Aug. 5, 1941. B. OLSSON 2,251,373

HIGH TENSION TRANSFORMER

Filed June 28, 1938 2 Sheets-Sheet 1

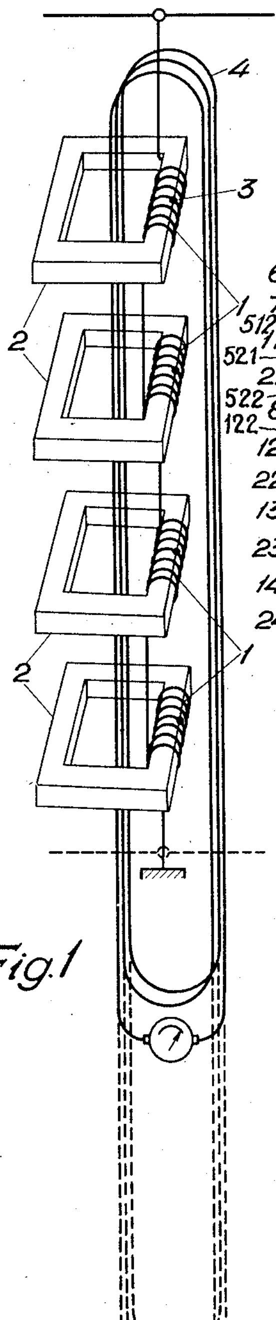

Fig.1

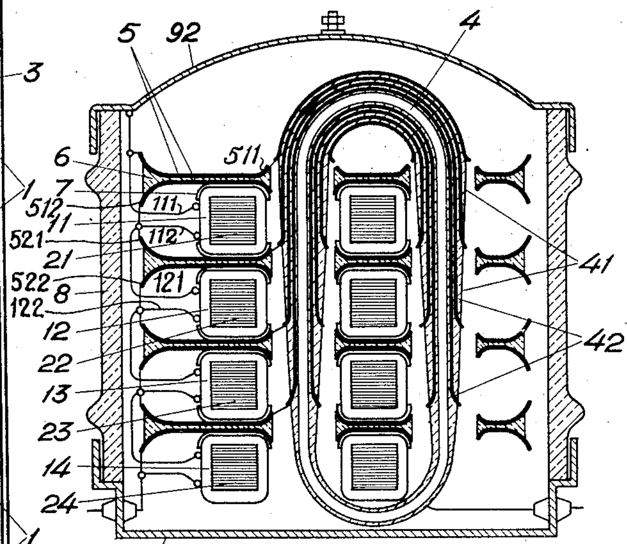

Fig.2

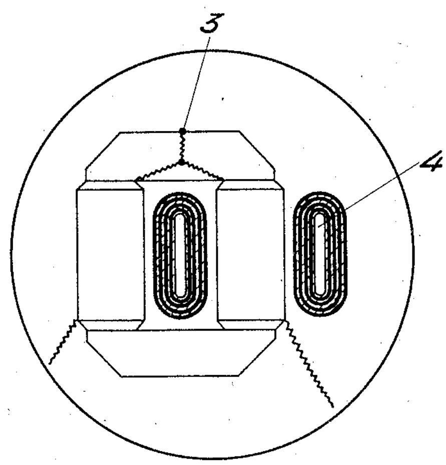

Fig.3

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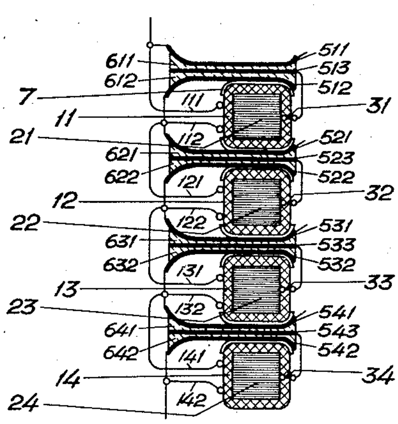
Fig. 4



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HIGH TENSION TRANSFORMER

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8 Claims. (Cl. 175—358)

In ordinary cascade connection of transformers the high tension winding is divided into two or several series connected parts each with its own closed iron core while the low tension winding is only arranged on that part which has one pole connected to ground in service. The connection simplifies the insulation problem but gives such a small load capacity that it has not found any considerable application.

According to the present invention, which means partial cascade connection, the insulation problem is simplified in comparison with the conventional construction of high tension transformers but the load capacity is not reduced. The arrangement may be adapted to all high tension transformers but preferably to potential transformers, particularly for grounding purposes, reactors with secondary winding and testing transformers. The principle of the connection is that the high tension winding is divided into two or more series connected parts, each with its own closed iron core which is connected to a point on the high tension winding of the part in question and that all turns of the low tension winding interlink with all the cores or the main part of the cores.

The attached drawings illustrate the invention diagrammatically.

