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EARTH LEAKAGE BREAKER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an earth leakage breaker, and particularly to an earth leakage
5 breaker having a zero phase current transformer having a magnetic shield structure suitable for miniaturization.

Description of the Related Art

In a conventional earth leakage breaker, as disclosed in JP-A-6-267396, magnetic shield is provided
10 all over the outside of a core and a secondary winding of a zero phase current transformer so as to more improve the balance characteristics.

In the conventional technique, it is necessary to increase the total volume of the magnetic shield to
15 improve the balance characteristics. As a result, the size of the zero phase current transformer becomes large, and, therefore, the size of the earth leakage breaker becomes large when the zero phase current transformer is provided in the housing of the earth leakage breaker.
20 Accordingly, it has been difficult to obtain an earth leakage breaker which is small in size and superior in balance characteristics.

SUMMARY OF THE INVENTION

It is therefore an object of the present

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invention to solve the foregoing problems so as to provide an earth leakage breaker which is small in size and superior in balance characteristics.

In order to achieve the above object, according to an aspect of the present invention, an earth leakage breaker comprises power supply side terminals provided for a plurality of poles respectively, load side terminals provided correspondingly to the power supply side terminals for the respective poles, fixed contact carriers electrically connected to the power supply side terminals, movable contact carriers provided in opposition to the fixed contact carriers, conductors electrically connected to the movable contact carriers and the load side terminals, a zero phase current transformer through which the conductors for the plurality of poles are disposed, an earth leakage detection means for detecting earth leakage on the basis of an output of the zero phase current transformer, and a breaker mechanism for opening the movable contact carriers on the basis of an output of the earth leakage detection means, wherein: each of the conductors is formed into a flat bar, and the conductor for at least one of the plurality of poles has a bent portion near a portion being disposed through the zero phase current transformer; and the zero phase current transformer has a magnetic shield portion provided in a portion thereof opposite to the bent portion.

Being formed in the form of a flat bar, each

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conductor can be bent into a U-shape at its bent portion so that the length of the conductor in the thickwise direction of the core at its portion extending through the zero phase current transformer can be reduced. In addition, the magnetic shield portion provided in the portion opposite to the bent portion of the zero phase current transformer can prevent the influence of a current of the conductor even if the conductor comes close to the core of the zero phase current transformer, so that required balance characteristics can be obtained. Further, the bent portion and the partial magnetic shield portion can prevent the zero phase current transformer from being extremely large in its size, so that it is possible to prevent the earth leakage breaker from being large in the size of its housing.

According to the present invention, it is possible to minimize the size a zero phase current transformer, and it is possible to provide an earth leakage breaker small in size and superior in balance characteristics.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view of an earth leakage breaker in a first embodiment of the present invention;

Fig. 2 is a sectional view of the earth leakage breaker in the first embodiment of the present invention;

Fig. 3 is an enlarged plan view of a load side portion of the earth leakage breaker in the first embodi-

ment of the present invention;

Fig. 4 is an enlarged sectional view of the load side portion of the earth leakage breaker in the first embodiment of the present invention;

5 Figs. 5A to 5D are diagrams for explaining the effects of the balance characteristics of the earth leakage breaker in the first embodiment of the present invention, in which Fig. 5A is a diagram illustrating arrangement of a zero phase current transformer not
10 provided with a magnetic shield portion and conductors penetrating the zero phase current transformer, Fig. 5B is a diagram illustrating arrangement of a zero phase current transformer partially provided with a magnetic shield portion and conductors penetrating the zero phase
15 current transformer, Fig. 5C is a diagram showing experimental results about balance characteristics in a case where a magnetic shield portion is not provided and in a case where a magnetic shield portion of this embodiment is provided, and Fig. 5D is a diagram showing
20 the experimental results of Fig. 5C with a graph;

Figs. 6A and 6B are perspective views of a zero phase current transformer of the earth leakage breaker in the first embodiment of the present invention, in which
Fig. 6A is a perspective view illustrating the appearance
25 of the zero phase current transformer of this embodiment, and Fig. 6B is a perspective view illustrating a specific configuration of the zero phase current transformer of this embodiment;

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Figs. 7A to 7C are perspective views each illustrating a modification of the zero phase current transformer in the first embodiment of the present invention, in which Fig. 7A is a perspective view
5 illustrating the appearance of the zero phase current transformer of this modification, Fig. 7B is a perspective view illustrating a specific configuration of the zero phase current transformer of this modification, and Fig. 7C is a perspective view illustrating another
10 specific configuration of the zero phase current transformer in this modification;

Fig. 8 is an enlarged sectional view of a load side portion of an earth leakage breaker in a second embodiment of the present invention; and

15 Figs. 9A and 9B are views illustrating the positional relationship among a ZCT of the earth leakage breaker, conductors penetrating the ZCT, and magnetic shield in the first embodiment of the present invention, in which Fig. 9A is a plan view illustrating the
20 positional relationship between the ZCT and the conductors being disposed through the ZCT, and Fig. 9B is an elevation illustrating the positional relationship between the ZCT and the conductors being disposed through the ZCT.

