

Nov. 2, 1948.

G. CAMILLI

2,452,901

ELECTROMAGNETIC INDUCTION APPARATUS

Filed Aug. 16, 1944

2 Sheets-Sheet 1

Fig. 1.

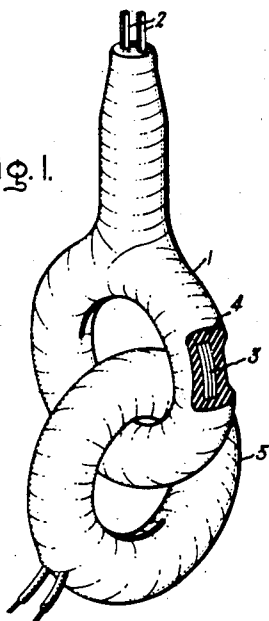


Fig. 2.

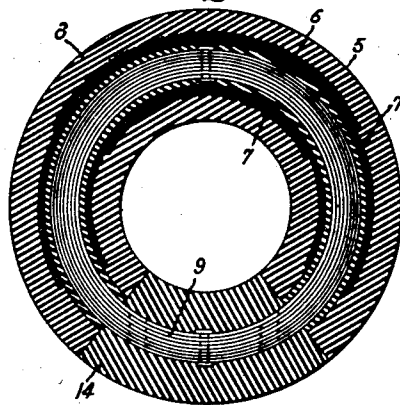


Fig. 3.

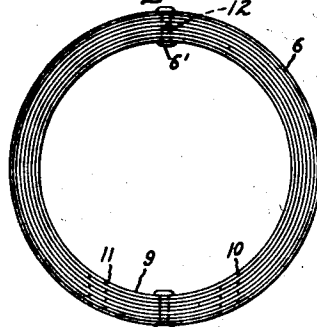


Fig. 8.

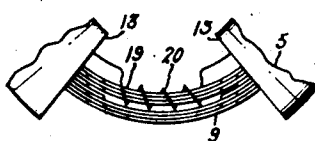


Fig. 5.

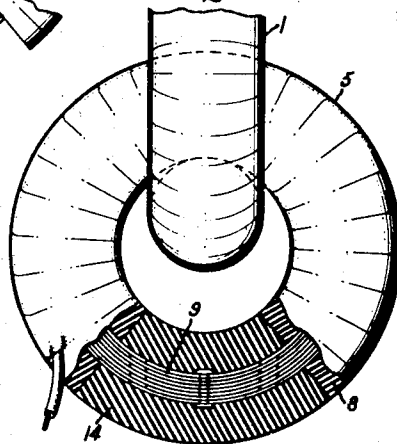
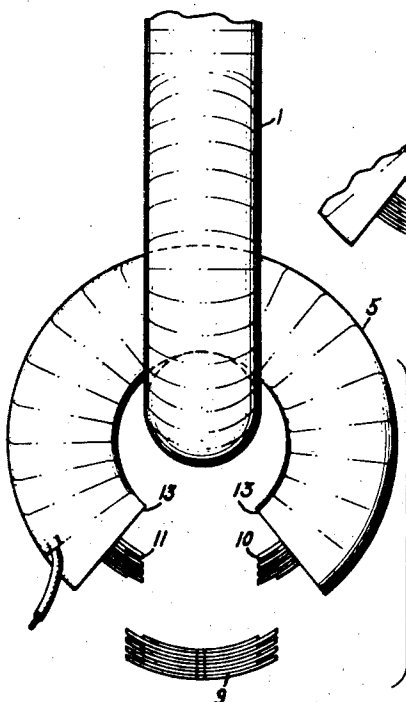


Fig. 4.



Inventor.
Guglielmo Camilli,
by *Harry E. Dinkens*
His Attorney.

Nov. 2, 1948.

G. CAMILLI

2,452,901

ELECTROMAGNETIC INDUCTION APPARATUS

Filed Aug. 16, 1944

2 Sheets-Sheet 2

Fig. 6.

