

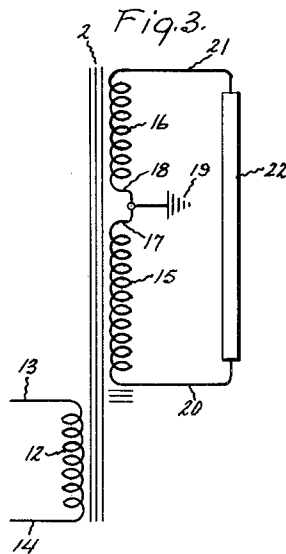
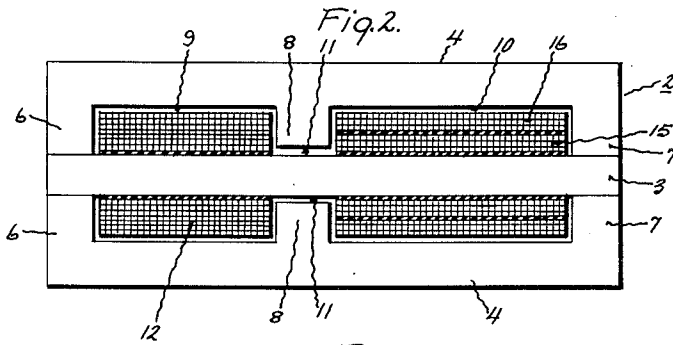
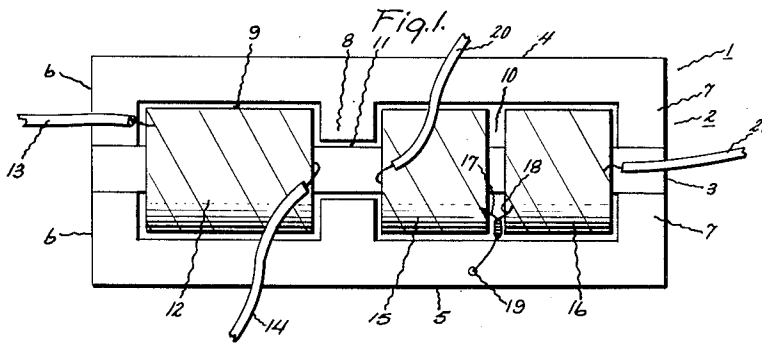
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J. R. CLARK

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HIGH REACTANCE TRANSFORMER

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Inventor:
James R. Clark,
by Robert G. Smith
His Attorney.

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2,810,113

HIGH REACTANCE TRANSFORMER

James R. Clark, Fort Wayne, Ind., assignor to General Electric Company, a corporation of New York

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This invention relates to high reactance transformers, and more particularly to high reactance transformers of the unbalanced, midpoint grounded secondary winding-type.

High reactance transformers are commonly used for starting and operating arc discharge devices, such as luminous tubes. Arc discharge devices are characterized by their negative resistance characteristic, i. e., their resistance decreases as the current flow therethrough increases. A high initial voltage is thus needed to break down or start the device, followed by a requirement for a high impedance in the circuit in order to limit the current flow to a value which will not destroy the device. The high reactance or leakage transformer is ideally suited for this dual purpose since it provides a high open circuit voltage for starting the device and high inductive reactance to limit the current flow after the device has started.

Luminous tubes, such as neon tubes of the type commonly used in signs, are generally cold-cathode type devices, i. e., no means for pre-heating the cathodes of the device to aid starting are provided. Thus, quite high open circuit voltages, i. e., frequently on the order of 1,000 to 15,000 volts, are required for starting. In order to reduce the safety hazards attendant with such high voltages, and also to reduce the insulation requirements of the transformer, high reactance transformers have in the past been constructed with the midpoint of the secondary winding grounded, thus providing an arrangement wherein the maximum open circuit voltage to ground is only one-half the open circuit terminal voltage of the secondary winding.

