May 16, 1939. J. A. COMSTOCK 2,158,275

HIGH LEAKAGE TRANSFORMER

Original Filed Aug. 31, 1935

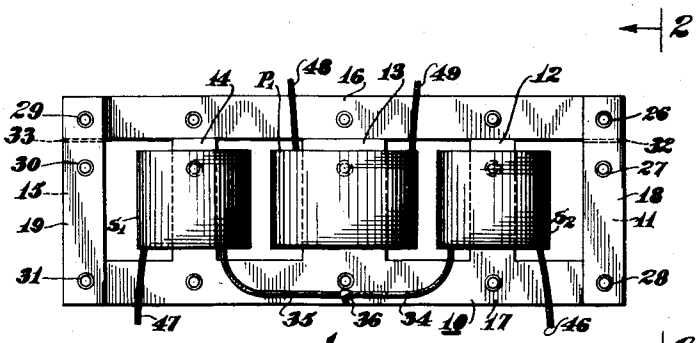


Fig. 1.

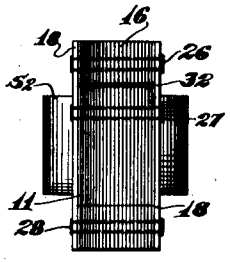


Fig. 2.

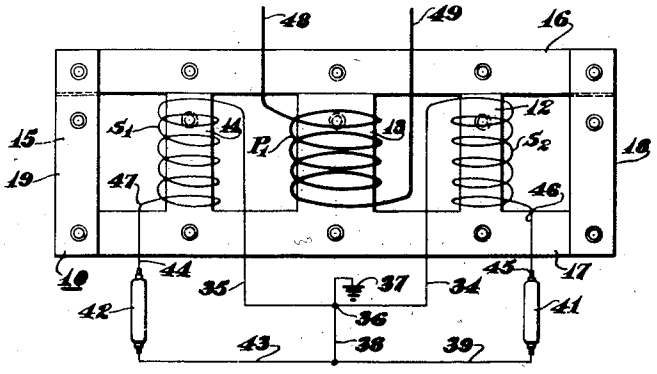


Fig. 3.

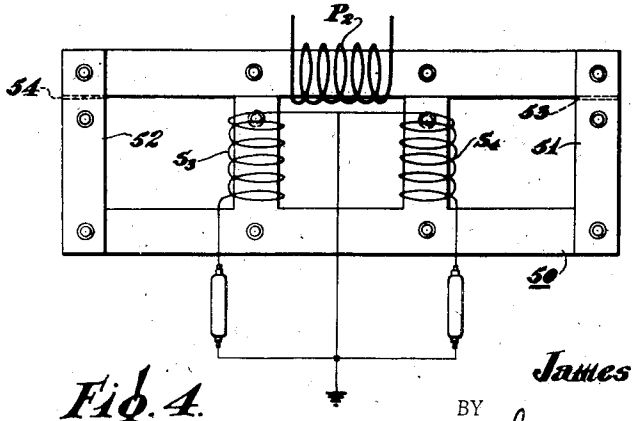


Fig. 4.

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HIGH LEAKAGE TRANSFORMER

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Original application August 31, 1935, Serial No. 38,756. Divided and this application December 26, 1935, Serial No. 56,159

8 Claims. (Cl. 171—119)

My invention relates to transformers and more particularly to high leakage reactance transformers, and is a division of my application No. 38,756, filed August 31, 1935, for High leakage reactance transformers.

An object of my invention is the provision of a transformer adapted to energize an electrical load having a variable resistance which, when the transformer is connected in circuit relation with the electrical load, gives a relatively high initial voltage when the resistance of the electrical load is relatively high, and gives a relatively low operating voltage after the resistance of the electrical load decreases to a relatively low value.

Another object of my invention is to provide for limiting and regulating the amount of flux which interlaces the secondary windings of the transformer in accordance with the current flowing through the said windings.

A still further object of my invention is to provide for by-passing a portion of the flux which interlaces the secondary windings, in accordance with the current flowing through the said windings.

It is also an object of my invention to provide, in a high leakage reactance transformer, external shunts for by-passing a portion of the flux that interlaces the secondary windings.

It is also an object of my invention to provide for limiting the short circuited current of either one of two secondary windings, while at the same time keeping the other secondary windings in an operative condition.

