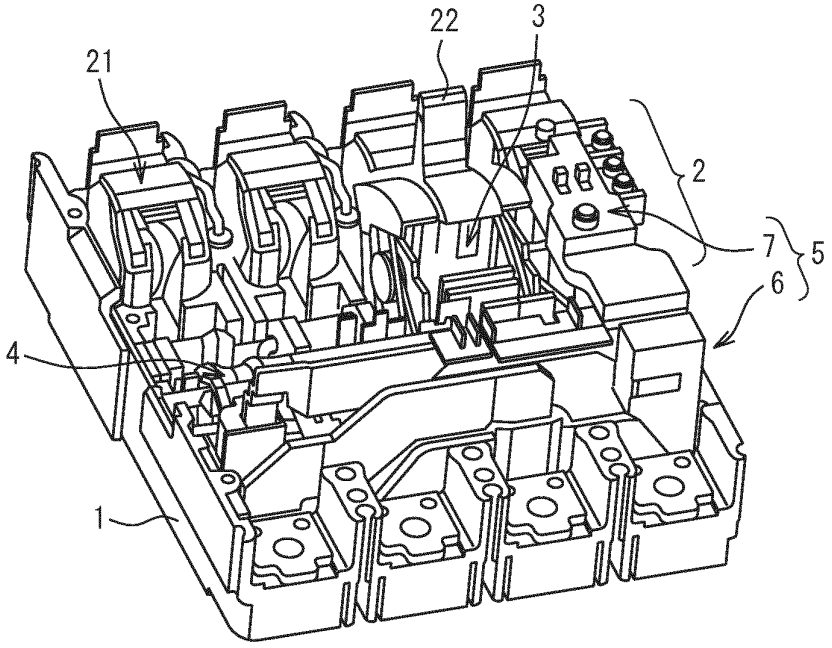
5. A multipolar type earth leakage breaker comprising:

an open-close mechanism for contacts of a power supply side circuit mounted in a main-body case;
an over-current tripping device mounted in the main-body case; and

a leakage tripping device mounted in the main-body case, the leakage tripping device including a combination of an earth leakage detection unit and a trip coil unit, the earth leakage detection unit including:

a zero-phase current transformer that has an annular core;
load side conductors that are arranged on either one side in an axial direction of the zero-phase current transformer, corresponding to respective phases of load side terminals;
power supply side conductors that are arranged on the other side in the axial direction of the zero-phase current transformer, corresponding to respective phases of a power supply side circuit;
through conductor portions among which a through conductor portion (s) corresponding to one phase or two phase is/are continuously fixed to either one(s) of a load side conductor (s) among the load side conductors and a power supply side conductor (s) among the power supply side conductors, and among which through conductor portions corresponding to the other phases are continuously fixed to the other ones of the other load side conductors and the other power supply side conductors, and each of which penetrates the annular core of the zero-phase current transformer to be joined to a joining portion of one of the load side conductors and the power supply side conductors that has a corresponding phase and to which any one of the through conductor portions is not continuously fixed; and
insulating coating portions each of which is formed at least on the outside of a portion of the through conductor portion continuously fixed to one of the load side conductors and the power supply side conductors at which one of the through conductor portions is continuously fixed.

