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Raupach

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[45] **Nov. 13, 1973**

[54] **TRANSFORMER FOR PRODUCING OR MEASURING HIGH AND VERY HIGH POTENTIALS OR FOR MEASURING CURRENTS AT HIGH POTENTIALS IN CASCADE CONNECTION**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **336/94,** 336/173, 336/178, 336/212, 336/DIG. 2

[51] **Int. Cl.** **H01f 27/04,** H01f 40/00

[58] **Field of Search** 336/DIG. 2, 173, 336/178, 90, 94, 173, 178, 212

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Attorney—John J. McGlew et al.

[57] **ABSTRACT**

The transformer includes an iron core with low voltage and high voltage windings, or high voltage winding parts which are spaced from each other and connected by coupling windings. The iron core is constituted by two substantially identical iron core halves arranged with corresponding end faces in facing relation with each other. Each iron core half carries respective windings, and two separate casings are provided, each enclosing a respective iron core half and its associated windings. Each casing has an inner end wall and the cases are alignable with the inner end walls superposed in surface-to-surface engagement to define an interspace or gap separating facing corresponding end faces of the iron core halves. The dimensions of the gap are determined by the combined thickness of the inner end walls at the areas thereof aligned with the end faces of the iron core halves. The thicknesses of the end walls, at these areas which correspond to the cross-sections of the iron core parts, are reduced in accordance with the desired dimensions of the gap between the two iron cores. The inner end walls of the casings may be formed of non-magnetic material or of non-conductive material, and the side walls of the casings comprise insulating jackets with the interior of the casings being filled with a liquid or gaseous insulating medium. When used as a current transformer, particularly a linearized current transformer, the two core halves are provided with additional air gaps preferably distributed uniformly along each core half. Each casing may contain several iron core parts with each core part of one casing being provided with one secondary winding and with the parts being provided with one half of the coupling winding, while the iron core parts of the other casing are provided with the other half of the coupling winding and with a common primary winding. The transformer may comprise one unit of a multi-unit cascade-type voltage or current transformer in which the units are arranged one above the other or one beside the other and connected to form a cascade.