Other objects and a fuller understanding of my invention may be had by referring to the following description and claims, taken in combination with the accompanying drawing in which:

Figure 1 represents a side elevational view of a high leakage reactance transformer, embodying features of my invention;

Figure 2 represents a right hand end view of the transformer shown in Figure 1;

Figure 3 represents a diagrammatical view of the transformer shown in Figure 1, together with circuits for connecting the secondary windings with two gaseous tubes; and

Figure 4 represents a modified form of a transformer, embodying the features of my invention.

With reference to Figures 1, 2 and 3, my transformer comprises, in general, magnetic core means indicated generally by the referenc character 10, a primary winding P1, two secondary windings S1 and S2, and two external magnetic shunts 11 and 15, which function to limit the secondary current.

As illustrated, the magnetic core means 10 may be constructed in the usual manner of a plurality of stacked laminations and held together by suitable rivets. The magnetic core means 10 comprises two main parts joined together to form the complete magnetic circuit. One of the parts comprises a base 17 and a plurality of legs 12, 13, and 14, together with the two external shunts 11 and 15, all stamped as one integral piece or lamination. These laminations when stacked may be held together with suitable rivets in accordance with the general construction of transformers. The other part of the magnetic core means comprises a relatively long core portion 16 which is likewise made up of a plurality of stack laminations held together with suitable rivets.

In assembling the transformer, the primary winding P1, and two secondary windings S1 and S2 are inserted respectively over, and suitably insulated from the magnetic core legs 13, 14, and 12, after which the upper longitudinal core portion 16 is placed on top of the butt ends of the legs 12, 13 and 14, thereby making a butt joint connection between the ends of the magnetic core legs 12, 13 and 14 and the underneath side of the upper longitudinal core portion 16. Any suitable means may be employed to connect the upper longitudinal core portion 16 to the lower portion of the magnetic core means. To this end, I have illustrated a set of end straps 18 and 19 which are riveted respectively to the opposite sides of the two external magnetic shunts 11 and 15, by means of rivets 27, 28, and 30 and 31. These straps 18 and 19 may be either non-magnetic or magnetic material, so long as the reluctance is not reduced too much by the magnetic material and so long as there is not too much local heating of the magnetic material. The upper end of these two sets of straps 18 and 19 are riveted to the ends of the upper longitudinal core portion 16 by means of the rivets 28, and 29, respectively. The external shunts 11 and 15 are slightly fore-shortened, so as to provide an air gap 32 between the end of the magnetic shunt 11 and the right hand end of the longitudinal core portion 16, and an air gap 33 between the end of the magnetic shunt 15 and the left hand end of the longitudinal core portion 16. These air gaps may be filled with any suitable non-magnetic material such as fish paper or the like. The purpose of the air gap is to cause the reluctance of the magnetic

shunts 11 and 15 to be higher than the reluctance of the magnetic core legs 12, 13 and 14.

In Figure 3, I have illustrated my transformer as being connected in circuit relation with two gaseous tubes 41 and 42. The upper electrode 45 of the gaseous tube 41 is connected to the secondary winding S2 by means of a conductor 46 and the upper electrode 44 of the gaseous tube 42 is connected to the secondary winding S1 by means of a conductor 47. The opposite end of the secondary winding S1 is connected to a common point 36 by means of a conductor 35 and the opposite end of the secondary winding S2 is connected to the common point 36 by means of a conductor 34.

The common point 36 is in turn connected to a ground 37. The lower end of the gaseous tube 41 is connected to the common point 36 by means of a conductor 39, and 38, and the lower end of the gaseous tube 42 is connected to the common point 36 by means of a conductor 43 and 38.

In explaining the operation of my transformer, let it be assumed that the primary winding P1 is energized by the two supply conductors 48 and 49. Immediately upon the energization of the primary winding P1, a primary flux is established which flows from the magnetic core leg 13 and thence through the central portion of the upper longitudinal core portion 16 and then through the two magnetic core legs 12 and 14 and then back through the central portion of the base of the core portion 17 to the central magnetic core leg 13. By reason of the air gaps 32 and 33, a relatively small amount of the primary flux in the first instance flows through the external shunts 11 and 15. This means that substantially all of the primary flux interlaces the secondary windings S1 and S2, and thus induces a relatively high voltage in both of the secondary windings S1 and S2, which ionizes the gas and thus illuminates the two gaseous tubes 41 and 42. Just as soon as the gas of the tubes is ionized, the electrical resistance thereof, immediately becomes relatively low, and thus a relatively large secondary current tends to flow through the secondary windings S1 and S2.

