March 19, 1929. A. BOYAJIAN ET AL 1,706,139

CURRENT TRANSFORMER

Filed May 21, 1928

Fig. 1.

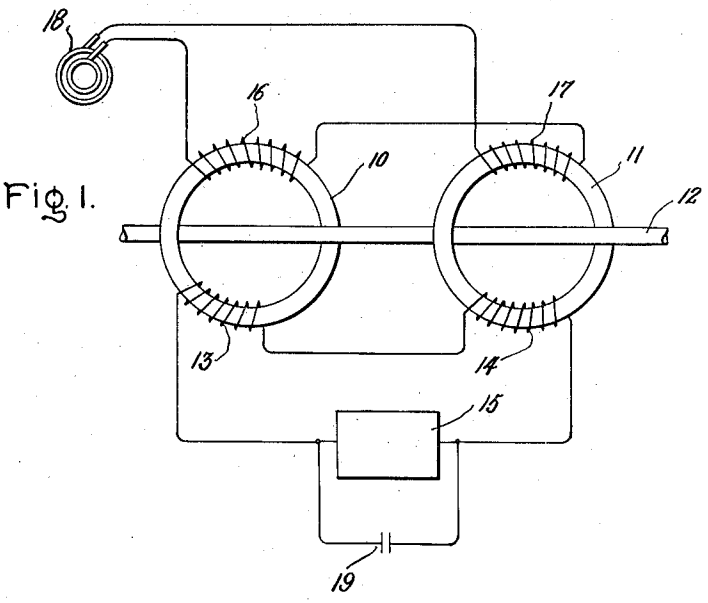


Fig. 2.

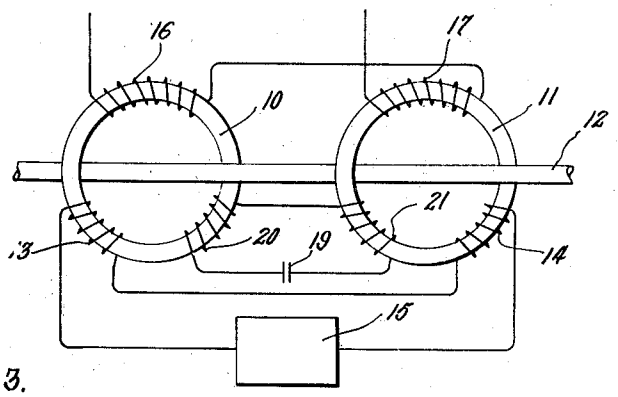
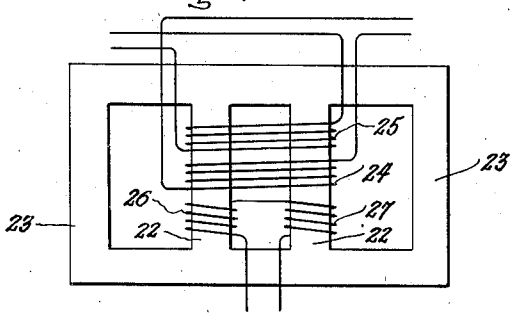


Fig. 3.



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UNITED STATES PATENT OFFICE.

ARAM BOYAJIAN AND GUGLIELMO CAMILLI, OF PITTSFIELD, MASSACHUSETTS, ASSIGNORS TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

CURRENT TRANSFORMER.

Application filed May 21, 1928. Serial No. 279,277.

Our invention relates to current transformers. If magnetic material such as may be used in a current transformer core is excited by two currents of high and low frequency respectively in two windings so arranged that the mutual inductance between them is negligible, then the current having the higher frequency will supply most of the active and reactance losses in the material. The effect of the high frequency excitation is that, with respect to the low frequency winding and current, the material acts with improved permeability and lower losses. The general object of the invention is to provide an improved current transformer with auxiliary means for exciting its core at a frequency higher than its normal primary and secondary frequency to make the ratio between the currents in the primary and secondary windings correspond more accurately to the inverse ratio between the numbers of turns in these two windings.

The invention will be better understood from the following description taken in connection with the accompanying drawing in which Fig. 1 is a diagrammatic view of a current transformer arranged in accordance with the invention; Fig. 2 is a view similar to that shown in Fig. 1 but with a modified detail, and Fig. 3 is a diagrammatic view of a modified form of the invention.

Like reference characters refer to similar parts in the different figures of the drawing.

In the form of the invention disclosed in Fig. 1, the current transformer includes a core formed in two parts 10 and 11, both of these parts preferably having as nearly identical magnetic characteristics as possible. Both of the core parts 10 and 11 have a common primary 12 with which they have the same inductive relation. The primary is shown in the drawing as being of the single turn type with respect to both core parts. A secondary is formed in two parts or sections 13 and 14 which are wound respectively on the two core parts 10 and 11. The secondary sections 13 and 14 are wound so that the voltages induced in them will tend to force current in the same direction in an outside circuit which may include a load device 15 such as an ammeter. As shown in the drawing, the secondary sections 13 and 14 are connected in series.

In the ideal current transformer, the ratio between the currents in the two windings would be exactly equal to the inverse ratio between the numbers of the turns in the two windings. If the losses in the core are supplied by energy from the primary current, however, it is obvious that the secondary current must be reduced from its ideal value. An auxiliary winding is formed in two parts or sections 16 and 17 wound respectively on the two core parts 10 and 11 and connected to a high frequency source of current 18 so that the two core parts are excited at high frequency by the current in this auxiliary winding. If the frequency of this auxiliary exciting current is higher than that of the currents in the primary 12 and the sections 13 and 14 of the secondary, then the larger part of the losses in the core parts 10 and 11 will be supplied from the auxiliary high frequency current. The ratio between the currents in the primary and secondary will thus be more nearly equal to the inverse ratio between the numbers of the primary and secondary turns than would be the case if all the core losses were supplied as usual by the primary current.