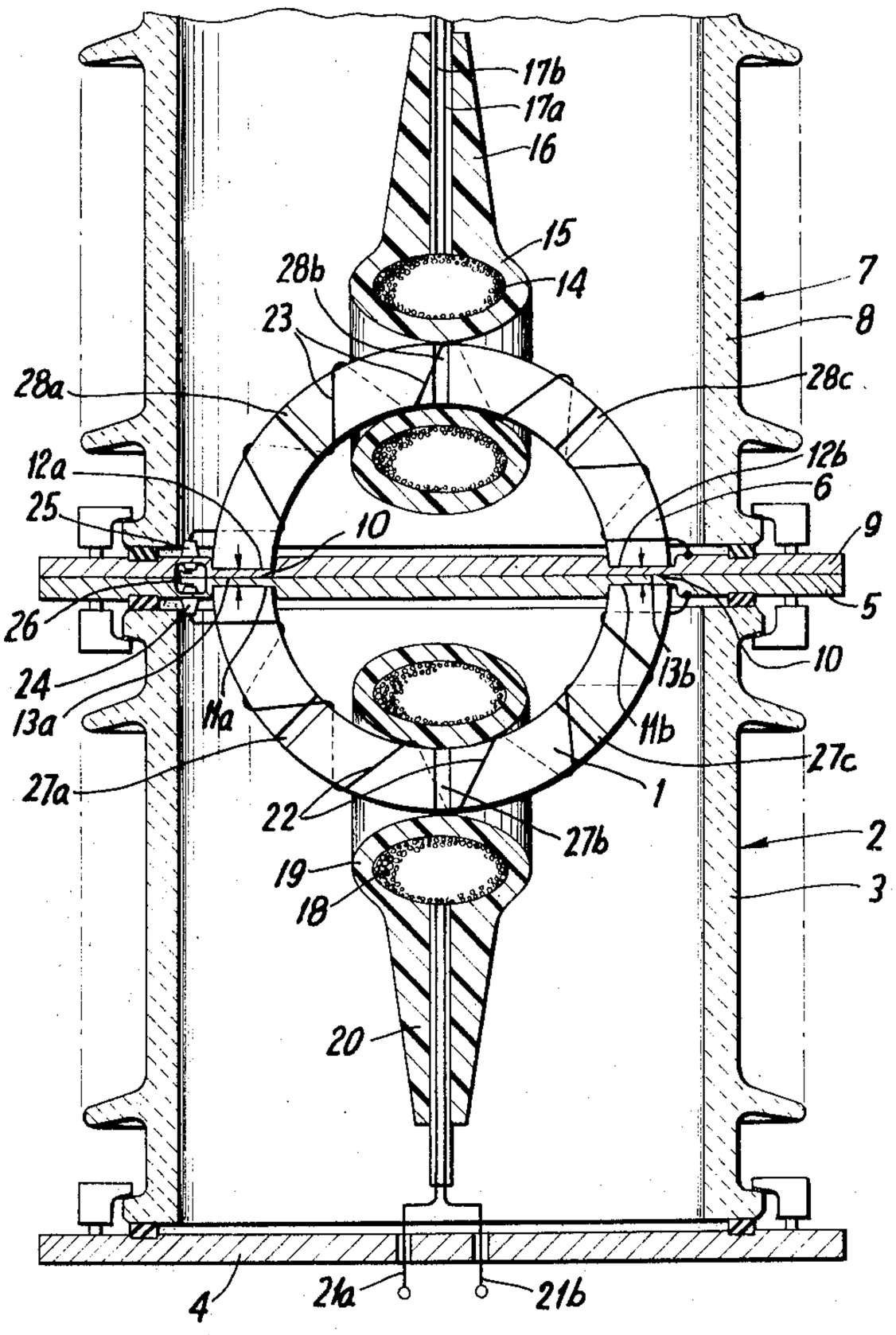
16 Claims, 2 Drawing Figures

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