FIG. 1


22
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7
5
6
4
1

FIG. 2

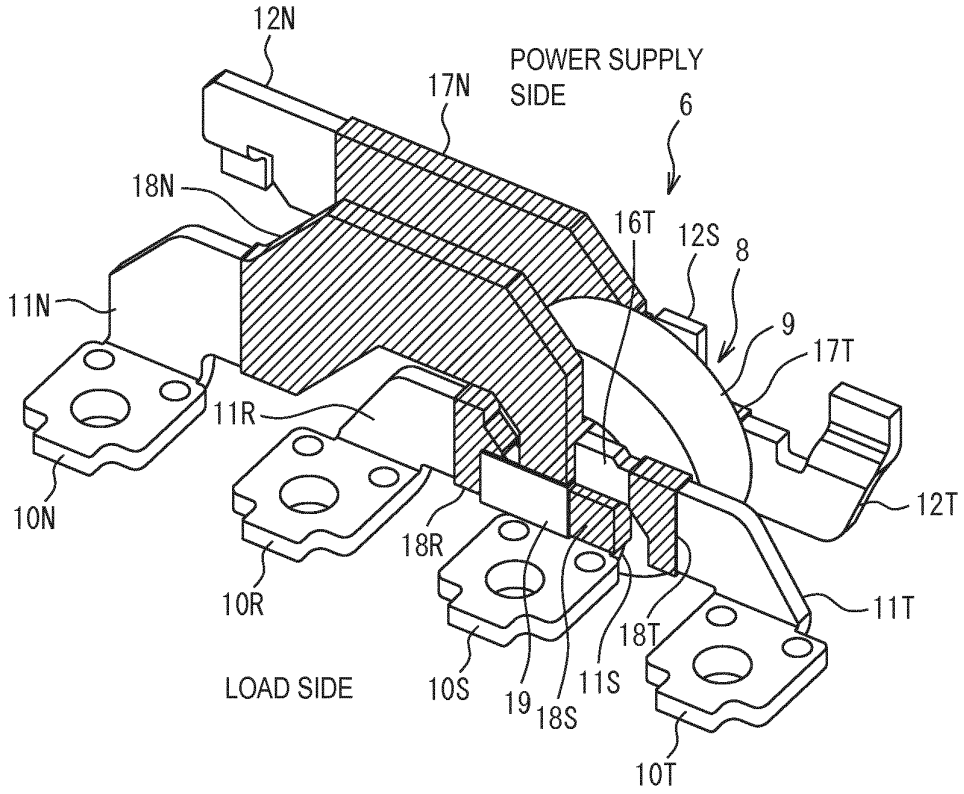

12N
POWER SUPPLY SIDE
17N
6
18N
16T
12S
8
11N
9
17T
11R
12T
10N
18R
10R
11T
18T
LOAD SIDE
10S
19
11S
18S
10T

FIG. 3

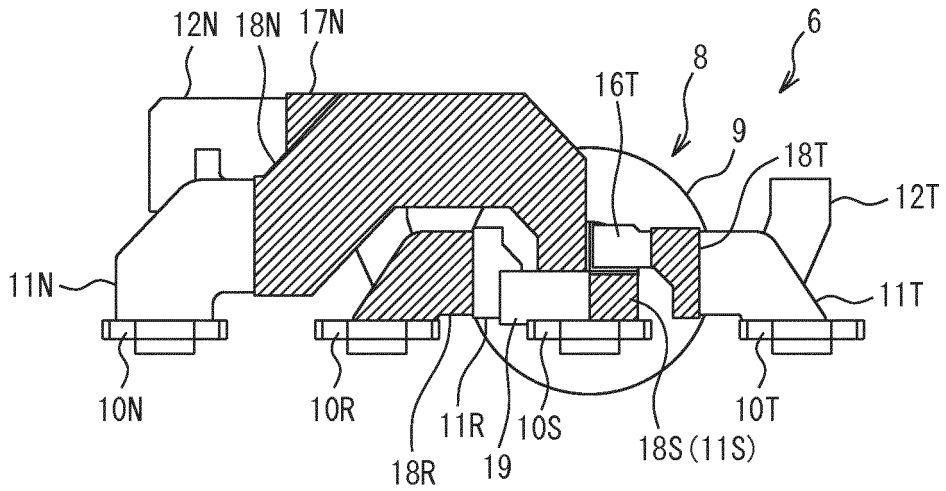

12N
18N
17N
6
8
16T
9
18T
12T
11N
11T
10N
10R
11R
10S
18S (11S)
10T
18R
19

FIG. 4

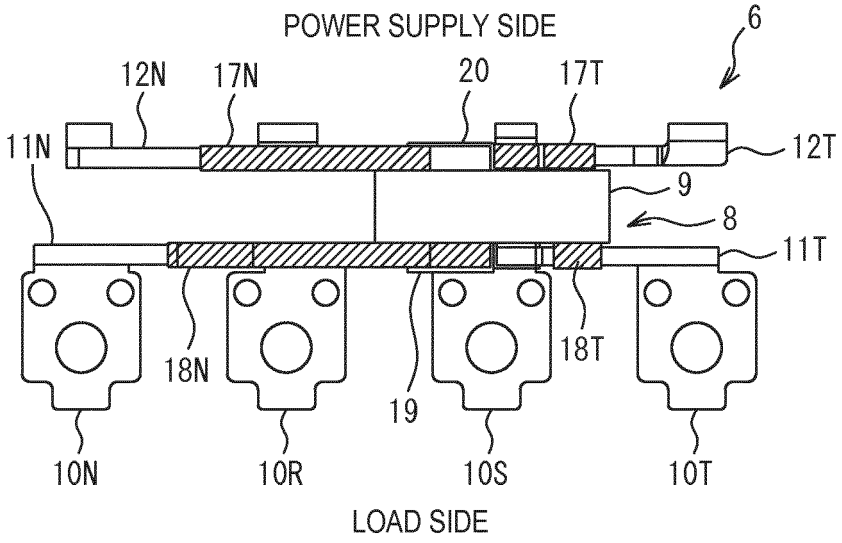

POWER SUPPLY SIDE
6
12N
17N