25 DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will be described below with reference to Fig. 1 to Figs. 9A and

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9B.

A first embodiment of the present invention will be described with reference to Fig. 1 to Figs. 7A to 7C, and Figs. 9A and 9B.

5 Fig. 1 is a plan view of an earth leakage breaker in this embodiment. Fig. 2 is a sectional view of Fig. 1. Fig. 3 is an enlarged plan view of a load side portion of Fig. 1. Fig. 4 is an enlarged view of the load side portion of Fig. 2. Figs. 5A to 5D show the
10 experimental results of the balance characteristics, and Figs. 6A and 6B are perspective views of a zero phase current transformer. Figs. 9A and 9B are diagrams illustrating the positional relationship among a ZCT, conductors being disposed through the ZCT, and magnetic
15 shield in this embodiment.

In the earth leakage breaker in this embodiment, a zero phase current transformer 2 (hereinafter abbreviated to "ZCT"), a printed board case 4 storing a printed board 3 on which an earth leakage detection means
20 60 for detecting earth leakage on the basis of the output of the ZCT 2 is mounted, a mechanism portion 5 as a breaker mechanism, a movable contact carrier 42 and a fixed contact carrier 32, and an arc chute 70 are stored in a housing 50 constituted by a cover 7 and a case 8.
25 The ZCT 2 is disposed close to a load side terminal 40, and the printed board 3 and the printed board case 4 are provided above the ZCT 2. The mechanism portion 5 and a handle 6 for operating this mechanism portion 5 manually

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are stored in nearly the center portion of the housing 50 as shown in Figs. 1 and 2. The movable contact carrier 42 is connected to the mechanism portion 5, and the fixed contact carrier 32 is disposed, in the bottom of the case 8, at a position opposite to this movable contact carrier 42. The arc chute 70 is disposed close to a power supply side terminal 30 in a space portion. Mainly in an earth leakage breaker of 400 A frame or more, there are provided an auxiliary power supply side terminal 9 and an auxiliary load side terminal 10 for making a large current flow into the normal power supply side terminal 30 and the normal load side terminal 40. A first conductor plate 1, a second conductor plate 11 and a third conductor plate 12 each of which has a bent portion formed as shown in Figs. 3 and 4 are provided so as to be disposed through the ZCT 2, and the printed board case 4, the printed board 3 and a board cover 17 are disposed above those conductor plates. In this embodiment, circuit parts mounted on the printed board are attached on the side opposite to the ZCT 2 in the board case 4 (on the side facing a bottom 50a of the earth leakage breaker). When indicators such as LED indicators, liquid crystal indicators, etc. are provided for indication of operation, pre-alarm, etc., the board cover 17 is made from a transparent material, and the indicators are installed to face the board cover 17 on the opposite side to the ZCT 2 in the board case (on the side facing a surface 50b of the earth leakage breaker).

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One conductor formed into a flat bar is electrically connected through a flexible conductor 43 to the movable contact carrier 42 for each pole. The conductor is constituted by the first conductor plate 1, the second conductor plate 11 and the third conductor plate 12 as shown in Fig. 4 in this embodiment. U-shaped bent portions 1a and 12a at portions being disposed through the ZCT 2 are formed on the first conductor plate 1 and the third conductor plate 12 respectively. Since the portions bent into a U-shape are bent substantially at a right angle respectively in this embodiment, the length of each portion of the first conductor plate 1 and the third conductor plate 12 being disposed through the ZCT 2 is only a sum of the axial length of a core 2a of the ZCT 2 (the thickwise length of the core 2a) and the length of a gap (about several mm) required for assembly between the conductors 1 and 12 and the surface of the core 2a. Accordingly, the portion where the conductors 1, 11 and 12 extend through the ZCT 2 can be reduced in size. In addition, the ZCT 2 has a magnetic shield portion 2b wider than any of the first and third conductor plates 1 and 12 in the right-left direction in Fig. 4 (in the direction perpendicular to the direction of extension of the first conductor plate 1, the second conductor plate 11 and the third conductor plate 12 through the ZCT 2). In this embodiment, the load side terminals 40 are formed respectively integrally with the remainder portions of the first conductor plate 1, the

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second conductor plate 11 and the third conductor plate 12 after extending through the ZCT 2.