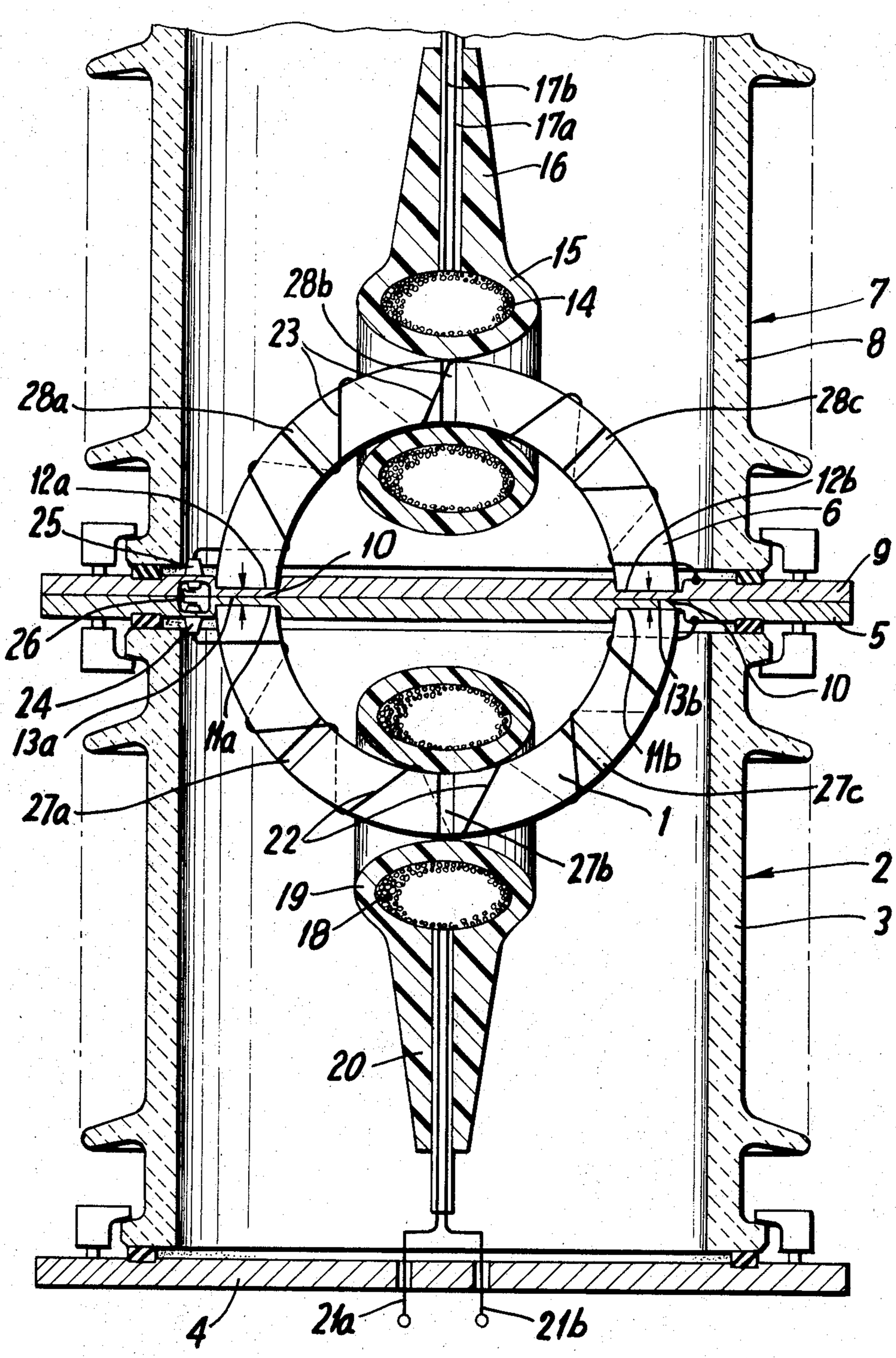

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13a
11a
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FIG. 1