Fig. 1 shows the general arrangement.

Fig. 2 is a longitudinal section and

Fig. 3 a transverse section of a grounding transformer.

Fig. 4 is a detail longitudinal section of an alternative arrangement of the primary high tension side of the transformer.

The high tension winding is divided into four parts **1** which are series connected and arranged each on its own core **2**. The core is in conductive connection with a point of the high tension coil of the part in question by means of the connecting lead **3**. The low tension winding is drawn as a long coil **4**.

As the low tension winding has practically ground potential it must be insulated from the high tension winding and from the iron core with sufficient insulation for the high tension potential to ground of the part in question. Such insulation is, however, very easily established on account of the simple, geometrical shape and small volume of the low tension winding and the absence of essential potential differences in the same. If paper insulation is used and if this is arranged in the same way as cable insulation, the insulation will not be very bulky. The arrangement is also well adapted for the use of porcelain as insulation on the outside of the low tension winding for such voltages for which porcelain is sufficient.

The insulation between the high tension winding and the cores will be a minimum as in ordinary cascade transformers. The arrangement thus profits by the greatest advantage of the cascade transformer. The drawback of the conventional cascade transformer is mainly that the load capacity is remarkably small in spite of equalizing windings. This depends upon the great leakage between the high and low tension winding which drawback is avoided by the new arrangement as this leakage is substantially the same as in an ordinary transformer with the two windings covering each other in the ordinary way. When used as potential transformer the arrangement therefore practically obtains the same high measuring accuracy and large load capacity as a conventional potential transformer. Contrary to such a one it has, however, the advantage of a considerably reduced insulation quantity.

By reason of the cascade division of the high voltage winding the component units, each comprising a core with its individual part of the high voltage winding, may be mounted one upon the other in superposed order with insulating layers between the parts, thus forming a vertical stack. The capacities between the parts are then constituting an inherent condenser made up of a chain of series connected elements. The capacity of this condenser may be increased in a simple manner by means of metallic layers in the insulation between the high voltage parts and on the outside of these and if required also in the insulation between the low tension winding and the high voltage parts. Each metallic layer may be suitably connected to the high voltage winding at a point thereon which, at normal frequency, carries the same potential as the metallic layer receives electrostatically. At steep fronts of the voltage waves the wave substantially passes through the condenser chain as this offers less resistance than the winding. The voltage is thereby distributed over the part condensers in accordance with their individual capacities and the connecting points between the part condensers are compelled to take the voltage fixed by the condensers. As the capacities of the part condensers are adjusted to have as near as possible the same proportion to each other as the impedances of the winding parts have to each other internally at normal frequency, overvoltages will be distributed on the winding parts in the same proportion as normal voltage. The voltage distribution within the winding at steep wave front will be substantially different from that at normal frequency if no special steps are taken. The more parts the winding is divided into the less will be the possible maximum impulse voltage between the adjacent turns within the winding. Instead of dividing the high voltage winding into a greater number of parts an additional metallic layer may be introduced for each part winding and so located in relation to the previously mentioned metallic layers that two new part condensers of equal capacity will be formed. These additional metallic layers are to be connected to the mid-point of the corresponding winding part, thereby dividing the voltage on the winding part equally on both halves thereof. The mid-point of the winding part is conveniently accessible if, as is practical, the part core has been connected to this point. With a sufficient number of such part capacitances to govern the voltage distribution within the winding, the arising of dangerous voltage concentration from surges due to atmospheric discharge or the like are avoided. The stack arrangement of the component parts as previously described is favorable especially because it facilitates the mounting of the transformer within a supporting shell of ceramic material or Bakelized paper or other Bakelite products or the like whereby the space required by the transformer will be very small.

The insulation between the parts in the high tension stack gets a simple form and can easily be composed of solid insulating material, for instance impregnated pressboard or ceramic material, and the conductive layers can for instance be made by metal squirting of suitable surfaces of these intermediary insulating walls. Moreover the conductive layers may be arranged for artificial governing of the voltage drop along the outer sides of the stack, for instance provided with rounded edges, protruding outside the stack.

As the insulation to ground is such that for moderately high voltages all parts of this insulation can be made of ceramic material or partly from ceramic material and partly from paper material, solidly impregnated, the transformer will not require any filling with oil or other insulation liquid or compound at these voltages. If oil impregnated paper is used for the highest voltages as insulation on the outside of the low tension winding, the design requires a particularly small oil quantity. From fire risk point of view it is advantageous to have unfilled constructions or at least constructions with a minimum of oil.

