

[54] **REGULATING AND FILTERING TRANSFORMER**
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[58] Field of Search.....323/6, 48, 50, 56, 60, 61,
 323/81, 78; 336/155, 160, 165, 178, 214

[56] **References Cited**

UNITED STATES PATENTS

3,546,571 12/1970 Fletcher et al.323/60

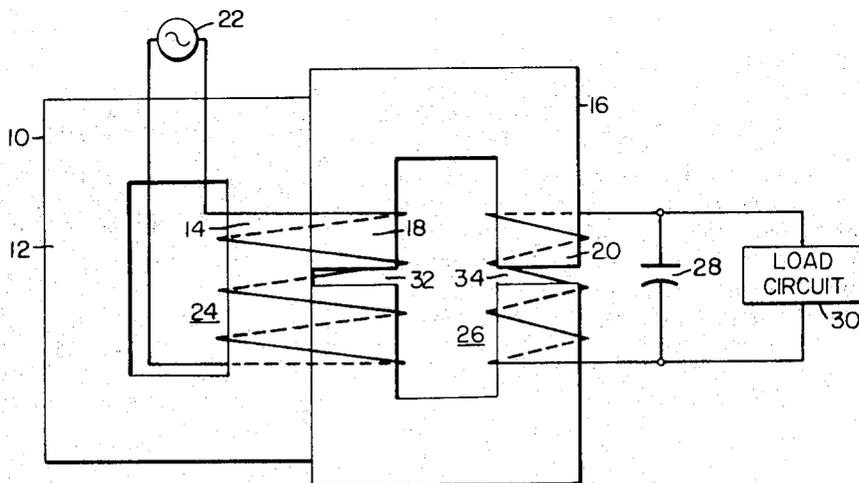
3,579,088	5/1971	Fletcher et al.	323/6
3,584,290	6/1971	Spreadbury	323/6
2,310,742	2/1943	Lord	323/61 X
2,706,271	4/1955	Fletcher et al.	323/60 X
2,442,214	5/1948	Short	323/61

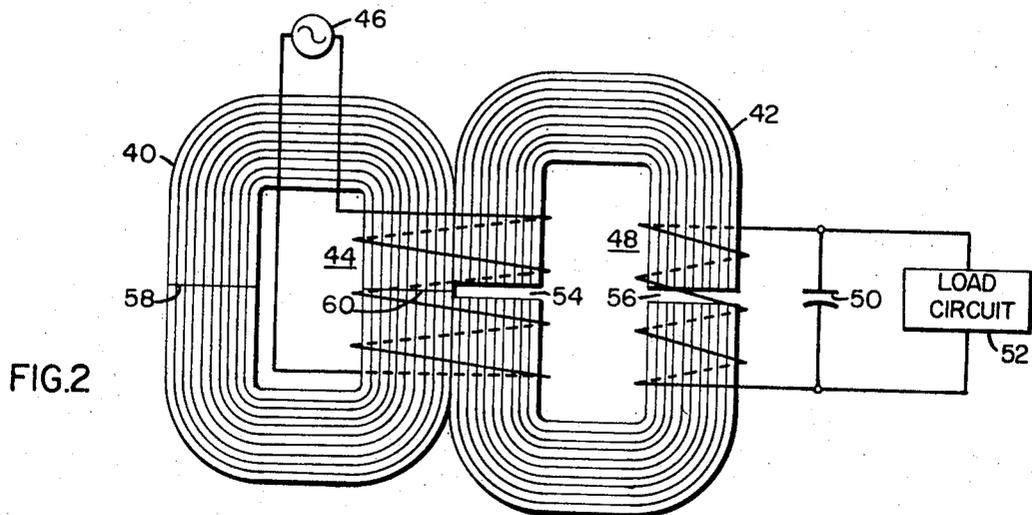
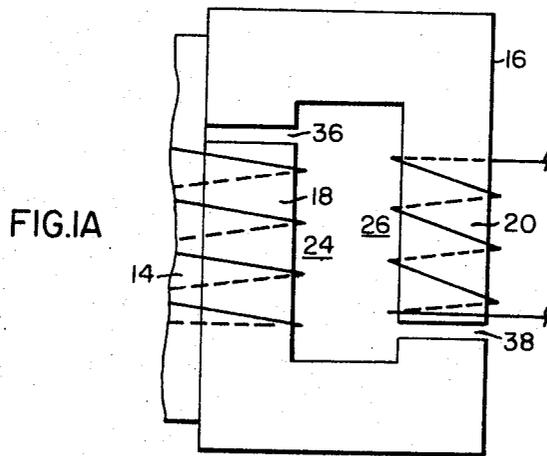
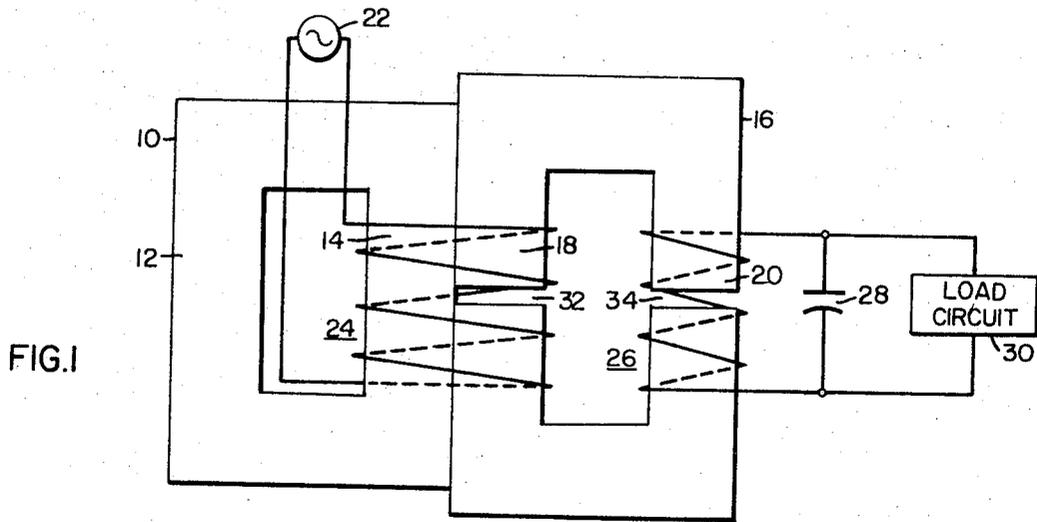
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[57] **ABSTRACT**