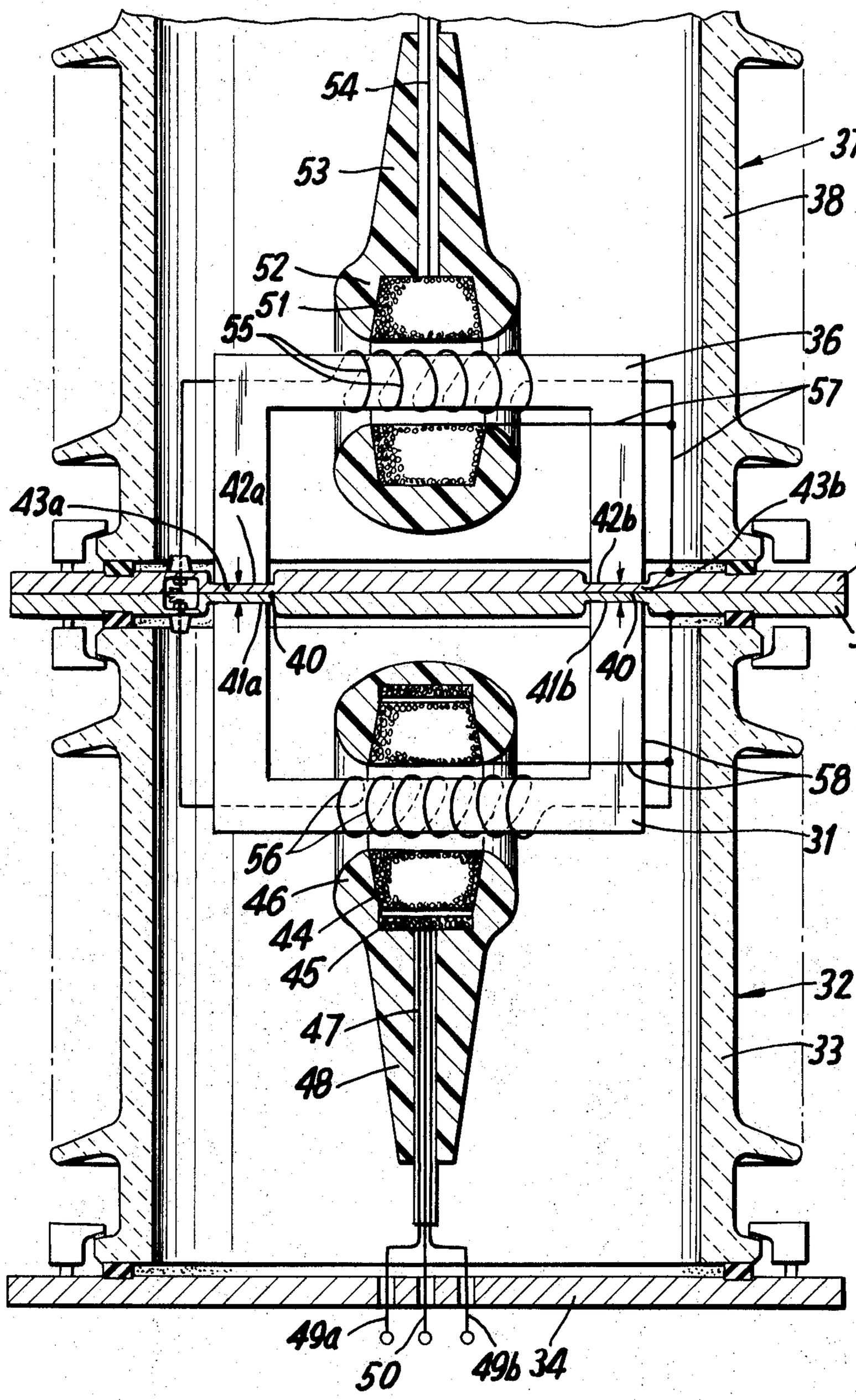

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FIG. 2

TRANSFORMER FOR PRODUCING OR MEASURING HIGH AND VERY HIGH POTENTIALS OR FOR MEASURING CURRENTS AT HIGH POTENTIALS IN CASCADE CONNECTION

FIELD AND BACKGROUND OF THE INVENTION

This invention relates to high voltage transformers and, more particularly, to an improved construction of high voltage transformers for producing or measuring high and very high voltages, or for measuring currents at high potentials in cascade connection.

Transformers for producing high voltages or potentials, and those for measuring high voltages, as well as current transformers for measuring currents at high potentials, are known, with the insulating problem being solved by using a dielectric cascade. The typical characteristics of a dielectric cascade reside in a core which is at approximately half the high voltage or potential, and exciting or high voltage windings, or high voltage winding parts, or primary and secondary windings, where the high voltage winding parts are responsible for the voltage reduction, toward the core, or for the voltage increase to a level of half the total voltage. The low voltage winding is connected with the high voltage winding, or with the high voltage winding parts, by means of coupling windings. In the case of extremely high and very high voltages, it is possible to combine, one above the other, several units, each of which may be formed as a dielectric cascade, and to connect these units to each other by means of coupling windings. However, this has the disadvantage of resulting in energy losses.

There are also known, in the prior art, current transformers with air gaps, to be used for the linear transformation of currents at high potentials, toward the secondary winding.

SUMMARY OF THE INVENTION

The invention is directed to a transformer for producing or measuring high and very high voltages, or for measuring currents at high potentials in cascade connection, and which transformer comprises an iron core and low voltage and high voltage windings, or high voltage winding parts, which are located in spaced relation to each other and interconnected by means of coupling windings.