Next, the experimental results of the balance characteristics will be described with reference to Figs. 5A to 5D. Fig. 5A shows the case where no magnetic shield portion is provided in the ZCT 2. Fig. 5B shows the case where the magnetic shield portion 2b of this embodiment is provided in the ZCT 2. Fig. 5C shows the experimental results about balance characteristics in three samples in each of the cases of Figs. 5A and 5B with respect to a 600 A frame earth leakage breaker. These experimental results were obtained in a manner so that a balanced current was made to flow into the conductors for a moment (about one to two cycles) to measure a current value in the limit where the ZCT 2 can operate normally (no output is generated from the ZCT 2). Fig. 5D shows the experimental results of Fig. 5C with a graph. It is understood from Fig. 5D that the current value (the graph (b) in Fig. 5D) of the limit of normal operation in the case where the magnetic shield portion 2b is provided is larger greatly than the current value (the graph (a) in Fig. 5D) of the limit of normal operation in the case where no magnetic shield portion is provided. The current value of the limit of normal operation is set to be ten times to over ten times larger than the current value of a normal frame, and set to 6,000 A in the 600 A frame. In this embodiment, the target value of 6,000 A or more can be attained from

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Fig. 5D, so that the embodiment can be applied to practical products. The magnetic shield portion 2b is provided thus in each portion opposite to the bent portions 1a and 12a of the conductors in the ZCT 2 in this embodiment, so that it is possible to prevent the influence from a current of any conductor even if the conductors 1 and 12 are disposed close to the core 2a of the ZCT 2, and it is possible to obtain required balance characteristics.

10 A specific configuration of the zero phase current transformer in this embodiment will be described with reference to Figs. 6A and 6B. Fig. 6A shows the appearance of the ZCT 2 provided with the magnetic shield portion 2b. To obtain a specific configuration of the magnetic shield portion 2b, as shown in Fig. 6B, a first shield member 13 where a plurality of sheets of magnetic shield members such as silicon steel or the like are laminated one on one is integrated with part of the outer circumference of the circular core 2a of the ZCT 2 by
15 taping, bonding or the like. Although the first shield member 13 is obtained by laminating, one on one, a plurality of magnetic shield plates of silicon steel plates or the like shaped into an arc in accordance with the outline of the ZCT 2, the first shield member 13 may
20 be of a single thick plate. The magnetic shield member 13 may be provided so as to be removable from the ZCT 2.
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 Figs. 9A and 9B are diagrams showing the positional relationship among the ZCT 2, the conductors

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being disposed through the ZCT 2, and the magnetic shield portion 2b applied thereto. Fig. 9A is a plan view of the ZCT 2 and the respective conductor plates. Fig. 9B is a sectional elevation of Fig. 9A taken from the load side terminal 40. The relation of the size of the magnetic shield portion 2b hatched in Fig. 9B is expressed by $C \leq A$ and $D \leq B$ by use of the sizes A, B, C and D in the drawing.

The closer the size C is to the size A, the more improved the balance characteristics are. In addition, the closer the size D is to the size B, the more improved the balance characteristics are. In addition, in the magnetic shield portion 2b shown in the hatched portion, the larger the thickness in the right-left direction in the drawing is, the more improved the balance characteristics are.

Figs. 7A to 7C are perspective views illustrating modifications of the magnetic shield portion 2b in this embodiment. The ZCT 2 in each of the modifications has a magnetic shield portion 2c formed into a U-shape as shown in Fig. 7A. Specifically, the magnetic shield portion 2c is formed of a lamination of shield plates and bent into a U-shape, as shown in Fig. 7B or it is formed of a thick plate and bent into a U-shape as shown in Fig. 7C.

To obtain the magnetic shield portion 2c of Fig. 7B, a second shield member 14 made of a plurality of silicon steel plates formed into an arc in accordance

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with the outline of the ZCT 2 and laminated on each other, and a pair of third shield members 15 each made of a lamination of a plurality of silicon steel plates are combined with each other into a U-shape. The second
5 shield member 14 and the third shield members 15 may be integrated with the circular ZCT 2 by taping, bonding or the like, may be detachably assembled with the latter.

The magnetic shield portion 2c of Fig. 7C is formed of a fourth shield member 16 which is made from a
10 thick plate bent into a U-shape. The ZCT 2 and the fourth shield member may be integrated with each other by taping, bonding or the like, or may be detachably assembled. The relation of size between the magnetic shield portion 2b and the conductors 1 and 12 described
15 in Fig. 9B can be applied to this modification. In this modification, the balance characteristics are more improved as the thickness of the portions added to the core 2a of the magnetic shield portion 2c in the thick-wise direction of the core 2, that is, the thickness of
20 the portions of the opposite sides of the U-shape is made larger, so that it is possible to obtain a ZCT superior in balance characteristics to that shown in Figs. 6A and 6B.