Concurrently with the sudden rise in secondary current, the secondary windings S1 and S2 established a secondary flux that opposes the passage of the primary flux through the two secondary windings. Because of the opposition of the secondary flux, the primary flux emanating from the primary winding P1, is constrained to flow through the external magnetic shunts 11 and 15. The by-passing of the primary flux through the external magnetic shunts 11 and 14, thus reduces the amount of the primary flux which interlaces the secondary windings S1 and S2, with the result that the voltage induced in the secondary windings S1 and S2 is reduced to a value which bears in relation to that portion of a primary flux still interlacing the secondary windings. This reduction in the secondary voltage in turn limits the value of the secondary current. The degree to which the secondary current is limited depends on the reluctance of the magnetic shunts 11 and 15 and upon the design and proportions of the various other co-acting parts of the transformer.

The result and effect of the two magnetic shunts 11 and 15 is such that, after the gas of the gaseous tube is ionized, the relatively high initial secondary voltage is immediately and automatically reduced to its normal operating value.

So long as the electric load of the secondary windings S1 and S2 is the same, the magnetic shunts 11 and 15 by-pass substantially the same amount of flux. However, let it now be assumed that a ground occurs at the upper electrode 45 of the gaseous tube 41. This means that the secondary winding S2 is now short circuited and that the secondary current of the secondary winding S2 immediately tends to rise to a high value, which if not limited to a safe value will burn out the winding S2. Under the short circuited condition, the magnetic shunt 11 by-passes substantially all or a major part of the primary flux which tends to pass through the secondary winding S2. As a result, the secondary current of the secondary winding S2 is limited to a safe value, while at the same time the normal operation of the secondary winding S1 is unimpaired. This means that the gaseous tube 42 continues to operate even though the secondary winding S2 is short circuited. The same, but a reverse short circuited condition arises, should a ground occur at the upper electrode 44 of the gaseous tube 42. Under this condition the primary flux which tends to flow through the secondary winding S1 is by-passed through the magnetic shunt 15. As a result, the short circuited current of the secondary winding S1 is limited to a safe value while the secondary winding S2 continued to operate in a normal manner to illuminate the gaseous tube 41. The action of the external shunts 11 and 15 is the same but of a smaller degree when the electric load of the two secondary windings is unequal as will be the case when the operating characteristics of the two gaseous tubes 41 and 42 are not the same. Under cases of an unequal load on the secondary windings S1 and S2, the magnetic shunts 11 and 15 tend to re-balance the electric load by by-passing a portion of the flux. This re-balancing action not only gives improved operation but also makes it possible to operate the gaseous tube of a given length and of a given characteristic at a lower "flickering" voltage (that is, the voltage at which a given tube just begins to flicker) than at which the tube could be operated with a transformer having no re-balancing action. Tests show that with a transformer embodying external shunts constructed substantially in accordance with the principles of my invention gives a much higher secondary current than transformers having internal shunts. The property of giving a high secondary current is a very important factor in the operation of high leakage reactance transformers which supply current to a load having a variable resistance.

In Figure 4, I show a modified arrangement of my high leakage reactance transformer. In this form of my invention, the reference character 50 designates generally the magnetic core means and the reference character 51 and 52 designates respectively the external shunts having air gaps 53 and 54 respectively. As illustrated, the primary winding P2 is mounted upon the central portion of the upper magnetic core portion, and arranged intermediate of the two secondary windings S3 and S4. The operation of this form of my transformer is substantially the same as that previously described with reference to the transformer shown in Figures 1, 2, and 3.

In all of the illustrations of my transformer, it is pointed out that the magnetic shunts func-

tion to limit the value of the secondary current by by-passing a portion of the primary flux.

Although I have described my invention with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

I claim:

1. An external shunt transformer comprising, in combination, magnetic core means having two spaced longitudinal core portions interconnected by two spaced secondary core portions, a secondary winding surrounding each of said secondary core portions, a primary winding disposed intermediate the secondary windings and arranged to cause primary flux to flow longitudinally of the longitudinal core portions and through the secondary core portions, each of said spaced longitudinal core portions extending outwardly from, and constituting a set of spaced ends integral with said longitudinal core portions upon opposite sides of the secondary core portions, magnetic shunt means shunting one of said secondary core portions and interconnecting a set of one of said spaced ends of the longitudinal core portions with an air gap therebetween, second magnetic shunt means shunting the other of said secondary core portions and interconnecting the other set of said spaced ends of the longitudinal core portions with an air gap therebetween, the arrangement of the magnetic core means, the primary and secondary windings, and the magnetic shunt means being such that the said windings are grouped upon the magnetic core means internally of the magnetic shunt means, to minimize the leakage reactance of the transformer and to cause the short circuit current of either secondary winding to be substantially the same as the short circuit current of both of the secondary windings in series.

