June 8, 1948. J. G. ABBOTT 2,442,751

VARIABLE TRANSFORMER

Filed June 5, 1946 2 Sheets-Sheet 1

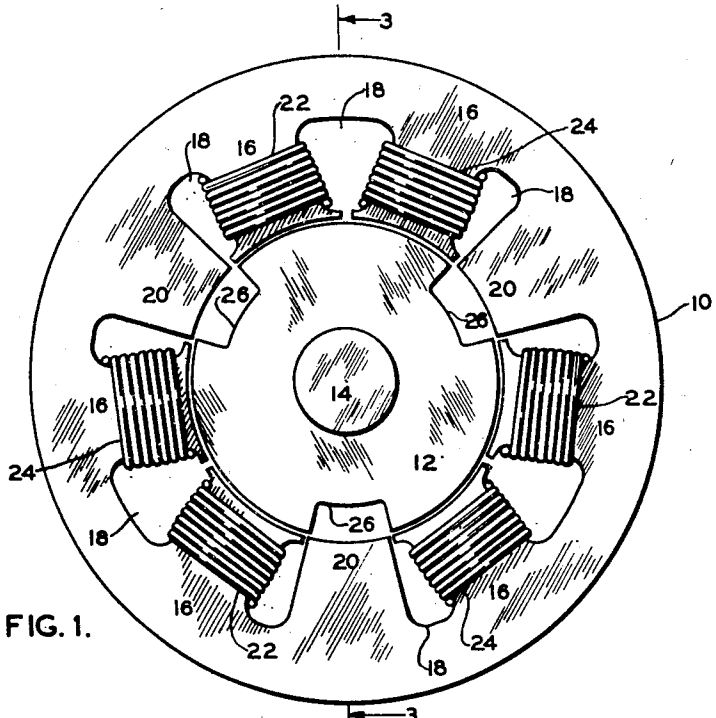


FIG. 1.

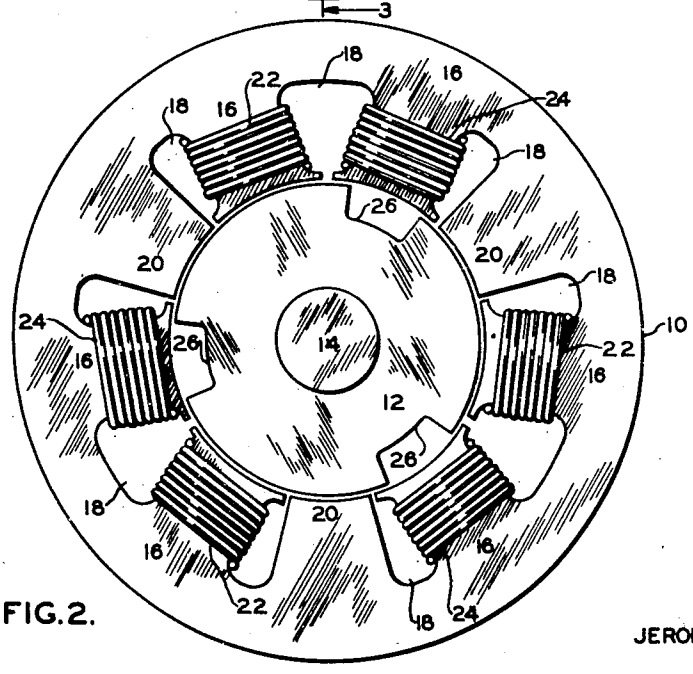


FIG. 2.