The design of the above-described transformer as grounding transformer is shown in the diagrammatic Figs. 2 and 3. The high tension winding is divided into four parts 11, 12, 13 and 14 each laid on its own laminated core 21, 22, 23 and 24. Each winding part is drawn as wound on two legs of the rectangularly drawn core because the connections between the parts will then appear most clearly on the figure. The circumferential distribution of the turns of each high voltage winding part on its core has however nothing to do with the cascade principle but is determined solely by the requirements on the reactance of the transformer. The core in each part is in conductive connection with a point on the high tension winding of the part by means of the lead 3. The low tension winding 4 is drawn as a single coil, but may also be made as two or several coils each coil interlinking with its own set of core legs. The number of coils and the arrangement of the same in relation to the high tension coils have influence on the leakage of the transformer. The insulation 41 between the low tension winding and the high tension winding is assumed to be an insulation body of for instance paper provided with conducting coatings on each layer similar to the insulation of a condenser bushing. Between the high tension parts in the stack of high tension coils and cores conductive coatings or sheet metal plates 5 applied on both sides of insulation spacers 6 are also inserted. These coatings are connected to the end points of the adjacent high tension coils so as to form a series condenser chain. Thus the end leads 111, 112 of the first coil 11 are connected to coatings 511 and 512 respectively. End leads 121, 122 of the second coil 12 are connected to coatings 521 and 522 respectively and so on for the other coils. These condenser plates together with the condenser layers in the insulation wall of the low tension winding are as far as possible, so dimensioned that they independently from the potential governing property of the winding will divide the voltage between them in the same manner as the voltage is distributed on the corresponding winding parts in proportion to the number of turns in each part. The condenser layers are connected to the corresponding interconnection between the high tension parts. If a further voltage division is desired by means of condensers more condenser layers may be inserted in a corresponding manner. Such an arrangement is shown in Fig. 4, where the insulation spacers are each made in two halves 611 and 612, 621 and 622, 631 and 632, 641 and 642 and intermediary coatings 513, 523, 533 and 543 applied between them, which coatings are connected to the middle-points 31, 32, 33, 34 of the coils 11, 12, 13, 14 respectively. The insulation between the condenser plates (Fig. 2) consists of discs 6 of solid insulation material, for instance porcelain or impregnated paper. The high tension winding is insulated from the adjacent condenser plate of other potential by means of intermediary solid insulation layers 7. For the rest the stack is filled up with spacing pieces so that it is straight and rigid. It is inserted in a porcelain shell 8 which is axially pressed in between the grounded bottom 91 and the high tension carrying top cover 92 and fastened to these by cementing, for example.

In transformers with complete insulation to ground for the whole high tension winding the construction will be principally similar to the above, but the transformer is provided with an additional porcelain shell inserted between the present shell and the bottom of the transformer. The additional shell is of such a height as to insulate to ground for the full working voltage. The low tension coil is extended downward to the level of the secondary terminals as indicated in broken lines on Fig. 1. The insulation of the low tension winding must partly be increased in such a manner that the innermost conductive layer is insulated from the low tension winding for the full working voltage. This is best done by extending the low tension winding downward and providing it with such insulation covering that no flash-over can take place from said innermost layer to the low tension winding or to the low tension terminals or to the bottom of the case. This insulation covering may be designed with condenser insertions for the purpose of better voltage governing. The bottom terminals of the high tension winding are taken out in a suitable manner in the joint between the porcelain shells.

I claim as my invention:

1. A high tension transformer of the character described, comprising a primary high tension winding divided into at least two series connected coils, a closed iron core for each of said winding coils, a link-shaped secondary low tension winding interlinking with the main part of said cores and comprising a plurality of turns, an insulation spacer positioned between the primary high tension coils, conducting coatings applied on both sides of said spacer, the end points of the coil being connected to the two coatings to form a condenser in shunt of the coil, and such condensers being so dimensioned that, even without potential governing by means of the winding, they divide the voltage between them in, as far as possible, the same manner as the voltage is divided in accordance with the winding turns of the corresponding coils of the high tension winding.

2. A high tension transformer of the character described, comprising a primary high tension winding divided into at least two series connected coils, a closed iron core for each of said winding coils, a connection from each core to its own coil, a link-shaped secondary low tension winding interlinking with substantially all of the said cores and comprising a plurality of turns, insulating spacers positioned between the primary high tension coils, conducting coatings applied on said spacers, the end points of the coil and the core being connected to said coatings to form two approximately equal capacities in shunt of the coil, and such condensers being so dimensioned that, even without potential governing by means of the winding, they divide the voltage between them in, as far as possible, the same manner as the voltage is divided in accordance with the winding turns of the corresponding coils of the high tension winding.

3. A high tension transformer of the character described, comprising a primary high tension winding divided into at least two series connected coils, a closed iron core for each of said winding coils, a link-shaped secondary low tension winding interlinking with the main part of said cores and comprising a plurality of turns, insulation for the secondary low tension coil, conducting coatings applied within and outside such insulation, an insulation spacer positioned between the primary high tension coils, conducting coatings applied on both sides of said spacer the said conducting coatings being connected together and to the end points of the coil to form a condenser in shunt of the coil, these condensers being so dimensioned that, even without potential governing by means of the winding, they divide the voltage between them in, as far as possible, the same manner as the voltage is divided in accordance with the winding turns of the corresponding coils of the high tension winding.