Transformer for providing a regulated and filtered output voltage. Input voltage is applied to an input winding which is wound around two magnetic cores. One magnetic core saturates for part of each half-cycle of the induced alternating flux during normal operation. The other magnetic core does not saturate during normal operation and includes air gaps in the legs thereof. An output winding is positioned around the non-saturating core and connected in parallel with a capacitor to form an output tank circuit resonant at the operating frequency of the transformer.

7 Claims, 3 Drawing Figures





REGULATING AND FILTERING TRANSFORMER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates, in general, to regulating transformers and, more particularly, to regulating transformers of the parametric type.

2. Description of the Prior Art

A regulating and filtering transformer which functions similar to the transformer disclosed herein is described in U.S. Pat. No. 3,584,290, issued on June 8, 1971, and assigned to the same assignee as this invention. The core-form embodiment of the transformer disclosed in U.S. Pat. No. 3,584,290 uses a three-leg magnetic core which has an air gap in the core leg over which the output winding is positioned. The purpose of the air gap is to increase and linearize the inductance of that particular region of the magnetic core, which properties are necessary for the proper operation of the transformer. Without an air gap in the output leg, it would be difficult to obtain a sinusoidal output voltage from the transformer.

The gap distance of the air gap is relatively critical for proper operation of the transformer. The output winding is connected in parallel circuit relationship with a capacitor to form a resonant tank circuit which has a resonant frequency equal to the operating frequency of the transformer. Due to tolerance changes in the capacitor and to variations in the magnetic core and winding structure, it is often necessary to tune the output circuit to resonance by adjusting the air gap.

With the core arrangements of regulating and filtering transformers according to the prior art, the air gap adjusting process is tedious and time consuming. After the core has been constructed and the windings placed into position, changing the gap distance requires that the structure be disassembled and that suitable core machining be accomplished to increase or decrease the gap distance. This procedure is economically inefficient and the "cut and try" method of gauging the gap distance does not always produce the ultimate gap distance.

Therefore, it is desirable, and it is an object of this invention, to provide a regulating and filtering transformer which has a core and winding configuration which readily permits tuning the air gap in the output circuit for the desired transformer performance.

It is also necessary in prior art regulating and filtering transformers to initially machine the core to establish the gap. Even if further machining becomes unnecessary because the gap distance created thereby is sufficient, the initial machining operation adds another step in the manufacturing of the transformer core. Usually, the core is constructed without any air gaps. The core is then cut across the legs to form at least two core sections. The length of the cut leg on one, or both, of the sections is ground or milled, thus making it shorter than the other leg portions. When the core sections are assembled with the winding structures, the shortened leg portion creates an air gap in that leg equal to the amount removed by machining.

It is also desirable, and it is another object of this invention, to provide a regulating and filtering transformer which contains an air gap in the output portion of the magnetic core which may be constructed without the necessity of machining a core leg to provide the gap.

