

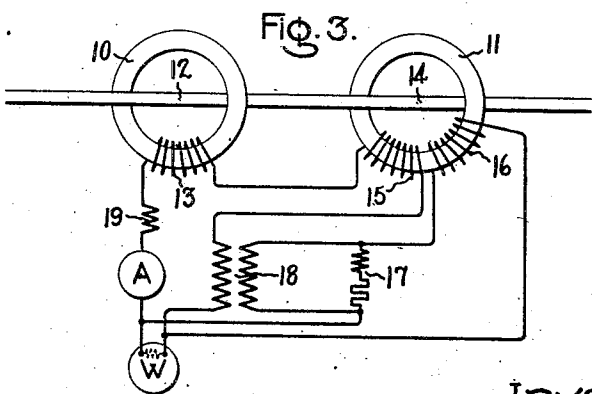
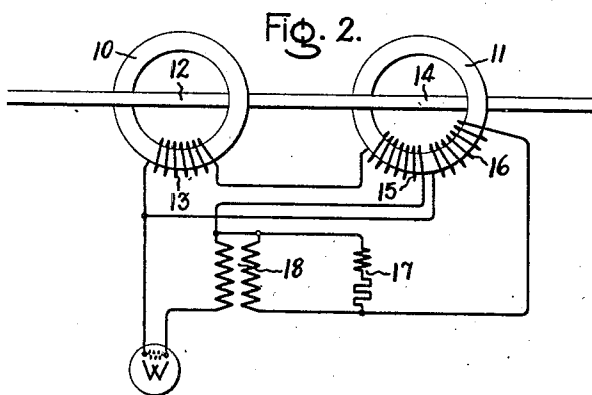
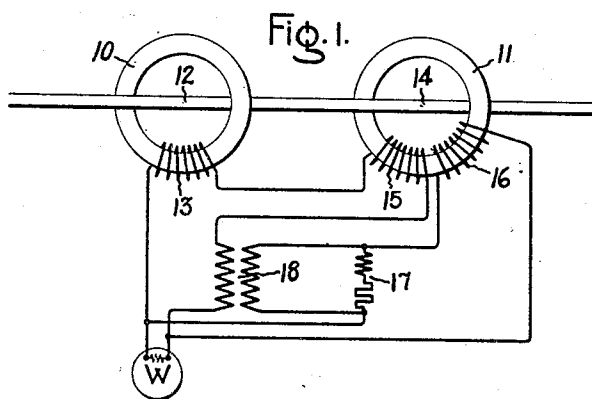
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CURRENT TRANSFORMER

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UNITED STATES PATENT OFFICE

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CURRENT TRANSFORMER

Application filed December 1, 1928. Serial No. 323,133.

Our invention relates to current transformers. In current transformers as usually constructed, the primary and secondary currents are generally not quite in phase with each other, the phase relation between these two currents is not constant for different loads and the ratio between the values of the two currents also varies as the load changes. These conditions result from the fact that a component of the primary current is required to supply the losses in the core and they affect appreciably the accuracy of a wattmeter, ammeter or other instrument connected to the transformer. In a current transformer of the bushing type, the primary winding is limited to very few turns and often to only a single turn and the inaccuracy of such a transformer is particularly serious.

Several arrangements have been proposed and used for improving the accuracy of current transformers. Some of these produce accurate results for only some one definite load on the transformer and a new adjustment is necessary for every change in the load. Other arrangements which have been suggested do not give the best results unless the instruments connected to them are specially constructed.

A current transformer which has satisfactory ratio and phase angle accuracy for different loads is disclosed in United States Patent No. 1,357,197, issued Oct. 26, 1920 to H. B. Brooks. This transformer is of a type known as two-stage, however, and for the best results a wattmeter, ammeter or other instrument used with it must be specially constructed with two current coils. The general object of the present invention is to provide an improved current transformer of the two-stage type which will give accurate results when used with an instrument as usually constructed with a single current coil.

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 transformer constructed and arranged in accordance with the invention and Figs. 2 and 3 show modified arrangements.

Like reference characters indicate similar

parts in the different figures of the drawing.