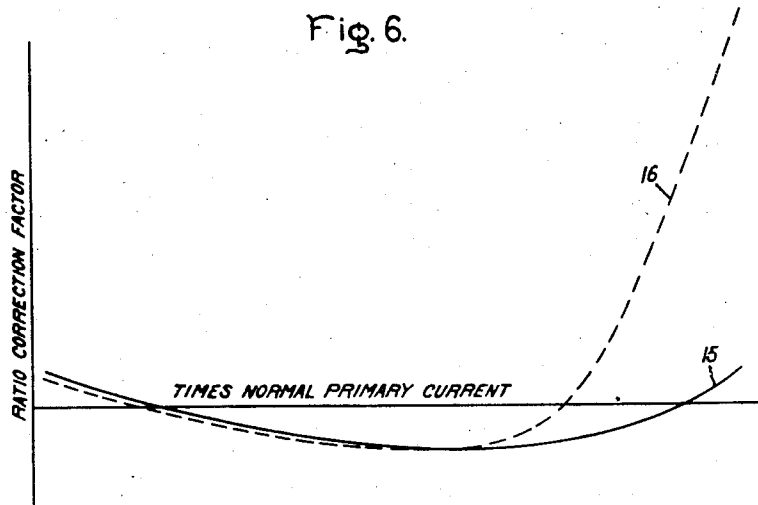
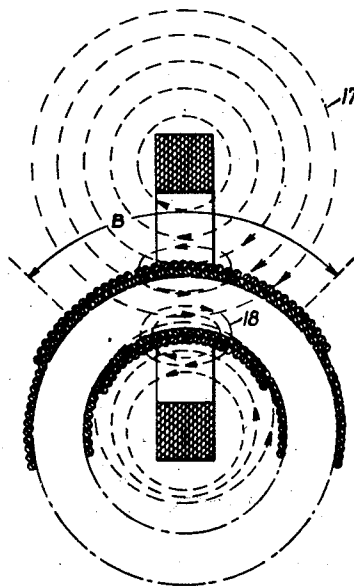


Fig. 7.



Inventor:
Guglielmo Camilli,
by *Harry E. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

2,452,901

ELECTROMAGNETIC INDUCTION
APPARATUSGuglielmo Camilli, Pittsfield, Mass., assignor to
General Electric Company, a corporation of
New York

Application August 16, 1944, Serial No. 549,779

6 Claims. (Cl. 175—358)

1

My invention relates to an electromagnetic induction apparatus having an interlinking primary winding and core member with a secondary winding distributed around the core member, and a method of producing the assembled interlinking primary winding and core member.

An object of my invention is to provide an improved electromagnetic induction apparatus having a primary winding and an interlinking closed core with a secondary winding distributed around the core, which apparatus is efficient in operation and simple to manufacture.

A further object of my invention is to provide an improved high voltage current transformer in which the ratio correction factor will be substantially constant over a relatively wide range of primary current.

A further object of my invention is to provide an improved method of producing an assembled insulated toroidally shaped primary winding and an interlinking insulated core member with a secondary winding distributed around the core member.

Further objects and advantages of my invention will become apparent from the following description referring to the accompanying drawing, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

In the drawing Fig. 1 is a perspective view illustrating an electric induction apparatus which is provided with an embodiment of my invention; Fig. 2 is a sectional side elevation of the core member and secondary winding of the apparatus of Fig. 1; Fig. 3 illustrates the core construction of Fig. 2; Figs. 4 and 5 illustrate the construction of Figs. 1 and 2 during the various steps of my improved method of assembly; Fig. 6 is a graph illustrating the ratio correction factor of the apparatus of Fig. 1 when applied as a high voltage instrument current transformer as compared with that of a prior arrangement; Fig. 7 diagrammatically represents the primary and secondary windings and their leakage fluxes and which will be used in explaining the results obtained with my apparatus which is shown in Fig. 6, and Fig. 8 illustrates a modification of the construction of Fig. 1.

In the drawing, I have illustrated my invention as applied to a high voltage instrument current transformer, but it will be understood that my invention may be employed with any other suitable type of electromagnetic induction apparatus.

Referring to Fig. 1 of the drawing, I have illus-

2

trated a transformer including a primary winding 1 having a generally toroidal shape construction with leads 2. The primary winding 1 may be of any suitable type and includes a few turns 3 which are surrounded with a relatively large thickness of insulation 4, and such a winding construction is described in further detail in my Patent 2,280,625, patented April 21, 1942, and assigned to the same assignee as this present invention. An insulated toroidally shaped member 5 links the toroidally shaped insulated primary winding 1 as is illustrated in Fig. 1, and as is shown more particularly in Fig. 2, the member 5 includes a core member 6 with a secondary winding 7 passing through and around the core member 6 and distributed around a portion of the periphery. A suitable amount of insulation 8 is built up through and around the core member 6 with the secondary winding 7.

As the particular construction illustrated in Figs. 1 and 2 is designed for relatively high voltage, a relatively large amount of insulation is placed both around the primary winding and the distributed secondary winding. This insulation may be distributed around the respective toroidally shaped members in any suitable manner, and it has been customary in the art to build up the insulation by winding and distributing through and around the toroidally shaped members layers of crepe paper until the desired thickness of layer insulation is obtained. In the construction described below, however, it will be understood that with the two doughnut members interlinking each other that one doughnut gets in the way as the insulation is built up on the other doughnut, and the more insulation is built up the less room there is for the operator to pull the layers of paper through and around the insulated members.