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VARIABLE TRANSFORMER

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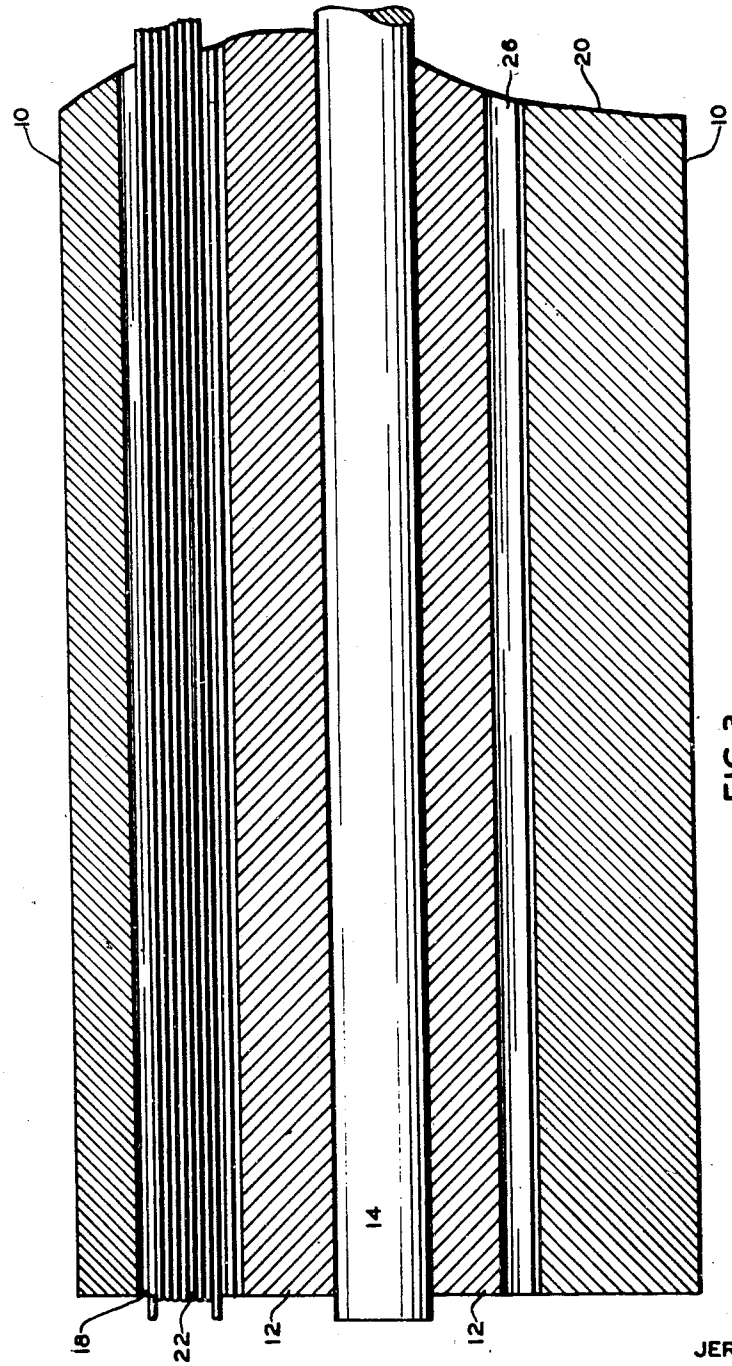


FIG. 3.

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UNITED STATES PATENT OFFICE

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VARIABLE TRANSFORMER

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4 Claims. (Cl. 171—119)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

The invention relates to variable transformers and particularly to transformers wherein the inductive coupling between the primary and the secondary windings thereof is determined by means of a magnetic path of variable reluctance.

It is an object of the invention to provide a transformer wherein the flux linkage between primary and secondary windings is varied by means of a magnetic path of variable reluctance. It is a further object of the invention to provide a means to vary simultaneously the reluctance of the magnetic paths of a polyphase transformer.

It is also an object of the invention to provide a transformer wherein maximum flux linkage may be achieved by the use of a minimum length of conductor in the primary and secondary windings thereof.

It is a further object of the invention to provide a transformer that shall be rugged, durable and easily fabricated.

It is a further object of the invention to provide a transformer that may readily be maintained at a constant operating temperature.

It is a further object of the invention to provide a transformer that is well adapted to be hermetically sealed.

These objects, together with other objects and advantages of the invention which will be apparent to one skilled in the art, are achieved in one embodiment of the invention by means of a stator having a plurality of longitudinally disposed pole pieces and at least one set of primary and secondary windings positioned on adjacent pole pieces of said stator. A rotor is mounted along the axis of said stator to intercept the magnetic path of said primary and secondary windings, the rotor being provided with at least one longitudinal air gap channel formed in the surface thereof. Rotation of said rotor will vary the coupling between the primary and secondary transformer windings from a maximum value to a minimum value, the nature of the variation being determined by the shape of the air gap channel formed in the rotor. In a transformer designed for polyphase operation, at least two sets of primary and secondary windings are positioned on adjacent pole pieces, a free pole piece being disposed between each pair of pole pieces bearing transformer windings.

For a better understanding of the invention, reference is made to the following specification of

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one embodiment thereof, the said specification to be read in connection with the accompanying drawings, in which

Figure 1 is a view in elevation of a device embodying the invention,

Figure 2 is a view in elevation showing a second operating condition of the device shown in Figure 1.

Figure 3 is an interrupted longitudinal view along line 3—3 of Figure 1.

Referring to the drawings, there is shown a laminated, cylindrical transformer stator core 10 having a length that is several times greater than the outside diameter. A laminated rotor 12, of substantially the same length as the stator 10, is rotatably mounted along the axis of the stator core 10 by means of a shaft 14. The stator core 10 and the rotor 12 are formed of a non-magnetic, permeable material, such as silicon steel.

The stator core 10 is divided longitudinally into three sets of wire bearing pole pieces 16 by means of wire cells 18, a free pole piece 20 occuring between each set of wire bearing pole pieces. The wire cells 18 extend longitudinally along the core 10 parallel to the axis thereof and open inwardly toward the rotor 12.