In particular, the invention is directed to a new way of constructing transformers for operation at high and very high voltages or potentials. The problem underlying the invention is to design a transformer in such a manner that it can be used for high voltages up to maximum values, but with its weight and dimensions not impeding insulation or transportation, and not precluding conventional type transportation thereof by road or rail.

In accordance with the invention, this problem is solved by dividing the iron core into two identical, or substantially identical, parts, with each iron core part and its respective windings being accommodated inside a respective one of two separable casings which can be placed in superposition in such a manner that, when the two casings are superposed, an interspace is obtained between the end faces of the two iron core parts or halves. The dimensions of this interspace are determined by the combined thickness of the juxtaposed inner end walls of the two casings in the areas where

the ends of the two iron core halves face each other. The active parts of the transformer, that is, the iron core and the windings, are divided into two parts, in accordance with the invention, so that they can be accommodated in two different, separately manufacturable, transportable and installable transformer units. In this way, the weight and the dimension of the parts to be accommodated in one unit can be reduced even when the transformer is designed for high and very high voltages or potentials.

In further accordance with the invention the inner end walls of the two casings, in the areas thereof where the two iron core parts face each other, may have reduced thicknesses along areas corresponding to the cross-sections of the iron core parts. In this way, the gaps or interspaces formed by the juxtaposed inner end walls, which latter preferably are made of a non-magnetic electrically conductive material or of electrically non-conductive material, especially also in the case of large transformer units, have dimensions which may be desirable, or at least not disadvantageous. Another advantage is that the gaps, which are determined by the thickness of the interspace, can be adjusted to a desired value by appropriately calculating the cross-sectional reduction of the inner end walls at the points aligned with the facing ends of the two iron core parts. This adjustability of the gaps is advantageous, especially for the construction of current transformers, and preferably linear current transformers.

It is expedient for both casings to consist of a jacket of insulating or dielectric material and metal end walls, and to be filled with a liquid or gaseous insulating material. In this way, the transformer units will be completely independent further in terms of insulation. The two casings can be detachably connected with each other through the medium of the two inner end walls, which are juxtaposed to form the interspace between the iron core parts.

In the case of a transformer which, in accrdance with the invention, is designed as a current transformer, the two core limbs or parts may be provided with further air gaps, preferably evenly distributed over the lengths of the two core limbs or parts, in order to obtain a linearized current transformer. If the current transformer is to be used as a multiple-core transformer each of the two casings contains several iron cores, with each iron core section of one casing being provided with a secondary winding and one half of the coupling winding, while each of the iron core parts of the other casing is provided with the other half of the coupling winding and with the iron core parts having a joint primary winding.

Finally, the transformer according to the invention, may be used as one link of a multiple-unit cascade transformer, if the level of the operating voltage requires it or makes it seem appropriate. In this case, the arrangement can be such that the cascaded units are placed one above the other or one beside the other and connected to form the cascade.

An object of the invention is to provide an improved transformer construction for transformers operating at high and very high voltages.

Another object of the invention is to provide such a transformer construction whose weight and dimensions do not impede insulation or transportation, and do not preclude conventional type transportation by road or rail.

A further object of the invention is to provide such a transformer construction in which the iron core and its associated windings are divided into two identical or substantially identical parts which are accommodated in respective separable casings which may be superposed.