The high frequency current should not, of course, affect the primary or secondary currents inductively or be affected by them and any harmonics in the high frequency current should not distort the current wave of either the primary or secondary current to such an extent as to cause an appreciable difference between the current values with and without distortion. These results are attained by arranging the high frequency winding non-inductively with respect to both the primary and secondary windings. The two sections 16 and 17 of the high frequency winding have the same number of turns and one of these sections is wound reversely with respect to the primary and secondary. Any voltages induced in either the primary or secondary by the current in one section of the high frequency winding is thus substantially exactly

balanced or opposed by equal voltages induced by the current in the other section of the high frequency winding.

The frequency of the high frequency exciting current is preferably several times that of the primary and secondary currents. In a particular case, it was found that the proportion of the core losses supplied by the high frequency current increased as the frequency of this current was increased until its frequency was about seven times that of the currents in the primary and secondary. Further increase in the frequency of the high frequency current, however, seemed to have little or no effect on the proportion of the core losses supplied by this high frequency current. It was found that without any auxiliary excitation of the core so that all core losses were supplied by the primary current, the value of the secondary current was not over about ninety three per cent of the ideal value as determined by the value of the primary current and the ratio between the numbers of the primary and secondary turns. With auxiliary excitation of the core at a frequency about seven times that of the primary and secondary currents, however, it was found that the value of the secondary current was about ninety nine per cent of the ideal value. Almost all of the core loss was supplied by the auxiliary high frequency current so that very nearly all of the primary current was available to induce a flow of current in the secondary and the ratio between the values of the primary and secondary currents was very nearly equal to the inverse ratio between the numbers of the primary and secondary turns.

The excitation volt-amperes required by a magnetic core comprises two components which are the hysteresis watts at unity power factor and the reactive magnetization volt-amperes at 90° lagging power factor. It has been found that of these two factors, the former is reduced to a far greater extent than the latter by the high frequency excitation. Therefore, to compensate for that part of the reactive magnetizing volt-amperes which may not be supplied by the high frequency excitation, it may sometimes be desirable to provide a condenser arranged to draw zero power factor leading volt-amperes equal to the residual low frequency zero power factor lagging volt-amperes required by the core. In Fig. 1, such a condenser is shown connected in parallel with the load device 15.

The arrangement shown in Fig. 2 is similar to that shown in Fig. 1 except that the condenser 19 is connected in circuit with an auxiliary winding having two similar sections 20 and 21 wound on the two parts 10 and 11 of the core respectively.

Another form of the invention is shown in Fig. 3 in which the two core parts are connected together into a single structure. Each of the core parts includes an inner leg 22 and an outer leg 23, all four legs being connected together by end yokes. The primary 24 and secondary 25 surround both inner legs 22 so that the direction of the magnetic flux is the same in both these legs, the return paths for the flux being through the outer legs 23. The auxiliary high frequency winding for exciting the core and supplying energy for the necessary core losses includes two sections 26 and 27 wound on the two inner legs 22 of the two core parts respectively. These two sections 26 and 27 of the auxiliary high frequency winding are wound reversely with respect to the primary and secondary windings so that the magnetic flux induced by this auxiliary winding will flow in opposite directions in the two inner legs 22. With respect to the primary and secondary, therefore, the inductive effect of the high frequency flux in either leg 22 is neutralized by its inductive effect in the other leg 22 and the inductive effects of the high frequency current on the voltages in the primary and secondary are negligible. The high frequency current, however, supplies energy for most of the core losses and the ratio between the values of the primary and secondary currents is more nearly equal to the inverse ratio of the numbers of primary and secondary turns.

The invention has been explained by illustrating and describing different forms thereof and it will be apparent that further changes may be made without departing from the scope of the invention as defined by the appended claims.

What we claim as new and desire to secure by Letters Patent of the United States, is,—

1. A current transformer including a magnetic core, a primary and a secondary on said core, an auxiliary winding on said core and arranged non-inductively with respect to both the primary and the secondary, and means for supplying current to said auxiliary winding at a frequency greater than that of the currents in said primary and secondary.

2. A current transformer including a magnetic core, a primary and a secondary on said core, an auxiliary winding on said core and arranged non-inductively with respect to both the primary and the secondary, and means for supplying current to said auxiliary winding at a frequency several times that of the currents in said primary and secondary.

3. A current transformer including a two part magnetic core, a primary and a secondary on both of said core parts, an auxiliary winding on both of said core parts, the auxiliary turns on one of said core parts being wound reversely with respect to both said primary and said secondary, and means for supplying current to said auxiliary winding at a frequency greater than that of the currents in said primary and secondary.

4. A current transformer including a two

part magnetic core, a primary and a secondary on said core parts, the primary and secondary each having the same number of turns on the two core parts, an auxiliary winding having the same number of turns on both of said core parts, the auxiliary turns on one of said core parts being reversely wound with respect to both said primary and said secondary, and means for supplying current to said auxiliary winding at a frequency greater than that of the currents in said primary and secondary.

In witness whereof, we have hereunto set our hands this 18th day of May, 1928.

ARAM BOYAJIAN.
GUGLIELMO CAMILLI.