In the arrangement shown in Fig. 1, the transformer includes two magnetic cores 10 and 11. The core 10 has a primary winding 12 and a main secondary winding 13. The core 11 has a primary winding 14, a main secondary winding 15 and an auxiliary secondary winding 16. The two primary windings 12 and 14 are connected in series and may be in the form of a single straight conductor passing through both cores. In an ideally perfect current transformer, the ratio of the primary and secondary currents would be equal to the inverse ratio of the numbers of turns in the primary and secondary windings and the two currents would be in phase opposition with each other for all load values. A component of the primary current is required to magnetize the core 10, however, and for this reason the secondary current in the winding 13 is not in phase with the primary current in the winding 12 and the secondary current is smaller than is required to make the current ratio equal to the inverse turn ratio.

The secondary windings 13 and 15 are connected in series and the currents in the two windings 14 and 15 of the second stage of the transformer are necessarily equal to the currents in the two windings 12 and 13 respectively of the first stage. These two currents oppose each other in their magnetizing effects in the two cores and their resultant is obviously vectorially equal to the magnetizing current in the first stage and also to the effective primary current which induces an electromotive force in the auxiliary secondary winding 16 of the second stage. The windings 13, 15 and 16 all have substantially the same number of turns. Under these conditions, it will be apparent that the current in the auxiliary secondary winding will be equal to the error of the current in the secondary winding 13 except for the slight loss due to the magnetization of the second stage core 11. This loss may be considered as the second stage magnetizing component of the first stage magnetizing current and it is therefore a loss of the second order of magnitude and generally negligible. Even this slight

error may be corrected, at least partially, by making the number of turns in the auxiliary secondary winding 16 a very little smaller than the number of turns in the winding 15.

5 The vector sum of the two secondary currents in the windings 13 and 16 is in phase opposition with the primary current in the winding 12 and the ratio between this total secondary current and the primary current is equal to the inverse turn ratio of the windings. In order that an instrument may respond accurately to the vector sum of the two secondary currents, it is necessary that there be no appreciable mutual impedance between the two secondary circuits. This requirement has been met by providing an instrument with two separate current coils to which the two secondary circuits are separately connected but this requires a special instrument and the usual form of instrument having a single current coil cannot be used with accurate results.

For accurate response of an instrument to the two secondary currents, however, it is not necessary that there be no mutual impedance between the two secondary circuits at every point but only that there shall be no resultant or net mutual impedance between them. Accordingly, the two secondary circuits may have any mutual impedance at one point provided it is neutralized by an equal and opposite mutual impedance at some other point. Both secondary circuits are connected to the same terminals of the instrument W so that both secondary currents take the same path through the instrument. This permits any ordinary wattmeter, ammeter or other instrument with a single current coil to be used. There is now a mutual impedance between the two secondary circuits which is the impedance of the current coil in the instrument W and it is necessary and sufficient to provide another equal and opposite impedance between the two secondary circuits. This equal and opposite impedance is provided by the impedance 17 and the transformer 18.

The impedance 17 is connected in series with the auxiliary secondary circuit from the winding 16 and is equal to the impedance of the current coil in the instrument W. One winding of the transformer 18 is connected in series with the main secondary circuit from the windings 13 and 15, the other winding of the transformer being connected across the impedance 17. The transformer 18 has such a voltage ratio and is so connected that it produces in the impedance 17 a voltage drop which is equal and opposite to that in the current coil of the instrument W. There is thus no resultant or net mutual impedance between the two secondary circuits and the two secondary currents flow simultaneously in the current coil of the instrument W with no interference between them.

If the impedance 17 is vectorially identical with the impedance of the current coil in the instrument W, then the voltage drop across the impedance 17 will be slightly different vectorially from that across the current coil in the instrument because of the effect of the magnetizing current in the transformer 18. This error may be avoided by making the impedance 17 proportionately different vectorially from the impedance of the current coil. It is very small, however, because the transformer 18 may have very low voltage windings and may be made far more accurate than the usual current transformer, particularly one of the bushing type.

In the modified arrangement shown in Fig. 2, the auxiliary secondary circuit from the winding 16 is connected across both the instrument W and the transformer 18 instead of across the instrument alone as in Fig. 1. The transformer 18 must therefore produce a voltage drop across the impedance 17 which is equal and opposite vectorially to that across both the instrument W and the winding of the transformer 18 which is in series with the instrument.

