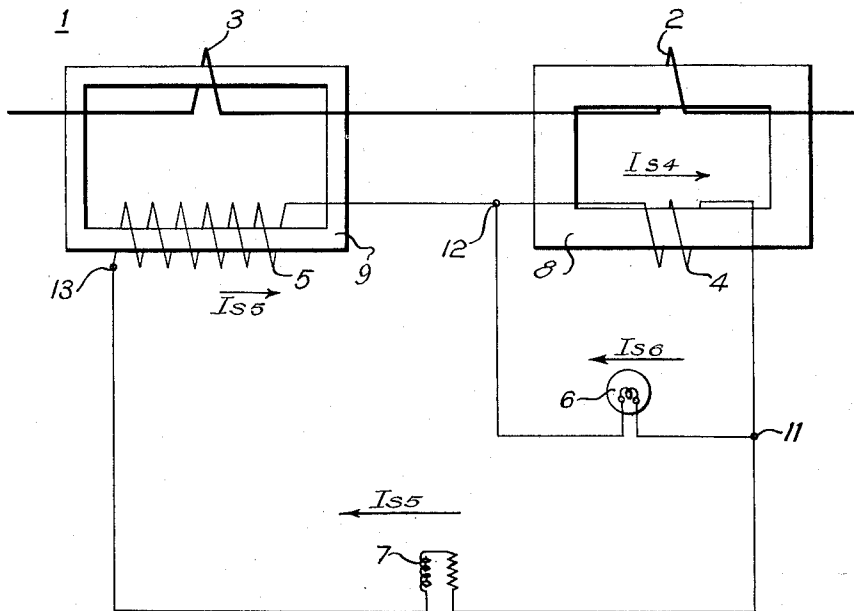


Aug. 30, 1927.

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CURRENT TRANSFORMER
Filed Oct. 1, 1925

1,640,554



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CURRENT TRANSFORMER.

Application filed October 1, 1925. Serial No. 59,770.

My invention relates to electrical translating devices and particularly to current transformers.

One object of my invention is to provide a current transformer that shall automatically compensate for errors due to the magnetizing currents necessary to energize itself.

Another object of my invention is to provide a current transformer that shall be free from the errors generally caused by reason of current losses in the secondary windings due to the transformer's own magnetizing currents.

In current transformers there is a difference between the theoretical ratio of the primary ampere-turns to the secondary ampere-turns, or unity, and the actual obtained ratio of the primary ampere-turns to the secondary-ampere turns. This difference is indicated by a current loss from the theoretical secondary current and is due to the absorption of a portion of the theoretical secondary current by the transformer core in order to magnetize itself. Where the error due to the ratio between the primary ampere-turns and the secondary ampere-turns is large, as in current transformers used in modern generating stations, the ratio of the measured current to the true primary current is sufficiently in error to cause substantial financial loss to the generating company.

I propose to minimize the loss due to such magnetizing currents by constructing a current transformer comprising main and auxiliary units, each of which comprises a specially designed burden so connected that the current traversing one of the burdens is not affected by the magnetizing currents of the two transformer units. This result is brought about by constructing the two core sections so that they require the same magnetizing current and so connecting them relative to one of the burdens that the magnetizing current of one unit cancels the magnetizing current of the other unit. In the accompanying drawings,

The single figure is a diagrammatic view of the circuits and apparatus embodying my invention.

My invention comprises, in general, a primary winding 1 of the through type having two sections 2 and 3 that are associated with main and auxiliary secondary

windings 4 and 5, respectively, that are, in turn, connected to main and auxiliary burdens 6 and 7, respectively. Core members 8 and 9 are associated with the secondary windings 4 and 5, respectively.

The main burden 6 is connected across the main secondary winding 4 and generally constitutes a winding of a suitable measuring instrument, such as an ammeter. The auxiliary burden 7 is connected across both secondary coils 4 and 5 in series relation and comprises both resistance and reactance characteristics. For ease of description, the point of connection common to the burden 7, the burden 6 and the secondary winding 4 is numbered 11; that of the junction common to the burden 6 and the secondary windings 4 and 5 is numbered 12 and that common to the secondary winding 5 and the common burden 7 is numbered 13.