SUMMARY OF THE INVENTION

This invention provides a regulating and filtering transformer wherein the magnetic paths therefor are provided by two separate magnetic cores. A saturating core is positioned adjacent to a non-saturating core. The adjacent regions of the two cores are induced with an alternating flux from an input winding. The output region of the non-saturating core provides a flux path for an output winding positioned thereon. The output winding is connected in parallel circuit relationship with a capacitor, with the resonant frequency of the tank circuit thereby formed being equal to the operating frequency of the transformer. The non-saturating core includes air gaps which increase the reluctance of the non-saturating core.

The non-saturating core includes two leg portions and two yoke portions. The gap distance of the two air gaps are equal. By this arrangement, the air gaps may be provided more economically and the gap adjusting procedure is simpler than in the prior art core arrangement. Since both gap distances are equal, separate machining of one leg is unnecessary. After the core has been cut in half, the two halves are merely positioned a sufficient distance apart to provide the required air gap. In the prior art transformer, at least one of the core legs does not contain any air gap, or contain an air gap having a different gap distance than the gap in the output leg. Consequently, moving the core halves apart, or together, changes gap conditions in both leg portions and thus changes the reluctance presented to the input circuit. With the present invention, both leg portions are contained in the output circuit only, thus changing the gap distances simultaneously does not change the gap conditions and the reluctance presented to the input circuit. Therefore, the regulating and filtering transformer disclosed herein may be tuned by simply moving the core halves in the output circuit, thereby eliminating the need for additional core machining.

BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages and uses of this invention will become more apparent when considered in view of the following detailed description and drawings, in which:

FIG. 1 is a view of a transformer constructed according to the teachings of this invention having magnetic cores of the stacked lamination type;

FIG. 1A is a partial view of the transformer shown in FIG. 1 with the air gaps positioned in different planes; and

FIG. 2 is a view of a transformer constructed according to the teachings of this invention having magnetic cores of the wound type.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the following description, similar reference characters refer to similar members in all figures of the drawing.

Referring now to the drawings, and FIG. 1 in particular, there is shown a regulating and filtering transformer constructed according to the teachings of this invention. The magnetic core 10 is constructed of a plurality of layers of metallic laminations. The magnetic core 10 includes a first region 12 and a second re-

gion 14. Adjacent to the magnetic core 10 is the magnetic core 16, which has a first region 18 and a second region 20.

A source of alternating voltage 22 is connected to an input winding 24. The input winding 24 is positioned around the second region 14 of the magnetic core 10 and the first region 18 of the magnetic core 16 and an output winding 26 is positioned over the second region 20 of the magnetic core 16 and connected in parallel circuit relationship with a capacitor 28. The output winding 26 and the capacitor 28 form a resonant tank circuit. The load circuit 30, which is electrically connected to the tank circuit, represents the load on the transformer. The resonant frequency of the tank circuit is substantially equal to the frequency of operation of the transformer, such as 60 hertz.

The magnetic core 16 contains air gaps 32 and 34 which are located in regions 18 and 20, respectively. The gap distance of the air gaps 32 and 34 are equal, and, in the embodiment illustrated in FIG. 1, are positioned in a plane which perpendicularly bisects the core regions 18 and 20. The gaps may be positioned in the yoke regions of the magnetic core 16 without departing from the teachings of the invention or reducing the usefulness thereof. It is also within the contemplation of this invention that the air gaps may be positioned in different planes, such as the air gaps 36 and 38 illustrated in FIG. 1A.

The electrical operation of the transformer illustrated in FIG. 1 is similar to the operation of the transformer disclosed in U.S. Pat. No. 3,584,290, issued on June 8, 1971. Another description of the operation is contained in the "Westinghouse Engineer," March, 1971, pages 42 to 45.

In FIG. 1, the core 10 is constructed of a suitable material, such as grain oriented silicon steel, and has dimensions which cause the core to saturate during part of each half-cycle of the alternating flux induced by the input winding 24. Before saturation, the reluctance of the magnetic core 10 is lower than the reluctance of the magnetic core 16. Thus, a greater portion of the flux induced by the input winding 24 traverses the magnetic path provided by the magnetic core 10. As a result thereof, the output winding 26 is only slightly linked by the flux provided by the input winding 24.

When the voltage applied to the input winding 24 is large enough to induce a quantity of flux into the magnetic core 10 which saturates the core 10, the reluctance of the magnetic core 10 increases. This increase in reluctance of core 10 causes more flux to flow in the magnetic core 16, and provides energy for oscillating the tank circuit comprising capacitor 28 and the output winding 26.

The air gaps 32 and 34 in the magnetic core 16 linearize the reluctance thereof and provide a means to tune the tank circuit comprising output winding 26 and the capacitor 28 to resonance. Since manufacturing tolerances of the capacitor 28, the output winding 26 and the magnetic core 16 may combine to prevent proper resonance of the tank circuit, means must be provided to compensate for the tolerances of manufacturing. The gaps may be maintained by placing a suitable non-magnetic material therein and clamping the halves of the core 16 together, by means which is not illustrated in FIG. 1.