Each set of wire bearing pole pieces 16 bears a primary transformer winding 22 and a secondary transformer winding 24. The wire cells 18, defining the sides of the free pole pieces 20, are of single size as compared to the double size cells formed between the pole pieces 16 of each set of wire bearing pole pieces. The double size cells 18 are necessarily larger than the single size cells since they must receive both one side of the primary transformer winding 22 and one side of the secondary transformer winding 24. Both the single and double cells 18 are sufficiently large to permit passage therethrough of a cooling medium after the transformer windings 22, 24 are in place.

The wire cells 18 defining each wire bearing pole piece 16 are substantially parallel along the greater part of their radial lengths, but are flanged transversely apart toward their innermost ends to constrain windings 22 and 24 in place about pole pieces 16.

Since the length of the stator core 10 is several times greater than its diameter, the length of conductor lying in the cells 18 is great compared to the length of conductor positioned about the ends of the pole pieces 16.

Each set of wire bearing pole pieces 16, bearing a primary winding 22 and a secondary winding 24, constitutes a single transformer. Windings 22, 24 are brought out to a panel board (not shown).

It will be apparent that the device may be used as a single phase transformer or may be used as a multiple-phase transformer in star or delta electrical arrangement.

The rotor 12 is provided with three longitudinally formed air gap channels 26 spaced 120° apart about the surface of the rotor. The channels 26 are of substantially the same width as the innermost faces of the free poles 20, the radial depth of the channels being slight as compared to the width.

It will be seen that maximum flux linkage between primary windings 22 and secondary windings 24 will be attained when the rotor is in the position shown in Figure 1. There the air gap channels 26 are positioned opposite the free poles 20 and lines of magnetic force generated by windings 22 and 24 readily pass through the low reluctance path furnished by the rotor.

Referring now to Figure 2, wherein the rotor 12 has been displaced through a counterclockwise angle of approximately 40 degrees, it will be seen that the flux path is now one of maximum reluctance since the channel 26 provides an air gap in the flux path between the primary winding 22 and the secondary winding 24. Further, it will be seen that flux generated by primary winding 22 is now free to escape through the free pole 20, whereas formerly it was constrained from escaping counterclockwise due to the positioning of the air gap channel 26 opposite the free pole 20. Thus at this position there is a minimum of flux linkage and correspondingly a minimum of energy transference.

It will be seen that for polyphase operation, displacement of rotor 24 results in equal and simultaneous attenuation for each set of windings 16, 18, since the channels 26 are equiangularly displaced. In the event that it is desired to provide non-uniform energy transference for the various sets of windings, the channels 26 would be non-equiangularly disposed.

There has thus been provided a variable transformer that may be easily cooled, that may be operated single phase or polyphase, and that may be varied without displacement of the position of the windings themselves. The flux linkage may be varied over a wide range, since the flux linkage is dependent upon the angular displacement of the rotor 24 from a position of maximum linkage. Depending upon the shape of the channels 26, the attenuation may be either linear or non-linear; and depending upon the angular position of the channels with respect to each other, each phase may be attenuated uniformly or non-uniformly.

It will be apparent that the transformer disclosed herein is well adapted to be hermetically sealed. Sealing may be accomplished in any well known manner, such as by the use of the gasket and bell cap arrangement commonly used to seal hermetically electric motors and generators.

There has thus been disclosed a novel type of variable transformer. It will be apparent that many modifications and changes may be made in the preferred embodiment disclosed herein. For example, the transformer core and the variable reluctance path may be linearly arranged, instead of being circularly arranged. It is therefore intended that the full scope of the invention be defined by the appended claims.

What is claimed is:

1. A variable transformer comprising a stator having a plurality of longitudinally disposed pole pieces, at least two sets of primary and secondary transformer windings, the primary and secondary windings of each set being positioned on adjacent pole pieces, a free pole piece disposed between each pair of pole pieces bearing transformer windings, a rotor positioned along the axis of said stator and included in the magnetic path of each set of primary and secondary transformer windings, said rotor having at least two longitudinally formed air gap channels disposed along the surface thereof, said channels being spaced to oppose said free pole pieces whereby rotation of said rotor will displace said channels from a position opposite said free pole piece to a position opposite said transformer windings.

2. The device according to claim 1, wherein said channels are shaped to provide a linear variation of coupling with respect to rotational displacement of said rotor.

3. The device according to claim 1, wherein said channels are shaped to provide a non-linear variation of coupling with respect to rotational displacement of said rotor.

4. A variable transformer comprising a stator having a plurality of longitudinally formed pole pieces, the length of said stator being several times the diameter of said stator, at least two sets of primary and secondary transformer windings, the primary and secondary windings of each set being positioned on adjacent pole pieces, a free pole piece disposed between each pair of wire bearing pole pieces, a wire cell occurring between each pole piece, said wire cells being of sufficient width to receive said windings and to form wind cells adjacent said windings, a rotor positioned along the axis of said stator and included in the magnetic path of each set of primary and secondary transformer windings, said rotor having at least two longitudinally formed air gap channels disposed along the surface thereof, said channels being spaced to oppose said free pole pieces whereby rotation of said rotor will displace said channels from a position opposite said free pole pieces to a position opposite said transformer windings.

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