The main secondary winding 4 and the main burden 6 correspond to the ordinary measuring circuits commonly employed with instrument transformers, in which the current traversing the burden or instrument 6 is less than its theoretical value, as determined by the ratio between the number of turns of the section 2 of the primary winding and the number of turns of the secondary winding 4. This error is occasioned by the absorption of a certain amount of the primary current by the core member 8 for the purpose of magnetizing that member. The effect of the loss of a part of the primary current to the secondary winding 4, is shown by resulting errors in the desired ratio and phase angle of the secondary current of the transformer.

The secondary winding 4, is given a proper number of turns to supply the burden 6 with the desired number of amperes for its rated current ratio and to supply an additional current for neutralizing the effect of the magnetizing current lost in the core member 8, in a manner to be hereinafter described. The secondary voltage of the measuring circuit is that voltage required to cause the rated secondary current of the circuit to traverse the burden 6. The magnetizing current for core member 8, expressed in terms of the secondary turns, is dependent upon the voltage across the secondary winding 4, but, since the voltage across the secondary winding 4 is dependent upon the

impedance of, and the current traversing, the burden 6, it follows that the magnetizing current for core member 8 bears an indirect relation to the impedance of the burden 6.

In order to compensate for the magnetizing current for the core member 8, a second or auxiliary circuit, comprising the secondary winding 5 and the auxiliary burden 7, is provided in which the magnetizing current for the core member 9 is given the same value and the same phase angle as that of the main core member 8 when expressed in terms of their secondary windings. The impedance of the auxiliary burden 7 is such that the voltage across it is always sufficiently greater than the voltage across the main burden 6 so that the magnetizing current of core member 9, in terms of its secondary-turns, will be equal to that of core member 8, in terms of its secondary-turns.

While the magnetizing currents actually are components of the primary current of the transformer, nevertheless, it is customary engineering practice to consider them in terms of secondary-turns of the transformer.

In order to have the same phase-angle in the core members 8 and 9, it is desirable that they shall be of the same grade of iron and shall have the same flux density, and the latter item may be controlled by the number of turns in the secondary winding 5 and the impedance 7. The magnetizing current of the core member 9 may also be controlled independently of the flux density, the grade of iron and the number of secondary-turns in the winding 5, by varying the length of the core member 9 and thereby varying the length of the flux lines traversing it.

The secondary windings 4 and 5 are so wound upon their respective core members 8 and 9 that their currents combine at points 11 and 12, so that the difference in their values traverses the main burden 6. The mathematical values of the two secondary currents are so chosen that the current traversing the secondary burden 6 has a desired ratio to the primary current, which ratio may correspond to a standard commercial ratio for instrument transformers.

Considering the point 11, the current which traverses the auxiliary burden 6 is the algebraic difference between the currents traversing the auxiliary burden 7 and the current delivered to that point. Since the current traversing the circuit between the points 11 and 12 is the current delivered by the secondary winding 5, and, since the current traversing the circuit through the secondary winding 4 between the points 12 and 11 is the current delivered by the secondary winding 4, it follows that the current traversing the main burden 6 between

points 11 and 12 is the difference between the currents delivered by the secondary windings 4 and 5.

The relation between the primary, secondary and magnetizing currents of the transformer are covered by the following simple mathematical expressions where: $-I_p$ represents the primary current; I_{s4} and I_{s5} represent the secondary currents in the windings 4 and 5, respectively; I_{m8} and I_{m9} represent the magnetizing currents for the core members 8 and 9, respectively; N_2 and N_3 represent the ratios of the secondary to the primary turns for the transformer units associated with primary sections 2 and 3, respectively; and I_{s6} represents the current traversing the burden 6. Then

$$I_{s4} = \frac{I_p - I_{m8}}{N_2} \quad (1)$$

$$I_{s5} = \frac{I_p - I_{m9}}{N_3} \quad (2)$$

$$I_{s6} = I_{s4} - I_{s5} \quad (3)$$

$$= \frac{N_3 - N_2}{N_2 N_3} I_p - \left(\frac{I_{m8}}{N_2} - \frac{I_{m9}}{N_3} \right) \quad (4)$$

By making

$$\frac{I_{m8}}{N_2} = \frac{I_{m9}}{N_3},$$

I_{s6} becomes independent of the magnetizing currents, and may be expressed as:

$$I_{s6} = \frac{N_3 - N_2}{N_2 N_3} I_p \quad (5)$$

which value is independent of the magnetizing currents, for the core members 8 and 9.