2. An external shunt transformer comprising, in combination, magnetic core means having two spaced longitudinal core portions interconnected by two spaced secondary core portions, a secondary winding surrounding each of said secondary core portions, a primary winding disposed around one of said longitudinal core portions and intermediate the secondary windings and arranged to cause primary flux to flow longitudinally of the longitudinal core portions and through the secondary core portions, each of said spaced longitudinal core portions extending outwardly from, and constituting a set of spaced ends integral with said longitudinal core portions upon opposite sides of the secondary core portions, magnetic shunt means shunting one of said secondary core portions and interconnecting a set of one of said spaced ends of the longitudinal core portions with an air gap therebetween, second magnetic shunt means shunting the other of said secondary core portion and interconnecting the other set of said spaced ends of the longitudinal core portions with an air gap therebetween, the arrangement of the magnetic core means, the primary and secondary windings, and the magnetic shunt means being such that the said windings are grouped upon the magnetic core means internally of the magnetic shunt means, to minimize the leakage reactance of the transformer and to cause the short circuit current of either secondary winding to be substantially the same as the short circuit current of both of the secondary windings in series.

3. An external shunt transformer comprising, in combination, magnetic core means having two spaced longitudinal core portions interconnected by two spaced secondary core portions and an intermediate primary core portion, a secondary winding surrounding each of said secondary core portions, a primary winding disposed around the said primary core portion and intermediate the secondary windings and arranged to cause primary flux to flow longitudinally of the longitudinal core portions and through the secondary core portions, each of said spaced longitudinal core portions extending outwardly from, and constituting a set of spaced ends integral with said longitudinal core portions upon opposite sides of the secondary core portions, magnetic shunt means shunting one of said secondary core portions and interconnecting a set of one of said spaced ends of the longitudinal core portions with an air gap therebetween, second magnetic shunt means shunting the other of said secondary core portion and interconnecting the other set of said spaced ends of the longitudinal core portions with an air gap therebetween, the arrangement of the magnetic core means, the primary and secondary windings, and the magnetic shunt means being such that the said windings are grouped upon the magnetic core means internally of the magnetic shunt means, to minimize the leakage reactance of the transformer and to cause the short circuit current of either secondary winding to be substantially the same as the short circuit current of both of the secondary windings in series.

4. A transformer that is adapted to energize an electrical load having a variable resistance comprising, in combination, a magnetic core having primary and secondary winding core portions, said primary winding core portion being disposed intermediate said secondary winding core portion, a primary winding disposed to surround the primary winding core portion, a secondary winding closely associated with and on one side of the primary winding and disposed to surround a portion of the secondary winding core portion, said portion being designated as the secondary core portion, means to minimize the leakage reactance of the transformer and to cause the short circuit current of either secondary winding to be substantially the same as the short circuit current of both of the secondary windings in series, said means comprising a first and a second magnetic shunt means each including an air gap, said first magnetic shunt disposed externally of and bridging said secondary core portion and being adapted, when the secondary core portion has a relatively low secondary flux opposing the passage of the primary flux produced by the primary winding, to provide a negligible by-pass for the flux produced by the primary winding thereby causing the induction of a relatively high voltage in the secondary winding, and said first magnetic shunt being adapted when the secondary core portion has a relatively high secondary flux opposing the passage of the primary flux produced by the primary winding to provide an appreciable by-pass for the flux produced by the primary winding, thereby reducing the voltage induced in the secondary winding with the result that the reluctance of the secondary core portion varies substantially inversely with changes in the resistance of the electrical load, a second secondary winding closely associated with and