In order therefore to provide a construction in which the two toroidally shaped members may be separately insulated before they are assembled and also so as to provide a very efficient resulting construction which is particularly adapted to high voltage instrument current transformers, I provide a core member 6 which has a removable yoke portion 9, and the secondary winding 7 is distributed around the core portion 6 which passes through the winding window of the primary winding. The insulation 8 may therefore be built up around the core member and secondary winding 7 before it is interlinked with the insulated primary winding. Any suitable type of core construction may be employed and in the construction illustrated in the drawing I provide a core which in-

3

cludes a plurality of curved sheets of magnetic material providing a portion 6 and a removable yoke portion 9 which fits between edges 10 and 11 of the ends of the core portion 6. The core may be formed in any suitable manner such as by assembling the core from two stacks of sheets of magnetic material, one stack forming the core portion 6 and the other stack forming the core portion 9. It will be noted that the various sheets which make up the core portion 6 are longitudinally displaced so as to provide an overlap butt joint in the joint areas 10 and 11. This may be accomplished in any suitable manner such as by providing openings 12 in the various sheets which form the core portion 6 which openings are slightly displaced from the longitudinal center of each of the sheets and then longitudinally reversing the sheets so that the end of one sheet will extend outwardly from the end of the next adjacent sheet. A rivet 6' may be provided through the openings 12 to hold the sheets together. For a more complete description of such a core construction and the method of forming such a core reference may be made to a copending Somerville application S. N. 536,748, filed May 22, 1944, and assigned to the same assignee as this present invention.

The electromagnetic induction apparatus as assembled in Fig. 1 may be produced in any suitable manner, and I have found a very convenient and improved method as follows: After a core construction, as is illustrated in Fig. 3, has been assembled and annealed, the winding 7 will be wound through and around the core portion 6 and distributed around only a portion of the total periphery of the core so that the winding 7 will be concentrated in that general portion of the core which passes through the primary winding window. This is accomplished by providing two layers of winding on the core portion 6 in the vicinity of the core under the primary winding. Suitable insulation 8 may then be applied to the core 6 and secondary winding 7 such as by winding on to a suitable thickness a flexible strip of insulating material such as crepe paper. The primary winding insulation may also be applied to the primary winding 3 in the same manner, that is by winding a plurality of layers of a suitable flexible insulating material such as crepe paper to the desired thickness around the primary winding as well as the leads 2. After the desired amount of insulation has been placed on the core and secondary winding, the toroidally shaped insulated primary winding may be passed through the space between the ends 10 and 11 of the core portion 6, and it will be understood that the ends will be spaced apart to have a distance approximately equal to the thickness of the insulated primary winding 1. After the primary winding 1 has been assembled with the partially completed core and insulated secondary winding in the manner illustrated in Fig. 4, the removable yoke portion 9 may be inserted so that the various sheets of the yoke portion will have the same relative position they had when the complete core member was removed from the strain relief anneal. Thus the various sheets of the yoke members may be inserted as a group, or the sheets may be inserted individually into their proper position. The space between the ends 13 of the insulation 8 may then be filled with suitable insulation 14 such as by winding on a plurality of layers of crepe paper in the manner described above.

My construction as described above not only may be formed in the very efficient and conven-

4

ient manner but I have found that such a construction produces a much more efficient high voltage instrument current transformer than in the prior art constructions where the secondary windings are distributed entirely all the way around the periphery of the core member. Thus I have illustrated in Fig. 6 a curve ratio correction factor vs. primary currents and it will be understood that the ratio correction factor is that factor with which the secondary winding current must be multiplied to obtain the true indication of the primary current. It is conventional to provide ratio corrections factors with instrument current transformers since the secondary winding current does not bear a constant ratio to the primary winding current due to the inherent losses of such a type of apparatus. In Fig. 6 the ratio correction factor is plotted on the ordinate axis and the times normal primary current on the abscissa axis. The curve indicated by the numeral 15 is the ratio correction factor curve of a high voltage instrument current transformer formed according to my invention as has been described above, while the curve illustrated by the numeral 16 is that of a transformer with the secondary winding having the same thickness all the way around the core periphery, or with a secondary winding distributed all the way around the periphery of the core. It will be noted that the characteristics of my improved transformer construction are much flatter than those of the prior art, thus making it much more convenient to be employed in metering and relaying operations. It appears that the reason that the ratio correction factor is a much flatter curve is that during overloads when the core tends to be saturated by leakage flux of the primary winding, by concentrating the secondary winding under the primary winding, that is in the zone marked B in Fig. 7, most of the leakage flux of the primary winding will be forced out or counteracted by the leakage flux produced by the current flowing in the secondary winding. This is diagrammatically shown in Fig. 7 in which the primary winding leakage flux is shown by the lines 17 while the secondary leakage flux is shown by the lines 18. With my improved construction the secondary winding leakage flux more effectively counteracts the primary winding leakage flux and keeps it out of the core, while in the construction where the secondary winding is distributed entirely around the periphery of the core, the primary winding leakage flux will pass through the core and prematurely saturate the core member and thus increase the core losses and magnetizing current, thus causing a larger ratio correction factor at heavier overload currents to obtain an indication of the primary current.

