Dec. 4, 1928. 1,694,318

H. GRÜNHOLZ

ELECTRIC INDUCTION APPARATUS

Filed Jan. 13, 1928

Fig. 1

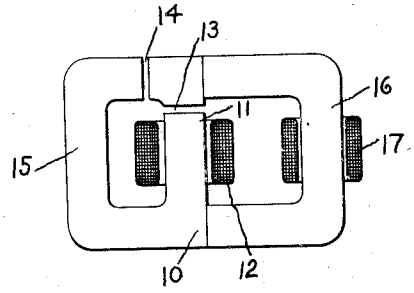


Fig. 2

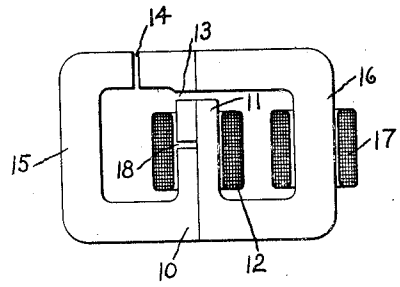
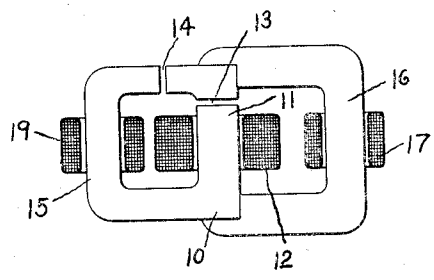


Fig. 3



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Patented Dec. 4, 1928. 1,694,318

UNITED STATES PATENT OFFICE.

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ELECTRIC INDUCTION APPARATUS.

Application filed January 13, 1928. Serial No. 246,454, and in Germany January 15, 1927.

My invention relates to electric induction apparatus such as reactances. If a current comprising both a direct current component and an alternating current component flows through a winding having a magnetic core, it is difficult to obtain any considerable inductance in the winding if the direct current component is large in comparison with the alternating current component. The large direct current component will induce a large preliminary saturation of the core unless the dimensions of the core are proportionately very great. The result is that the upper flattened part of the magnetization curve is used. Thus, for a large change in current there is only a small corresponding change in the magnetic field and, consequently the impedance which the winding offers to the superposed alternating current is small. This disadvantage has been partly overcome by providing an air gap in the magnetic core so that with a given direct current component the preliminary saturation will be reduced. The magnetization curve will then be steeper so that a given alternating current component will cause greater variations in the magnetic field. The effectiveness of an air gap is limited, however, because if the air gap is too large its reluctance will again cause a flattening of the magnetization curve. The general object of the invention is to provide an improved arrangement in which the two components of the magnetic field due to the direct and alternating components respectively of the current are more or less separated so as to increase the impedance of the winding.

The invention will be better understood from the following description taken in connection with the accompanying drawing in which Fig. 1 shows a reactor constructed in accordance with the invention, Fig. 2 shows a modified form of the reactor shown in Fig. 1 and Fig. 3 shows a transformer constructed in accordance with the invention.

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

The reactor shown in Fig. 1 includes a magnetic core 10 having three winding legs connected by yokes in the manner of the usual shell type core. The central winding leg 11 is surrounded by a winding 12 through which may flow a current having direct current and alternating current components. The central winding leg 11 is provided with an air gap 13 and a second air gap 14 is formed somewhere in the portion of the core comprising the outer leg 15 and the yoke connections between this outer leg 15 and the central leg 11. This part of the core including the outer leg 15, the central leg 11 and their yoke connections is laminated to prevent objectionable eddy currents. The other outer leg 16 and the yoke connections between it and the central leg 11 are, however, not laminated but are substantially solid. The outer leg 16 may be surrounded by a closed or short circuited winding 17.

All of the magnetic flux induced by the direct and alternating components of the current in the winding 12 passes through the central leg 11 of the core and through its air gap 13. The division of the direct component of this flux through the two outer core legs 15 and 16 is determined by the relative magnetic reluctances offered to this direct flux in the two paths through these outer legs. This reluctance is greatest through the core leg 15 because of the air gap 14 and consequently the greater part of the direct flux will flow through the other outer core leg 16. The greater part of the alternating component of the flux, however, flows through the outer core leg 15 since it cannot build up in the solid outer leg 16 because of eddy currents or because of currents in the closed winding 17. The saturation of the greater part of the alternating flux path is therefore small even with small air gaps 13 and 14. The alternating compound of the flux, therefore, works along the straight part of the magnetization curve where it is comparatively steep due to the small air gap.

In the arrangement shown in Fig. 2, the separation of the direct and alternating components of the flux is also effected through the central core leg 11. The portion or side of this central leg nearest the outer laminated leg 15 is laminated and the side nearest the outer solid leg 16 is solid. In the laminated portion or side of the central leg, an air gap 18 is provided which causes the direct component of the flux to flow in the solid side of this central leg.

In order to obtain some increased reactance, it is not necessary that the outer core leg 16 be arranged to keep out the alternating flux component in the manner indicated. It is only important that most of the direct component of the flux be kept out of the core leg 15. If some of the alternating component

of the flux is permitted to flow in the core leg 16 as well as in the core leg 15, there will still be some increase in reactance even in connection with this part of the alternating flux in the core leg 16. The alternating component of the flux in the core leg 16 flows, however, in a heavily saturated part of the core and therefore the alternating current and the alternating magnetic flux cannot both be of sine wave form at the same time and this is objectionable for many purposes.

Some arrangement to keep the alternating component of the flux out of the core leg 16 is necessary, however, if voltage is to be induced in the winding 12 from a winding 19 on the core leg 15 and it is desired to keep the magnetizing current in the winding 19 as small as possible. This arrangement is shown in Fig. 3. With a given alternating current in the winding 19, the alternating flux in the central core leg 11 should be as strong as possible. With this object in view, the outer core leg 16 must be prevented from acting as a magnetic shunt for the alternating flux.

The invention has been explained by describing and illustrating different specific applications thereof and it will be apparent that other changes may be made within the scope of the invention as defined by the appended claims.

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

1. Electric induction apparatus comprising a magnetic core, and a winding on said core, said core having portions forming parallel paths of different magnetic reluctance for the magnetic flux, the core portion forming one of said parallel paths being laminated and provided with an air gap, and the core portion forming the other parallel path being substantially solid.

2. Electric induction apparatus comprising a magnetic core, and a winding on said core, said core having portions forming parallel paths of different magnetic reluctance for the magnetic flux, the core portion forming one of said parallel paths being provided with an air gap, and the core portion forming the other parallel path being surrounded by a closed winding.

3. Electric induction apparatus comprising a magnetic core, and a winding on said core, said core having portions forming parallel paths of different magnetic reluctance for the magnetic flux, the core portion forming one of said parallel paths being provided with an air gap, and the core portion forming the other parallel path being substantially solid and surrounded by a closed winding.

In witness whereof, I have hereunto set my hand this 30th day of December, 1927.

DR. HANS GRÜNHOLZ.