The ease with which the air gaps 32 and 34 may be established is an important advantage of this invention. After the core 16 has been cut in half, only the separation distance of the two halves of the core 16 need be established to set the air gaps 32 and 34. In the prior art arrangement, it is necessary to machine a half portion of one leg of the core to establish the air gap distance. Adjustment of the air gaps 32 and 34 is also an advantageous feature of the core constructed according to this invention. Additional machining is required by the prior art arrangement. According to the teachings of this invention, the air gaps 32 and 34 may be changed without extra machining of the core, simply by moving the two halves of the core 16 together or apart.

FIG. 2 illustrates a regulating and filtering transformer constructed according to the teachings of this invention. The magnetic core 40 is constructed by winding a magnetic material in the form of the core. The magnetic core 42 is similarly constructed, but is dimensioned and constructed so that it will not saturate at the induced flux level which will saturate the magnetic core 40. An input winding 44 is positioned over the cores 40 and 42 and connected to an alternating voltage generator 46. An output coil 48 is positioned over the magnetic core 42 and connected to the capacitor 50 and the load circuit 52. The air gaps 54 and 56 in the legs of the core 42 function similar to the air gaps 32 and 34 in the core 16 of the transformer illustrated in FIG. 1. The joints 58 and 60 in core 40 are produced by cutting the wound core 40 in half to allow placement of the input winding 44 thereon.

A 120 VA regulating and filtering transformer constructed according to this invention was tested and it was observed that the output voltage remained constantly at 116.0 volts while the input voltage was changed from 105 volts to 130 volts in 5-volt steps. It was also observed that the noise filtering and input distortion was equally as good as the prior art regulating and filtering transformer.

There has been disclosed a regulating and filtering transformer which offers the advantages of the prior art arrangement with an additional advantage from a manufacturing standpoint. Since numerous changes may be made in the above described apparatus and different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all of the matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative rather than limiting.

We claim as our invention:

1. A regulating and filtering transformer comprising a first magnetic core having first and second regions, a second magnetic core having first and second regions, an input winding having a plurality of turns with each of said turns wound around the second region of said first magnetic core and the first region of said second magnetic core to induce alternating flux therein, an output winding which links the flux in the second region of said second magnetic core and which is connected in parallel circuit relationship with a capacitor to provide a resonant tank circuit, said first magnetic core being constructed and dimensioned to cause it to saturate during a portion of each half-cycle of the alternating flux therein, said second magnetic core being constructed and dimensioned to provide a higher reluctance path for the alternating flux induced by said

input winding than the path provided by said first magnetic core when said first magnetic core is not saturated, and said second magnetic core being constructed and dimensioned to provide a lower reluctance path for the alternating flux produced by said input winding than the path provided by said first magnetic core when said first magnetic core is saturated.

2. The regulating and filtering transformer of claim 1 wherein the second magnetic core includes an air gap for increasing the reluctance of the magnetic core.

3. The regulating transformer of claim 1 wherein the second magnetic core includes two air gaps for increasing the reluctance of the magnetic core, one of the air gaps being positioned in the first region of said second magnetic core and the other of said air gaps being positioned in the second region of said second magnetic core.

4. The regulating and filtering transformer of claim 3 wherein the two air gaps have equal gap distances.

5. The regulating and filtering transformer of claim 1 wherein the magnetic cores are constructed of layers of laminations.

6. The regulating and filtering transformer of claim 1 wherein the magnetic cores are of the wound type.

7. A regulating and filtering transformer comprising a first wound magnetic core having first and second regions, a second wound magnetic core having first and second regions, and an input winding having a plurality

of turns with each of said turns wound around the second region of said first wound magnetic core and the first region of said second wound magnetic core, said input winding inducing alternating flux into said first and second wound magnetic cores, an output winding positioned around the second region of said second magnetic core and connected in parallel circuit relationship with a capacitor to provide a resonant tank circuit, said first magnetic core being constructed and dimensioned to cause it to saturate during a portion of each half-cycle of the alternating flux therein, said second wound magnetic core being dimensioned and containing air gaps to provide, when said first wound magnetic core is not saturated, a higher reluctance path for the alternating flux provided by said input winding than the path provided by said first wound magnetic core, said second wound magnetic core providing, when said first wound magnetic core is saturated, a lower reluctance path for the alternating flux induced by said input winding than the path provided by said first wound magnetic core, a first of said air gaps being positioned in the first region of said second wound magnetic core, a second of said air gaps being positioned in the second region of said wound magnetic core, with the gap distances of said first and second air gaps being substantially equal.

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