4. A high tension transformer of the character described, comprising a primary high tension winding divided into at least two series connected coils, a closed iron core for each of said winding coils, a connection from each core to its own coil, a link-shaped secondary low tension winding interlinking with substantially all of the said cores and comprising a plurality of turns, insulating spacers positioned between the primary high tension coils, conducting coatings applied on said spacers, insulation for the low tension coil, conducting coatings applied within and outside such insulation and connected to the coatings applied to said spacers, and the end points of the high tension coil and the core being connected to said coatings to form two approximately equal capacities in shunt of the coil, these condensers being so dimensioned that, even without potential governing by means of the winding, they divide the voltage between them in, as far as possible, the same manner as the voltage is divided in accordance with the winding turns of the corresponding coils of the high tension winding.

5. A high tension transformer of the character described, comprising a primary high tension winding divided into at least two series connected coils, a closed iron core for each of said winding coils, a link-shaped secondary low tension winding interlinking with the main part of said cores and comprising a plurality of turns, an insulation spacer positioned between the primary high tension coils, conducting coatings applied on both sides of said spacer, the end points of the coil being connected to the two coatings to form a condenser in shunt of the coil, and such condensers being so dimensioned that, even without potential governing by means of the winding, they divide the voltage between them in, as far as possible, the same manner as the voltage is divided in accordance with the winding turns of the corresponding coils of the high tension winding, the said winding coils being arranged in a stack, and the said coatings being in the form of discs with the axis substantially parallel with the axis of the stack, and certain of said coatings having equal potential difference, being shaped to protrude outside the stack for artificially governing the voltage drop along the outer sides of the stack.

6. A high tension transformer of the character described, comprising a primary high tension winding divided into at least two series connected coils, a closed iron core for each of said winding coils, a connection from each core to its own coil, a link-shaped secondary low tension winding interlinking with substantially all of the said cores and comprising a plurality of turns, insulating spacers positioned between the primary high tension coils, conducting coatings applied on said spacers, the end points of the coil and the core being connected to said coatings to form two approximately equal capacities in shunt of the coil, these condensers being so dimensioned that, even without potential governing by means of the winding, they divide the voltage between them in, as far as possible, the same manner as the voltage is divided in accordance with the winding turns of the corresponding coils of the high tension winding, the said winding coils being arranged in a stack, and the said coatings being in the form of discs with the axis substantially parallel with the axis of the stack, and certain of said coatings having equal potential difference, being shaped to protrude outside the stack for artificially governing the voltage drop along the outer sides of the stack.

7. A high tension transformer of the character described, comprising a primary high tension winding divided into at least two series connected coils, a closed iron core for each of said winding coils, a link-shaped secondary low tension winding interlinking with the main part of said cores and comprising a plurality of turns, insulation for the low tension coil, conducting coatings applied within and outside the said insulation, an

insulation spacer positioned between the primary high tension coils, conducting coatings connected to the said coatings and applied to both sides of said spacer and the end points of the coil being connected to the two coatings to form a condenser in shunt of the coil, these condensers being so dimensioned that, even without potential governing by means of the winding, they divide the voltage between them in, as far as possible, the same manner as the voltage is divided in accordance with the winding turns of the corresponding coils of the high tension winding, the said winding coils being arranged in a stack, and the said coatings being in the form of discs with the axis substantially parallel with the axis of the stack, and certain of said coatings having equal potential difference, being shaped to protrude outside the stack for artificially governing the voltage drop along the outer sides of the stack.

8. A high tension transformer of the character described, comprising a primary high tension winding divided into at least two series connected coils, a closed iron core for each of said winding coils, a connection from each core to its own coil, a link-shaped secondary low tension winding interlinking with substantially all of the said cores and comprising a plurality of turns, insulation for the low tension coil, conducting coatings applied within and outside the said insulation, insulating spacers positioned between the primary high tension coils, conducting coatings connected to said coatings and applied to said spacers, and the end points of the coil and the core being connected to said coatings to form two approximately equal capacities in shunt of the coil, these condensers being so dimensioned that, even without potential governing by means of the winding, they divide the voltage between them in, as far as possible, the same manner as the voltage is divided in accordance with the winding turns of the corresponding coils of the high tension winding, the said winding coils being arranged in a stack, and the said coatings being in the form of discs with the axis substantially parallel with the axis of the stack, and certain of said coatings having equal potential difference, being shaped to protrude outside the stack for artificially governing the voltage drop along the outer sides of the stack.

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