on one side of the primary winding and disposed to surround another portion of the secondary winding core portion, said portion being designated as the second-mentioned secondary core portion, said second magnetic shunt disposed externally of and bridging said second-mentioned secondary core portion and being adapted, when the second-mentioned secondary core portion has a relatively low secondary flux opposing the passage of the primary flux produced by the primary winding, to provide a negligible by-pass for the flux produced by the primary winding, thereby causing the induction of a relatively high voltage in the second-mentioned secondary winding, the said second-mentioned magnetic shunt being adapted, when the second-mentioned secondary core portion has a relatively high secondary flux opposing the passage of the primary flux produced by the primary winding, to provide an appreciable by-pass for the flux produced by the primary winding, thereby reducing the voltage induced in the second-mentioned secondary winding with the result that the reluctance of the second-mentioned secondary core portion varies substantially inversely with changes in the resistance of the electrical load, said magnetic core separating the two shunt means in space relation from each other and causing each of said shunt means to individually shunt the secondary core portion with which each said shunt means bridges.

5. An external shunt transformer comprising, in combination, magnetic core means having two spaced longitudinal core portions interconnected by two spaced secondary core portions, a secondary winding surrounding each of said secondary core portions, a primary winding disposed intermediate the secondary windings and arranged to cause primary flux to flow longitudinally of the longitudinal core portions and through the secondary core portions, means to minimize the leakage reactance of the transformer and to maintain the short circuit current of either secondary winding to be substantially the same as the short circuit current of both of the secondary windings in series, said means comprising magnetic shunt means including an air gap magnetically associated with one end of the magnetic core means and shunting one of said secondary core portions, and second magnetic shunt means including an air gap magnetically associated with the other end of the magnetic core means and shunting the other said secondary core portion, said two spaced longitudinal core portions separating the two shunt means in space relation from each other and causing each of said shunt means to individually shunt the secondary core portion with which each said shunt means is associated.

6. An external shunt transformer comprising, in combination, magnetic core means having two spaced longitudinal core portions interconnected by two spaced secondary core portions, a secondary winding surrounding each of said secondary core portions, a primary winding disposed around one of said longitudinal core portions and intermediate the secondary windings and arranged to cause primary flux to flow longitudinally of the longitudinal core portions and through the secondary core portions, means to minimize the leakage reactance of the transformer and to maintain the short circuit current of either secondary winding to be substantially the same as the short circuit current of both of the secondary windings in series, said means comprising magnetic shunt means including an air gap magnetically associated with one end of the magnetic core means and shunting one of said secondary core portions, and second magnetic shunt means including an air gap magnetically associated with the other end of the magnetic core means and shunting the other said secondary core portion, said two spaced longitudinal core portions separating the two shunt means in space relation from each other and causing each of said shunt means to individually shunt the secondary core portion with which each said shunt means is associated.

7. An external shunt transformer comprising, in combination, magnetic core means having two spaced longitudinal core portions interconnected by two spaced secondary core portions and an intermediate primary core portion, a secondary winding surrounding each of said secondary core portions, a primary winding disposed around the said primary core portion and intermediate the secondary windings and arranged to cause primary flux to flow longitudinally of the longitudinal core portions and through the secondary core portions, means to minimize the leakage reactance of the transformer and to maintain the short circuit current of either secondary winding to be substantially the same as the short circuit current of both of the secondary windings in series, said means comprising magnetic shunt means including an air gap magnetically associated with one end of the magnetic core means and shunting one of said secondary core portions, and second magnetic shunt means including an air gap magnetically associated with the other end of the magnetic core means and shunting the other said secondary core portion, said two spaced longitudinal core portions separating the two shunt means in space relation from each other and causing each of said shunt means to individually shunt the secondary core portion with which each said shunt means is associated.

8. A transformer that is adapted to energize an electrical load having a variable resistance comprising, in combination, magnetic core means, a primary winding disposed to surround a portion of the magnetic core means, two closely spaced secondary windings disposed to surround two other portions of the magnetic core means, means to minimize the leakage reactance of the transformer and to maintain the short circuit current of either secondary winding to be substantially the same as the short circuit current of both of the secondary windings in series, said means comprising two balancing magnetic shunt means each including an air gap connected respectively to the opposite ends of the magnetic core means, one of said magnetic shunt means having a construction which extends to one side of and bridges the secondary core portion that is surrounded by one of said secondary windings, the other magnetic shunt means having a construction which extends to one side of and bridges the secondary core portion that is surrounded by the other said secondary winding, said magnetic core means separating the two shunt means in space relation from each other and causing each of said shunt means to individually shunt the secondary core portion with which each said shunt means bridges.

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