20
17T
11N
12T
9
8
11T
18N
18T
19
10N
10R
10S
10T
LOAD SIDE

FIG. 5

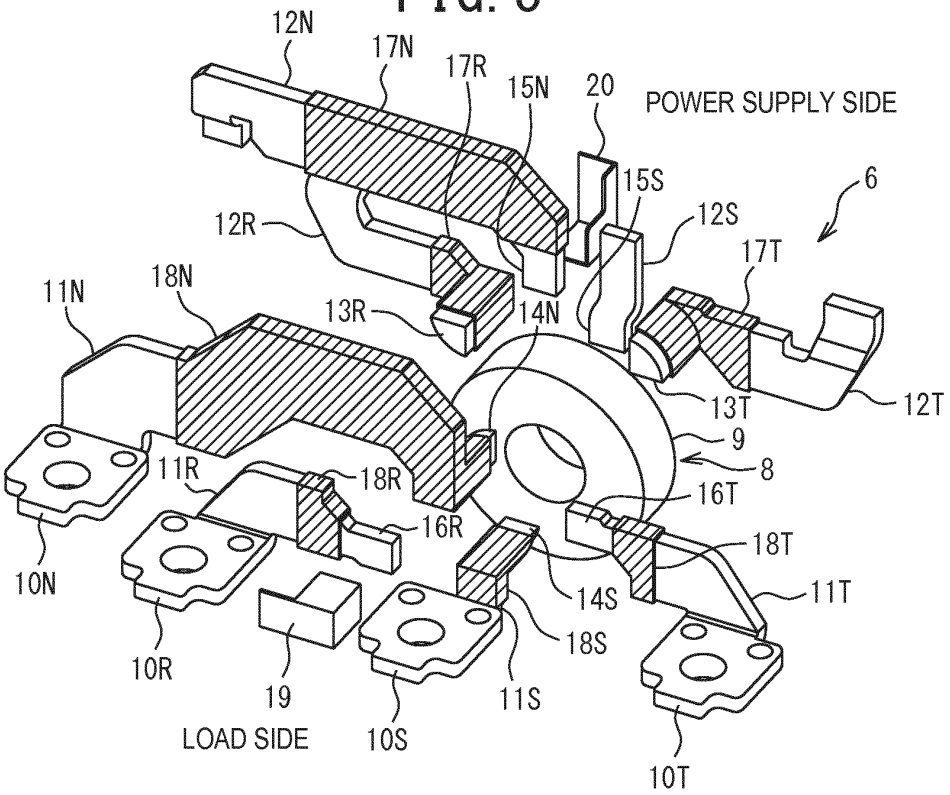


FIG. 6

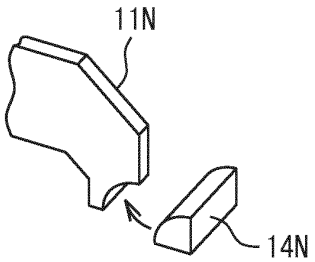


FIG. 7

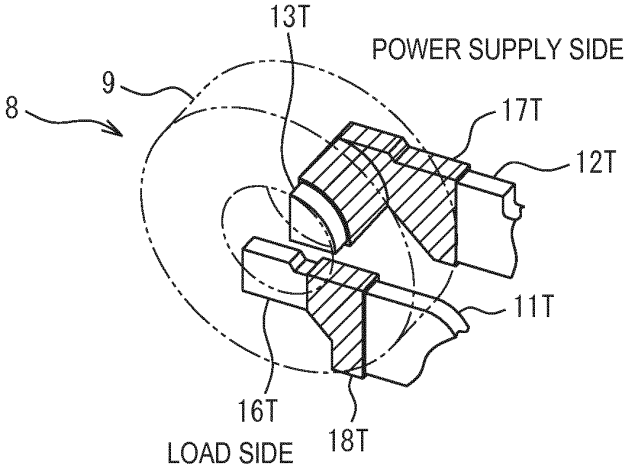


FIG. 8

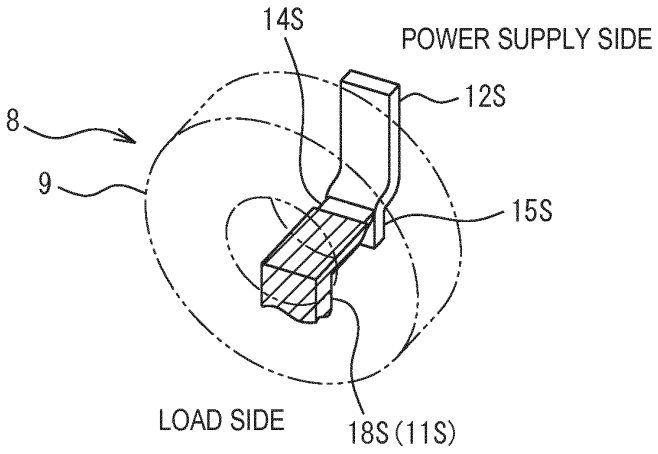


FIG. 9

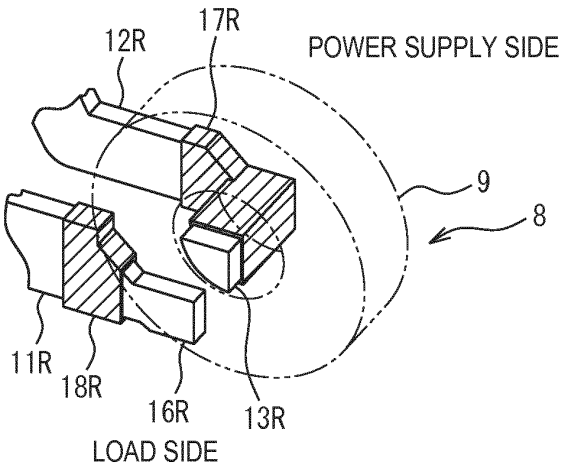


FIG. 10

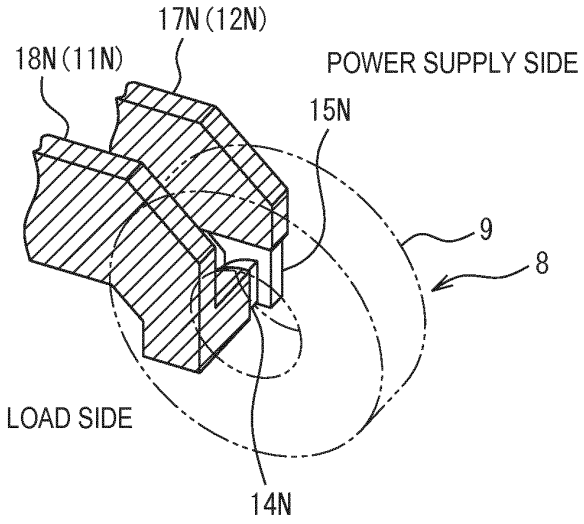


FIG. 11

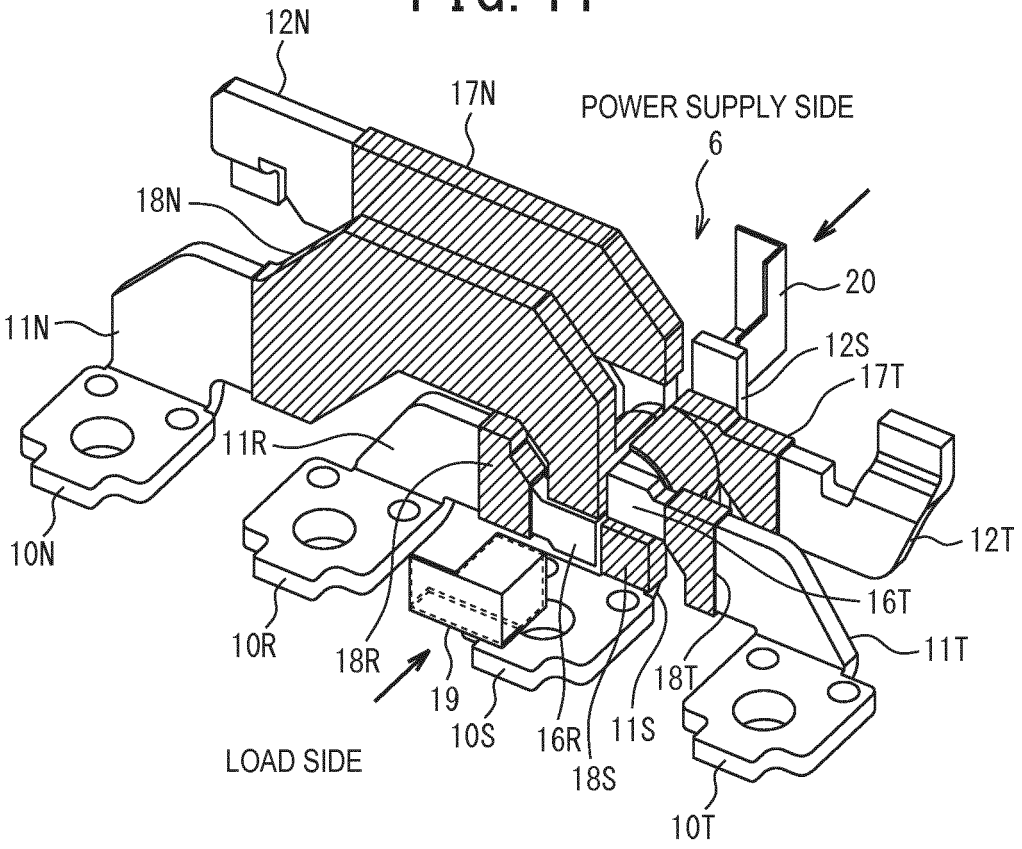

12N
17N
POWER SUPPLY SIDE