Yet another object of the invention is to provide such a construction in which an interspace between the iron core parts is obtained by superposed inner end walls of the two separable casings, with its thickness being determined by the combined thickness of the inner end walls in those areas aligned with the facing ends of the two iron core parts.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the Drawings:

FIG. **1** is a longitudinal sectional view through a current transformer, embodying the invention, in a one-step cascade connection; and

FIG. **2** is a longitudinal sectional view through a voltage transformer, embodying the invention, also in a one-step cascade connection.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, the casing **2**, containing one iron core half **1**, is formed by a jacket **3** of insulating or dielectric material, a base or outer end wall **4**, and a lid or inner end wall **5**. The second casing **7**, containing the other iron core half **6**, is formed by a jacket **8**, of insulating or dielectric material, a base or inner end wall **9**, and a terminal cap or outer end wall which has not been shown in the drawings and in which are accommodated, in a known manner, the primary connections and, if the transformer is to be reversible on the primary side, also the reversing means. The inner end walls **5** and **9** of the casings **2** and **7**, respectively, preferably are formed of a non-magnetic, electrically conductive material, such as aluminum or brass, or of an electrically non-conductive material such as plastic, ceramics, cast resin, or the like.

The cross-sections of the inner end walls **5** and **9** are so dimensioned that these can individually carry the weight of the liquid or gaseous insulating compound, preferably oil, inside the respective casings **2** and **7**, and possibly also the weight of the active parts of the current transformer within the respective casings. In the areas where the iron core halves or sections **1** and **2** face each other and contain inner end walls **5** and **9**, respectively, and form an interspace **10**, the inner end walls **5** and **9** are reduced in cross-section as at **11***a*, **11***b* and **12***a*, **12***b*, respectively. This reduction in cross-section should be such as to leave the thicknesses of inner end walls **5** and **9** at a magnitude sufficient to form gaps **13***a* and **13***b* of a predetermined length or dimension. Consequently, by appropriately dimensioning the cross-sectional reductions **11***a*, **11***b* and **12***a*, **12***b*, gaps **13***a* and **13***b*, between the facing ends of the iron core halves **1** and **6**, can be adjusted to the desired value. The cross-sectional reductions **11***a*, **11***b* and **12***a*, **12***b* can be effected in a known manner by milling, electro-erosion, or the like operations. Casings **2** and **7** are detachably interconnected through the medium of their respective inner end walls **5** and **9**, in the area of interspace **10** between the respective iron core sections **1** and **6**, for example by screw or clamping means.

Upper iron core section **6** is provided with the primary winding **14** whose insulation **15** is calculated for only half the voltage if the two iron core sections **1** and **6**, as is normal with one-step cascade connections, are subjected to a medium potential. The bushing **16** which is connected or integral with winding insulation **15**, and which is provided for the primary side connections **17***a* and **17***b* to which a high potential is applied, may be designed as a controlled bushing. In an analogous manner, the lower iron core section **1** is provided with the secondary winding **18** having insulation **19**, bushing **20** and secondary connections or leads **21***a* and **21***b*.

Coupling turns or windings **22** and **23** are wound directly onto the respective iron core sections **1** and **6**, and each has one end connected to the associated inner end member **5** or **9** of the respective casing, while the other ends of the windings **22** and **23** are interconnected through aligned bushings **24** and **25**, with the aid of a flexible connection **26**. If inner end walls **5** and **9** are formed of an insulating or dielectric material, such as a cast resin plate with glass fiber reinforcement, the first-mentioned ends of windings **22** and **23** are also connected to each other through bushing means.

If the transformer is to be used as a so-called linearized current transformer, whose transmission ratio must be linear in the over-current range up to several magnitudes of the primary rated current, it is an added advantage if the two iron core sections **1** and **6** are provided with further respective air gaps **27***a*, **27***b*, **27***c* and **28***a*, **28***b* and **28***c*, which are preferably evenly distributed over their circumferences. The gaps **13***a*, **13***b* and **27***a*, **27***b*, **27***c* and **28***a*, **28***b*, **28***c* are so dimensioned that their overall dimensions correspond to the total gap length required. Core parts **1** and **6**, with their respective windings **18**, **22** and **14**, **23** may be fixed in the transformer head or to the other end plate **4** in a known manner so as accurately to define the size of the gaps **13***a*, **13***b*. However, the cores also may be fixed to inner end walls **9** and **5**.

