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ELECTROMAGNETIC INDUCTION APPARATUS

Filed Feb. 1, 1945

Fig. 1.

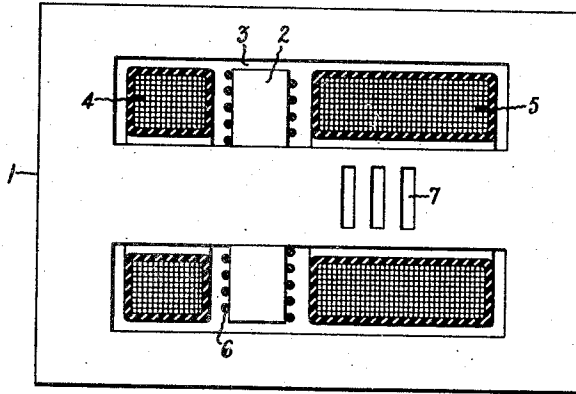


Fig. 2.

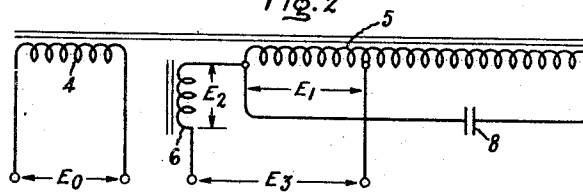


Fig. 3.

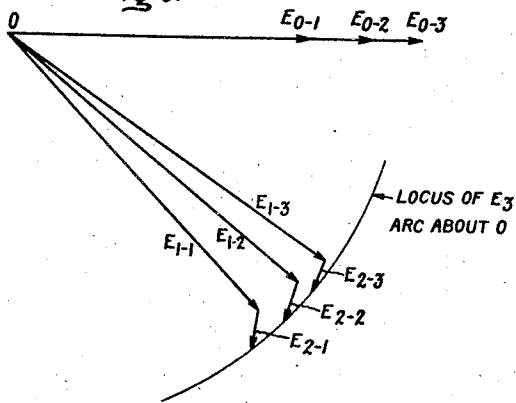
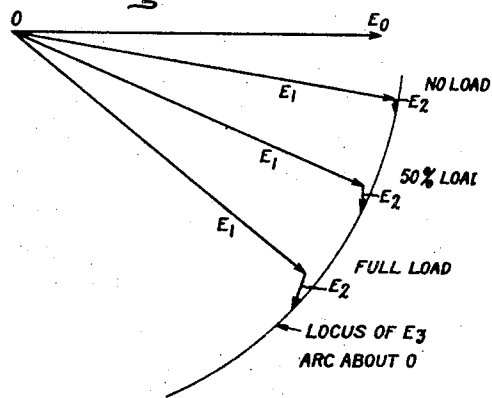


Fig. 4.



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ELECTROMAGNETIC INDUCTION
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3 Claims. (Cl. 323-60)

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This invention relates to electromagnetic induction apparatus and more particularly to improvements in static constant voltage transformers.

By a "static constant voltage transformer" is meant a device which with no moving parts converts a variable alternating supply voltage to an alternating output voltage which is substantially constant over an appreciable range of variation of output current and input voltage. Many devices of this kind are available both in the literature and on the market.

This invention is characterized by input and output circuits which are coupled by means of a unitary magnetic core in such a manner that an abnormally high leakage reactance exists between the circuits and a compensating voltage which is proportional in magnitude and phase with the leakage reactance voltage drop between the two circuits is inserted in the output circuit.

An object of the invention is to provide a new and improved electromagnetic induction apparatus.

Another object of the invention is to provide a new and improved static constant voltage transformer.

The invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing Fig. 1 is a sectional view of the transformer portion of an embodiment of the invention, Fig. 2 is a circuit diagram of an embodiment of the invention utilizing the structure shown in Fig. 1, Fig. 3 is a vector diagram illustrating the operation of the invention at full load unity power factor and with varying input voltage, and Fig. 4 is a vector diagram illustrating the operation of the invention with fixed input voltage and varying load.

Referring now to the drawing and more particularly to Fig. 1, there is shown therein a magnetic core 1 of the forced core type having integral magnetic shunts 2, although it will be obvious to those skilled in the art that the core may be of the interleaved type with inserted shunts, if desired. The magnetic shunts are provided with air gaps 3 for reasons which will be explained more fully below. Mounted on the core with the magnetic shunts between them are a primary winding 4 and a secondary winding 5. A compensating winding 6, the purpose of which will also be described below, is wound on the magnetic shunts.

The primary and secondary fluxes are prefer-

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ably substantially equal but the maximum secondary flux density is substantially higher than the primary flux density. This is accomplished by making the sections of the core traversed by the primary and second fluxes of substantially equal area and providing the portion of the core which is traversed by the secondary flux with restricted sections 7. These sections are saturated during normal operation of the device while the main portion of the secondary section is not saturated.