It will be understood that an instrument current transformer formed according to the above will facilitate the application of partial compensation, and in Fig. 8 I have illustrated a similar construction in which a portion of the secondary winding passes through a part 19 of the removable yoke portion as some of the sheets which make up the removable yoke portion 9 have been left out, thus leaving a space through which turns 20 may be threaded. It will be understood by merely leaving out a couple of sheets in any particular part of the removable yoke portion that the relative portion of the core which is linked by the partial turns 20 may be controlled.

Although I have shown and described particular embodiments of my invention, I do not desire to be limited to the particular embodiments de-

scribed, and I intend in the appended claims to cover all modifications which do not depart from the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An electromagnetic induction apparatus including a winding having a winding window, a closed magnetic core passing through the winding window, only a small fraction of the length of said core being in said window, and a second winding passing through and around said core member; said second winding having an inner layer which extends over most of the circumference of said core and having an outer layer which is symmetrically disposed on said inner layer but which extends only over the portion of the inner layer which is in the vicinity of said winding window so as to facilitate cancellation of leakage flux of said first winding by a bucking flux of said second winding.

2. An electromagnetic induction apparatus including a toroidally shaped primary winding, a toroidally shaped core member linking said primary winding, said primary winding surrounding only a small part of the circumference of said core, and a secondary winding passing through and around said core member, said secondary winding having an inner layer which extends over most of the circumference of said core and having an outer layer which is symmetrically disposed on said inner layer but which extends only over the portion of the inner layer which is in the vicinity of said winding window, so as to minimize the passage of primary winding leakage flux through said core member.

3. An electromagnetic induction apparatus including a primary winding having a winding window, a closed core member having a portion passing through said winding window and a removable yoke portion, a secondary winding passing through and around said core member and being concentrated around said portion of said core member passing through said winding window, separate insulation surrounding said primary winding and said secondary winding, said removable yoke portion having a length at least approximately the same as the thickness of said insulated primary winding so that said core member portion and distributed secondary winding may be insulated before said core member is linked with said primary winding, said secondary winding extending over substantially all of said core except said removable yoke portion, the concentrated portion of said secondary winding having more turns per unit length than the remainder of said secondary winding.

4. An electromagnetic induction apparatus including a substantially toroidally shaped primary winding having a winding window, a substantially toroidally shaped core member comprising a plurality of flatwise curved sheets of magnetic material passing through said winding window, a secondary winding concentrated

around the portion of said curved sheets which extend through said window, insulation between said primary and secondary windings with a portion passing through and around said toroidally shaped primary winding and a separate second portion passing through and around said flatwise curved sheets of said core member and secondary winding, said core member having a removable yoke portion so that said secondary winding and second insulating portion may be distributed around said flatwise curved sheets of said core member before said sheets are linked to said primary winding, said secondary winding extending over substantially all of said core except said removable yoke portion, the concentrated portion of said secondary winding having more turns per unit length than the remainder of said secondary winding.

5. A transformer comprising, in combination, a pair of linked rings which are narrow in comparison with their outside diameter, one of said rings being an insulated conductive winding, the other of said rings being a core on which is wound an insulated conductive winding, said last-mentioned winding being concentrated as to its number of layers and turns in the vicinity of the first-mentioned winding, while extending over most of the circumference of said core.

6. A transformer comprising, in combination, a pair of linked rings which are narrow in comparison with their outside diameter, one of said rings being an insulated conductive winding, the other of said rings being a core on which is wound an insulated conductive winding, said last-mentioned winding being concentrated in the vicinity of the first-mentioned winding but extending over substantially all of said core, said core having a removable joint remote from said first-mentioned winding whereby said rings can be separately preconstructed and subsequently linked together.

GUGLIELMO CAMILLI.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
791,021	Fortescue	May 30, 1905
1,102,513	Johannesen	July 7, 1914
1,786,853	Klemm	Dec. 30, 1930
1,830,541	Harris	Nov. 3, 1931
1,873,049	Schrader	Aug. 23, 1932
1,889,552	Keinath	Nov. 29, 1932
2,284,406	D'Entremont	May 26, 1942
2,316,558	Camilli	Apr. 13, 1943
2,331,106	Camilli	Oct. 5, 1943
2,360,835	Kongsted et al.	Oct. 24, 1944

FOREIGN PATENTS

Number	Country	Date
640,832	Germany	Jan. 13, 1937