If the current transformer is to be designed as a multi-core transformer, it is possible to accommodate several cores or core halves in casings **2** and **7**. Inner end walls **5** and **9** then would be provided with a correspondingly increased number of areas having a reduced cross-section. If several cores are accommodated in casings **2** and **7**, each core has a secondary winding and a coupling winding, while the primary winding embraces all the cores conjointly. If it is intended that one or several of these cores serve as a measuring core, the additional air gaps **27***a* – **27***c* and **28***a* – **28***c* are provided. The effect of gaps **13***a* and **13***b*, in the case of measuring cores in which air gaps are not desired, can be compensated for in a known manner by providing shunt capacitors of appropriate dimensions at the secondary terminals. The current transformer forming the subject matter of the invention is particularly suitable to serve as one unit in a multi-unit cascade, wherein the individual units may be connected one above the other or one beside the other.

If the cross-sections of inner end walls **5** or **9** are not too large, it is possible to omit the cross-sectional reductions or to provide them in only one of the two inner end walls, preferably in the inner end wall **5**. It is also possible to locate the interspace **10** of the core

parts 1 and 6 offset toward the outer end of one of the two core parts rather than being located centrally of the two core parts, although this would result in an inferior core-window utilization factor which, in turn, would lead to an excessive structural height. However, this disadvantage could be avoided by using inner end walls 5 and 9 which have appropriate recesses and which should be arranged so that the windings located on the core sections having the shorter legs are at least partially located within these recesses.

Referring to FIG. 2, a voltage transformer, in accordance with the invention, has a frame-like iron core including a lower iron core half 31 arranged within a lower casing 32 comprising an insulating or dielectric jacket 33, an outer end wall 34 and an inner end wall 35. The second or upper iron core half 36 is accommodated in a second or upper casing 37 comprising an insulating or dielectric jacket 38, an inner end wall 39, and an outer end wall or terminal cover which has not been shown in the drawing. The cross-sectional reduction in the inner end walls, in the area of the junction interspace 40, are indicated at 41*a*, 41*b* and 42*a*, 42*b*, while the gaps formed thereby are indicated at 43*a* and 43*b*.

On lower iron core half 31, there is located one half 44 of the high voltage winding, which is preferably designed as a layer winding. The secondary winding 45 is applied onto the outer layer of high voltage winding half 44, and windings 44 and 45 are conjointly insulated, relative to iron core half 31 which is at one half the high voltage potential, by means of insulating jacket 46. A grounded metal tube 47, which is embraced by a bushing 48, accommodates the connecting wires or leads 49*a* and 49*b* of secondary winding 45, as well as that end 50 of high voltage winding 44 which is at ground potential, these leads being led out through outer end wall 34 to respective terminals. The other half 51 of the high voltage winding is located on the upper iron core half 36, and is connected in series with winding half 44. The insulation 52 and the bushing 53 for the high voltage connection 54 are designed analogously to the corresponding parts on the lower core limb 31.

The coupling windings 55, 56 are wound directly onto the respective core limbs 31 and 36, and one end of each coupling winding is connected with the respective inner end wall 39 or 35, while the other ends of the windings are interconnected directly with each other through bushings, as described in connection with FIG. 1. The two high voltage winding halves 44 and 51 are interconnected in series by means of connecting leads 57, 58 which are at a medium potential and which are connected with the iron core parts 31 and 36. The effect of the gaps 43*a*, 43*b* on the accuracy of measurement is compensated by the capacitance provided or by incorporating additional capacities. At the same time, this provides a means of assuring an even voltage distribution over the two casings.

With respect to the arrangement and design of the casing parts, such as the inner end walls 39 and 35, in the junction interspace 40 of iron core parts 31 and 36, the description given in connection with FIG. 1 applies analogously. The same applies with respect to the material of the casing parts. It is possible also in the case of the voltage transformer shown in FIG. 2 to arrange the interspace 40 of the two core parts 31 and 36 offset toward the outer end of one or the other of the two core parts.