As shown in Fig. 2, the primary winding 4 is connected to input terminals, the voltage between which is E_0 , and the compensating winding 6 whose voltage is E_2 is connected in series with a portion of the secondary winding 5 whose voltage is E_1 between a pair of output terminals, the voltage between which is E_3 . Also, a capacitor 8 is coupled to the secondary winding and, as shown, it is connected across the entire winding. However, it will be obvious to those skilled in the art that capacitor 8 could be coupled to the winding whose voltage is E_1 by connecting it across another winding which is closely coupled thereto.

The capacitor 8 is of such a value that with the output circuit open the capacitor 8 and the secondary winding are tuned to near resonance. In other words, the capacitor supplies the exciting current required to operate the restricted section at saturation. This provides a relatively stable secondary voltage. With this condition the flux through the shunt is small at no load and increases rapidly with increasing load.

The operation of the illustrated embodiment of the invention can best be explained by reference to the vector diagrams. Referring now to Fig. 3, the three vectors E_{0-1} , E_{0-2} and E_{0-3} represent respectively minimum, nominal and maximum values of input voltage. The corresponding values of secondary winding voltage which are in the output circuit are E_{1-1} , E_{1-2} and E_{1-3} . These are more nearly equal than the three E_0 voltages because of the saturation of the portion of the core traversed by the secondary flux, that is to say, by the saturation of the restricted sections 7. The vector difference between the corresponding E_0 and E_1 vectors is the leakage reactance voltage drop of the transformer, and the air gaps 3 of Fig. 1 are so proportioned that the phase displacement between the E_0 and E_1 voltages will be in the range of 30-40 degrees at full load unity power factor. The voltages E_{2-1} , E_{2-2} and E_{2-3} are the corresponding voltages of the compensating winding 6. As the vector sum of the secondary voltage and the leakage reactance voltage drop equals

the input voltage, it will be seen that the E_2 voltages are opposite in phase to the leakage reactance voltage. By properly proportioning the compensating winding 6 the vector sums of the E_1 and E_2 voltages may be made to terminate on an arc of a circle whose center is at 0 in Fig. 3 and this arc will be the locus of the output voltage E_3 as it will be seen from Fig. 2 that $E_3 = E_1 + E_2$ and Fig. 3 shows how these voltages add vectorially.

It will be noted that the compensating action of E_2 in Fig. 3 is due primarily to its shift in phase with changes in input voltage rather than to changes in its magnitude. Ordinarily the magnitude of the voltage E_2 will be of the order of 10-20 per cent of E_3 at full load.

Referring now to Fig. 4, the values of E_1 and E_2 at no load, half load and full load for a constant value of input voltage E_0 are shown. It will be observed that again the E_2 vectors terminate on an arc of a circle about point 0 so that E_3 is substantially constant throughout the full range of load, which load is preferably a unity power factor load. In Fig. 4 it will be observed that the compensating action of E_2 is due primarily to its change in magnitude with changes in load magnitude rather than to changes in phase of this voltage with changes in load magnitude. The increasing phase displacement between E_0 and E_1 with increases in load is of course due to the increase in leakage flux due to the increased load current, which increased leakage flux produces an increased leakage reactance voltage.

It will of course be understood that the above-described constant voltage transformer may be provided with a suitable harmonic filter or frequency compensator or power factor compensator or any combination thereof.

While there has been shown and described a particular embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications can be made therein without departing from the invention and, therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. A constant voltage transformer comprising, in combination, a unitary magnetic core having a primary winding receiving section, a secondary winding receiving section and a magnetic shunt between said sections, primary and secondary windings on their respective core sections, a compensating winding on said magnetic shunt connected in series with a portion of said secondary

winding, and a capacitor connected across said secondary winding, said secondary winding receiving section having a normally saturated restricted section, said core sections normally carrying substantially equal flux and having substantially equal cross sectional areas except for said restricted section.

2. A constant voltage transformer comprising, in combination, a unitary magnetic core having a primary winding receiving section, a secondary winding receiving section and a magnetic shunt between said sections, primary and secondary windings on their respective core sections, a compensating winding on said magnetic shunt connected in series with a portion of said secondary winding, and a capacitor connected across said secondary winding, said secondary winding receiving section having a normally saturated restricted section, said core sections normally carrying substantially equal flux and having substantially equal cross sectional areas except for said restricted section, said compensating winding having a voltage of 10-20 per cent of the output voltage of said transformer.

3. A constant voltage transformer comprising, in combination, a unitary magnetic core having a primary winding receiving section, a secondary winding receiving section and a magnetic shunt between said sections, primary and secondary windings on their respective core sections, a compensating winding on said magnetic shunt connected in series with a portion of said secondary winding, a capacitor connected across said secondary winding, said secondary winding receiving section having a normally saturated restricted section, said core sections normally carrying substantially equal flux and having substantially equal cross sectional areas except for said restricted section, and an air gap in said magnetic shunts so proportioned that the leakage reactance of said transformer displaces the primary and secondary voltages of said transformer by 30-40 degrees at full load, said compensating winding having a voltage of 10-20 per cent of the output voltage of said transformer at full load.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,599,570	Lucas	Sept. 14, 1926
2,143,745	Sola	Jan. 10, 1939