6
18N
20
11N
12S
17T
11R
12T
10N
16T
10R
18R
19
18T
11T
10S
16R
11S
LOAD SIDE
18S
10T

FIG. 12

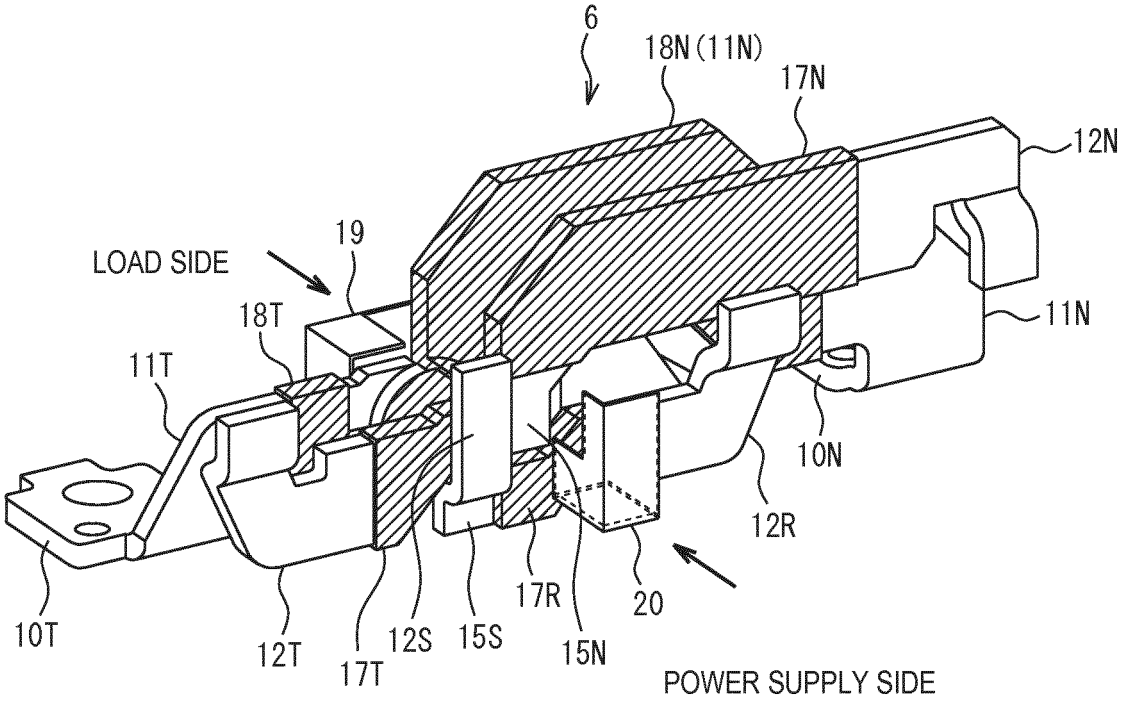

6
18N (11N)
17N
12N
19
LOAD SIDE
18T
11N
11T
10N
12R
10T
17R
20
12T
12S
15S
17T
15N
POWER SUPPLY SIDE

FIG. 13

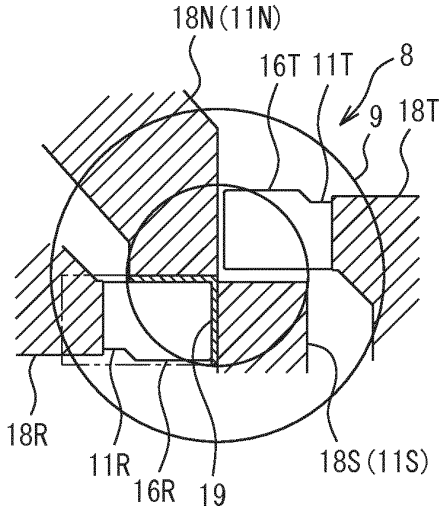


FIG. 14

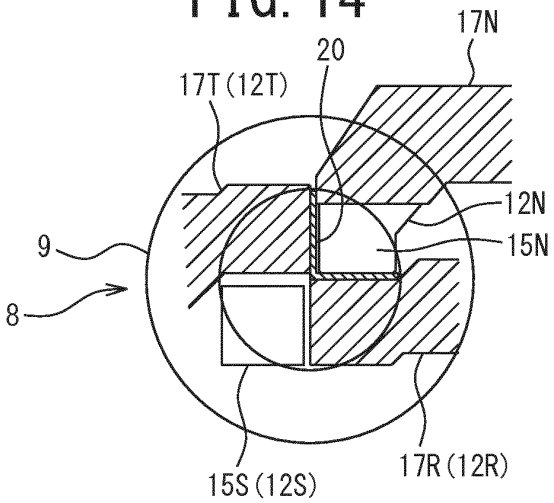


FIG. 15

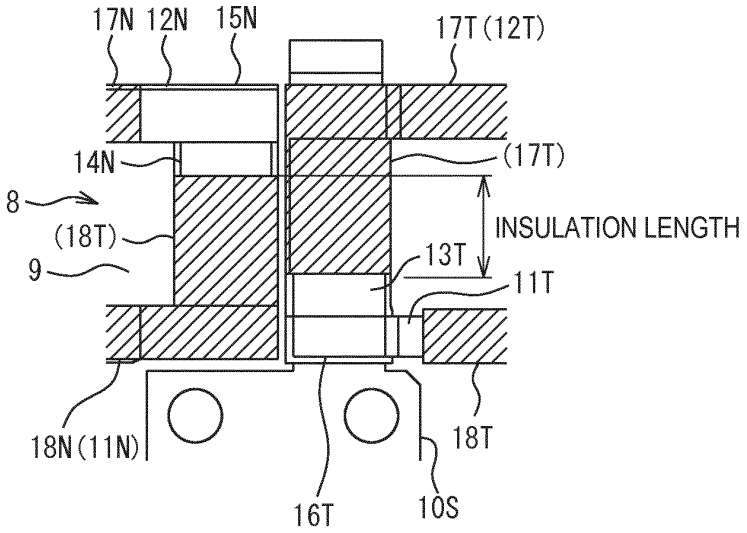


FIG. 16

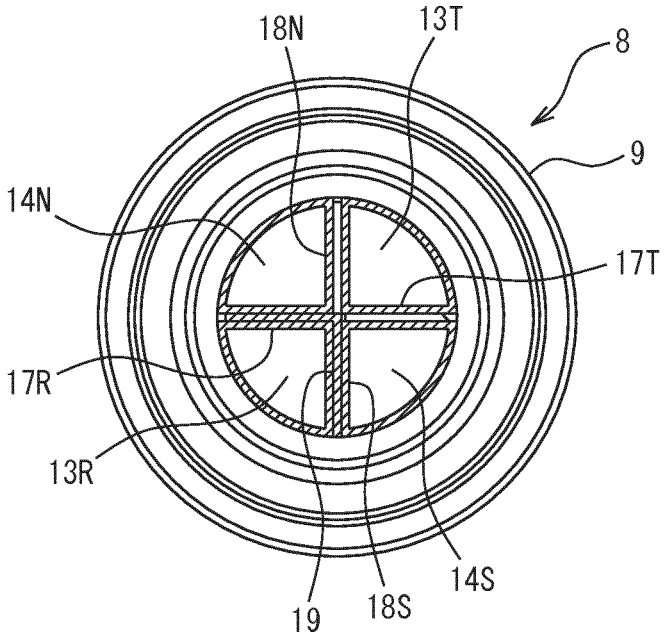