Although the description of the invention has been directed essentially to a current transformer and a voltage transformer, it is not limited thereto. The voltage transformer shown in FIG. 2 also can be designed as a testing transformer, in which case, the winding 45 would be the exciting winding. Another possible embodiment in accordance with the invention in a combination current and voltage transformer. The preferred range of application of transformers embodying the invention is in the range from 380 kV up to the maximum existing or planned voltage levels. For voltages of 380, 500 and 750 kV, the transformer can be designed in accordance with the construction shown in FIGS. 1 and 2. With higher voltage ranges, two cascades or multicascades are preferred, with each unit of the cascade being designed in accordance with the invention.

While specific embodiments of the invention have beem shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. In transformers for producing high and very high voltages, for measuring high and very high voltages, and for measuring currents at high voltages, of the type including an iron core divided into two substantially identical iron core halves which, with their associated respective windings, are arranged in two superposable separable casings having inner end walls arranged to be superposed, the end faces of both iron core halves being positioned in the respective casings in engagement with the respective inner end wall such that, when the inner end walls are superposed with each other, the respective ends of the iron core halves are in facing relation with each other to define an interspace constituted by the thickness of the two inner end walls in the areas of the facing ends of the two iron core halves, the inner end walls being formed of non-magnetic material, the improvement comprising, in combination, respective coupling windings on each iron core half, each coupling winding being uniformly distributed over its associated iron core half; the adjacent ends of said two coupling windings being interconnected through said inner end walls.

2. In a transformer, the improvement claimed in claim 1, in which said inner end walls, at areas thereof aligned with and laterally coextensive with the end faces of said iron core halves, are reduced in thickness.

3. In a transformer, the improvement claimed in claim 2, in which the reduction in thickness of said inner end walls is calculated in accordance with the desired dimension of said interspace.

4. In a transformer, the improvement claimed in claim 1, in which each casing consists of a jacket of dielectric material and metal inner end walls defining an enclosure; and a filling of insulating medium in each casing.

5. In a transformer, the improvement claimed in claim 4, in which said insulating medium is liquid.

6. In a transformer, the improvement claimed in claim 4, in which said insulating medium is gaseous.

7. In a transformer, the improvement claimed in claim 1, in which said transformer is a current transformer; each of said iron core halves being formed with gaps which are in addition to said interspace, said gaps

providing for said current transformer to be used as a linearized current transformer.

8. In a transformer, the improvement claimed in claim **7**, in which said last-named gaps are distributed evenly along the length of each iron core half.

9. In a transformer, the improvement claimed in claim **1**, in which said transformer is a current transformer; each casing containing plural iron core parts each cooperable with a respective iron core part in the other casing; each iron core part in one casing having a respective secondary winding in one half of the associated coupling winding; each iron core part in the other casing being provided with the other half of the respective coupling winding, and all the iron core parts in said other casing having a joint primary winding.

10. In a transformer, the improvement claimed in claim **1**, in which said transformer is adapted to constitute one unit of a multi-unit cascade-type current transformer.

11. In a transformer, the improvement claimed in claim **1**, in which said transformer is adapted to constitute one unit of a multi-unit cascade-type voltage transformer.

12. In a transformer, the improvement claimed in claim **1**, in which the transformer is a potential transformer for measuring high and very high voltages.

13. In a transformer, the improvement claimed in claim **1**, in which said transformer is a current transformer for measuring currents at high voltages.

14. In a transformer, the improvement claimed in claim **1**, in which said transformer is a testing transformer for producing high and very high voltages.

15. In a transformer, the improvement claimed in claim **1**, in which said inner end walls consist of a nonmagnetic material; the ends of said two coupling windings being connected together through ducts provided in said inner end walls.

16. In a transformer, the improvement claimed in claim **1**, in which said end walls consist of a nonmagnetic electrically conductive material; each coupling winding having at least one end electrically connected to its associated inner end wall.

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