Two or more instruments are sometimes connected to a current transformer but great accuracy may be desired in only part of these instruments or in only one of them. Such an arrangement is shown in Fig. 3 where a wattmeter W, an ammeter A and a coil 19, which may be the coil of a relay, are connected to the transformer. The usual accuracy of an ordinary current transformer may be satisfactory for the ammeter and relay but the greatest possible accuracy may be desired for the wattmeter. The auxiliary secondary circuit from the winding 16 is therefore connected only across the wattmeter. The second or auxiliary stage of the transformer supplies current only to the wattmeter and any errors in it are smaller than if it were connected to supply current also to one or both of the other instruments.

If the two windings of the transformer 18 have the same number of turns, then the current circulated through the impedance 17 by this transformer 18 will be equal to the current supplied to the instrument W by the main secondary winding 13. Under these conditions, the impedance 17 must be equal to the impedance of the current coil in the instrument W to make the voltage drops across them the same. It will be apparent, however, that a different turn ratio may be used, if desired in the transformer 18 if a corresponding change is made in the value of the impedance 17 to maintain the voltage drop across it vectorially equal as well as opposite to that due to the main secondary current in the current coil of the instrument.

The invention has been explained by describing and illustrating various modifications thereof and it will be apparent that

further changes may be made without departing from the scope of the invention as defined in the appended claims.

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

1. The combination with an instrument of a current transformer, said current transformer including means for producing a main secondary current in said instrument, means for producing an auxiliary secondary current in said instrument with mutual impedance between said currents within the instrument, and means for producing between the circuits carrying said secondary currents a mutual impedance substantially equal and opposite vectorially to the said mutual impedance within the instrument.

2. The combination with an instrument having a current coil, of a current transformer, said current transformer including means for producing a main secondary current in said instrument coil, means for producing an auxiliary secondary current in the same instrument coil, and means for producing between the circuits carrying said secondary currents a mutual impedance substantially equal and opposite vectorially to the impedance of the instrument coil.

3. The combination with an instrument having a current coil, of a current transformer, said current transformer including means for producing in said instrument coil a main secondary current differing vectorially from the desired current, means for producing in the same instrument coil an auxiliary current substantially equal vectorially to the difference between said main and desired currents, and means for producing between the circuits carrying said secondary currents a mutual impedance substantially equal and opposite vectorially to the impedance of the instrument coil.

4. The combination with an instrument having a current coil, of a current transformer, said current transformer including a magnetic core having a primary winding and a main secondary winding, a second magnetic core having a primary winding and main and auxiliary secondary windings, said main secondary windings being connected to supply a main secondary current to said instrument coil, said auxiliary secondary winding being connected to supply auxiliary secondary current to the same instrument coil, and means for producing between the circuits carrying said secondary currents a mutual impedance substantially equal and opposite vectorially to the impedance of the instrument coil.

5. The combination with an instrument having a current coil, of a current transformer, said current transformer including a magnetic core having a primary winding and a main secondary winding, a second magnetic core having a primary winding and

main and auxiliary secondary windings, said main secondary windings being connected to supply a main secondary current to said instrument coil, said auxiliary secondary winding being connected to supply auxiliary secondary current to the same instrument coil, an impedance in the auxiliary secondary circuit, and means for producing across said impedance a voltage drop substantially equal and opposite vectorially to the voltage drop produced across said instrument coil by said main secondary current.

6. The combination with an instrument having a current coil, of a current transformer, said current transformer including a magnetic core having a primary winding and a main secondary winding, a second magnetic core having a primary winding and main and auxiliary secondary windings, said main secondary windings being connected to supply a main secondary current to said instrument coil, said auxiliary secondary winding being connected to supply auxiliary secondary current to the same instrument coil, an impedance in the auxiliary secondary circuit, and a transformer having its primary winding connected in the main secondary circuit and its secondary winding connected across said impedance, the value of said impedance and the voltage ratio of said transformer being so related as to produce a voltage drop across said impedance vectorially equal and opposite to that produced across said instrument coil by said secondary current.

7. A current transformer including a magnetic core having a primary winding and a main secondary winding, a second magnetic core having a primary winding and main and auxiliary secondary windings, said main secondary windings being connected in series, an impedance in the auxiliary secondary circuit, and a transformer connected between the main secondary winding circuit and said impedance, whereby a voltage controlled by the main secondary current may be applied across said impedance.

In witness whereof, we have hereunto set our hands this 26th day of November, 1928, and this 24th day of November, 1928, respectively.

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