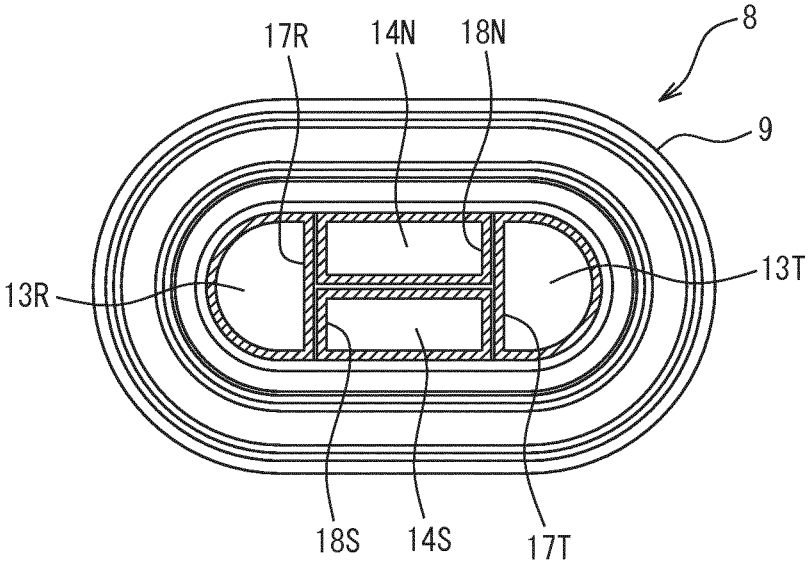

18N
13T
8
9
14N
17T
17R
13R
14S
19
18S

FIG. 17


17R
14N
18N
8
9
13R
13T
18S
14S
17T

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/006202

A. CLASSIFICATION OF SUBJECT MATTER
H01H83/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01H83/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 5-114523 A (Fuji Electric Co., Ltd.), 07 May 1993 (07.05.1993), paragraphs [0004], [0016]; fig. 4, 7 to 8 (Family: none)	1-5
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 119033/1971(Laid-open No. 73717/1973) (Kasuga Denki, Inc.), 13 September 1973 (13.09.1973), specification, page 2, lines 2 to 12; fig. 1 to 2 (Family: none)	1-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 February 2015 (24.02.15)	10 March 2015 (10.03.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/006202

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 63810/1974(Laid-open No. 151311/1975) (Matsushita Electric Works, Ltd.), 16 December 1975 (16.12.1975), specification, page 2, line 7 to page 3, line 16; fig. 1 to 2 (Family: none)	1-5
A	JP 10-321116 A (Fuji Electric Co., Ltd.), 04 December 1998 (04.12.1998), entire text; all drawings (Family: none)	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3704885 B **[0003]**
- JP 4736949 B **[0003]**