By way of a specific example:—

$$\text{Let } N_2 = 10 \quad (6)$$

$$N_3 = 30 \quad (7)$$

and

$$\frac{I_{m8}}{N_2} = \frac{I_{m9}}{N_3} \quad (8)$$

then from equation (4)

$$I_{s6} = \frac{20}{300} I_p - \left(\frac{I_{m8}}{N_2} - \frac{I_{m9}}{N_3} \right) = \frac{1}{15} I_p \quad (9)$$

which represents the values for a transformer having a ratio of 15 to 1.

$\frac{I_{m8}}{N_2}$ may be made equal to $\frac{I_{m9}}{N_3}$ by several methods. One method is to use the same kind of iron in both of the cores members 8 and 9; design the auxiliary burden 7 so that it has twice the voltage drop across it that exists across the main burden 6 in order that the voltage drop between points 11 and 12 will be the same as between the points 12 and 13; have the cross sectional area of core member 9 one third as great as that of core member 8 because the secondary winding 5 has three times as many turns

as the secondary winding 4; and make iron circuit 9 three times as long as iron circuit 8.

Accordingly, a current, the value of which is in excess of the measured current is utilized to combine with the current delivered by the secondary winding 5 whereby the effect of the magnetizing current incidental to the core member 8 is neutralized by the magnetizing current incidental to the core member 9.

It will thus be seen that I have provided a current transformer in which, an auxiliary transformer unit and burden are utilized for neutralizing the magnetizing current incidental to the main measuring circuit. Accordingly, the current traversing the measuring instrument is unaffected by the magnetizing current for the core member associated therewith.

It is to be understood that such changes may be made in the arrangement, number and connection of the several parts as shall fall within the scope of the appended claims.

I claim as my invention:

1. In a current transformer, a main unit, an auxiliary unit, a main burden and an auxiliary burden, the auxiliary burden controlling the direction of the magnetizing currents for the transformer.

2. In a current transformer, a main unit, an auxiliary unit, a main burden and an auxiliary burden, the two burdens being so interconnected with the units that one of the burdens is substantially unaffected by the magnetizing currents in the transformer.

3. In a current transformer, a main unit, an auxiliary unit, a main burden and an auxiliary burden, the two burdens being so interconnected with the units that the magnetizing currents are substantially neutralized in one of the burdens.

4. In a current transformer, a main unit and an auxiliary unit, the secondary windings of which are equally affected by their respective magnetizing currents, a main burden and an auxiliary burden so interconnected with the units that the magnetizing currents are substantially neutralized in one of the burdens.

5. In a current transformer, a main unit and an auxiliary unit, the secondary windings of which are equally affected by their respective magnetizing currents, an auxiliary burden for controlling the direction of the magnetizing currents and a main burden, the burdens being so interconnected with the units that the magnetizing currents are substantially neutralized in the main burden.

6. In combination, a main and an auxiliary transformer unit, the primary and secondary windings thereof being connected in series relation, a main burden connected in parallel circuit to the main secondary winding, and an auxiliary burden connected in series relation to the secondary windings.

7. In combination, a main and an auxiliary transformer unit requiring substantially the same magnetizing currents, the primary and secondary windings thereof being connected in series relation, with an auxiliary burden for controlling the direction of the magnetizing currents and a main burden connected in shunt circuit to the main secondary winding whereby the magnetizing currents from the transformer units substantially neutralize each other in the main burden.

In testimony whereof, I have hereunto subscribed my name this 25th day of September, 1925.

JOHN F. PETERS.