A second embodiment of the present invention
25 will be described with reference to Fig. 8.

Fig. 8 is a sectional view of a load side portion of an earth leakage breaker in this second embodiment. A ZCT 2 is provided so as to be one-sided

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toward one of the poles on the opposite sides in this embodiment. The ZCT 2 is disposed on the side of the pole where a first conductor plate 1 is provided in this embodiment. In this embodiment, the first conductor
5 plate 1 has a bent portion 1a having a rising edge which is short, and a portion opposite to the ZCT 2 which is extremely small. A third conductor plate 12 has a bent portion 12a having a rising edge which is long, and a portion opposite to the ZCT 2 which is long. Therefore,
10 the balance characteristics of the ZCT 2 receive influence mainly from a current flowing in the bent portion 12a.

In order to prevent this influence, a magnetic shield member 2b is provided only on a portion of the ZCT
15 2 opposite to the bent portion 12a of the third conductor plate 12 in this embodiment. A printed board case 4, a printed board 3 and a board cover 17 are disposed above the ZCT 2 and respective conductors in the same manner as in the first embodiment. The other configuration is
20 similar to that of the first embodiment.

Also in this embodiment, the conditions $C \leq A$ and $D \leq B$ are established in the size relationship of the shield member in Fig. 9B. The closer the size C is to the size A , or the closer the size D is to the size B ,
25 the more improved the balance characteristics are. In addition, in an added shield member shown in the hatched portion, the larger the thickness in the right-left

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direction is, the more improved the balance characteristics are.

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WHAT IS CLAIMED IS:

1. An earth leakage breaker comprising power supply side terminals provided for a plurality of poles respectively, load side terminals provided correspondingly to said power supply side terminals for said respective poles, fixed contact carriers electrically connected to said power supply side terminals, movable contact carriers provided in opposition to said fixed contact carriers, conductors electrically connected to said movable contact carriers and said load side terminals, a zero phase current transformer through which said conductors for said plurality of poles are disposed, an earth leakage detection means for detecting earth leakage on the basis of an output of said zero phase current transformer, and a breaker mechanism for opening said movable contact carriers on the basis of an output of said earth leakage detection means, wherein each of said conductors is formed into a flat bar, and the conductor for at least one of said plurality of poles has a bent portion near a portion being disposed through said zero phase current transformer; and said zero phase current transformer has a magnetic shield portion provided in a portion thereof opposite to said bent portion.

2. An earth leakage breaker comprising power supply side terminals provided for a plurality of poles respectively, load side terminals provided correspondingly to said power supply side terminals for said

respective poles, fixed contact carriers electrically connected to said power supply side terminals, movable contact carriers provided in opposition to said fixed contact carriers, conductors electrically connected to said movable contact carriers and said load side terminals, a zero phase current transformer through which said conductors for said plurality of poles are disposed, an earth leakage detection means for detecting earth leakage on the basis of an output of said zero phase current transformer, a breaker mechanism for opening said movable contact carriers on the basis of an output of said earth leakage detection means, and a housing shaped into a substantially rectangular parallelepiped so as to store at least said fixed contact carriers, said movable contact carriers, said conductors, said zero phase current transformer, said earth leakage detection means and said breaker mechanism, wherein each of said conductors for said plurality of poles are disposed near a bottom portion of said housing; said zero phase current transformer is disposed between said breaker mechanism and said load side terminals near said bottom portion of said housing; each of said conductors is formed into a flat bar and the conductor for at least one of said plurality of poles has a bent portion near a portion being disposed through said zero phase current transformer; said zero phase current transformer has an annular core and a magnetic shield portion provided in a portion of said core opposite to said bent portion, and

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is disposed so that an axial direction of said core is substantially parallel with a direction from said power supply side terminals toward said load side terminals; and said earth leakage detection means is disposed between an inner side of said housing opposite to said bottom portion and said zero phase current transformer.

3. An earth leakage breaker according to Claim 1, wherein said bent portion is U-shaped.

4. An earth leakage breaker according to Claim 2, wherein said bent portion is U-shaped.

5. An earth leakage breaker according to Claim 1, wherein said magnetic shield portion is U-shaped and installed in said zero phase current transformer.

6. An earth leakage breaker according to Claim 2, wherein said magnetic shield portion is U-shaped and installed in said zero phase current transformer.