Two types of high reactance, midpoint grounded secondary winding transformers have been provided; balanced and unbalanced. In the balanced type, a secondary winding coil is physically located on either side of the primary winding, while in the unbalanced type, both secondary winding coils are physically located on one side of the primary. The balanced type construction is satisfactory from a performance standpoint, however, two magnetic shunts are required for leakage flux, whereas only one is required in the unbalanced type of construction. Thus, from an economic standpoint, the industry has preferred the unbalanced type of construction.

In the past, in the unbalanced type of construction, the two coils of the secondary winding have had the same number of turns. In this construction, however, one secondary coil is more loosely coupled to the primary winding than the other secondary winding coil. When the turns of the two coils are equal, the more loosely coupled coil has higher inductive reactance than the more closely coupled coil. Thus, when the more closely coupled coil is short circuited to ground while the more loosely coupled coil is open circuited, a higher short circuit current flows due to the lower inductive reactance of the more closely coupled coil than flows when the more loosely coupled coil is short circuited to ground with the more closely coupled coil open circuited. Since the trans-

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former must be designed to withstand the short circuit current of either secondary winding coil without overheating, heavier wire must be provided in the more closely coupled coil; this in turn requires more winding space and thus a larger core. It is thus seen that in the unbalanced midpoint grounded secondary winding high reactance transformer with an equal number of turns in both secondary coils, more copper and iron is required than would be necessary for normal operation, in order to provide for the high short circuit current in the more closely coupled secondary winding coil.

It is therefore desirable to provide an unbalanced, midpoint grounded secondary winding high reactance transformer in which the short circuit current of the more closely coupled secondary winding is made more nearly equal to the short circuit current of the more loosely coupled secondary winding coil thus reducing the amount of copper and iron required.

It is therefore an object of this invention to provide an improved high reactance transformer incorporating the desirable features set forth above.

This invention in its broadest aspects, provides a high reactance transformer comprising a core formed of magnetic material with a primary winding arranged thereon adapted to be connected to a source of alternating current. A first secondary winding coil is arranged on the core loosely coupled to the primary winding and a second secondary winding coil is also arranged on the core more loosely coupled to the primary winding than the first secondary winding coil. One end of each of the secondary winding coils is connected to a ground and the other ends of the secondary winding coils are respectively adapted to be connected to an arc discharge device, the secondary winding coils being connected in additive voltage relationship in order to provide sufficient open circuit voltage for starting the device. In order to make the short circuit current of both coils more nearly equal, the more closely coupled secondary winding coil is provided with more turns than the more loosely coupled secondary winding coil. This increases the inductive reactance of the more closely coupled secondary winding coil and reduces the short circuit current sufficiently to permit a reduction in wire size with an accompanying saving in copper and iron.

In the drawing,

Fig. 1 illustrates an unbalanced, midpoint grounded secondary winding high reactance transformer incorporating this invention;

Fig. 2 illustrates another type of unbalanced, midpoint grounded secondary winding high reactance transformer incorporating this invention; and

Fig. 3 is a schematic illustration of the transformers of Figs. 1 and 2.

Referring now to Fig. 1, there is shown a high reactance transformer generally identified as 1 having a core 2 formed of a stacked plurality of relatively thin laminations of magnetic material. Core 2 comprises a center winding leg 3 and a pair of outer yoke members 4 and 5. Yoke members 4 and 5 are respectively provided with end legs 6 and 7 which abut the ends of center winding leg 3, and shunts 8 respectively intermediate the end legs 6 and 7. Shunts 8 define primary winding windows 9 with end legs 6 and secondary winding windows 10 with end legs 7. Shunts 8 are spaced from center winding legs 3 by airgaps 11 thus providing a high reluctance path for leakage flux.

A primary winding 12 is arranged on center winding leg 3 of core 2 in primary winding windows 9 and has its leads 13 and 14 adapted to be connected to an external source of alternating current (not shown). A first secondary winding coil 15 is arranged on center winding leg 3 in secondary winding windows 10 adjacent shunts 8 and a second secondary winding coil 16 is arranged

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on center winding leg 3 in secondary winding windows 10 adjacent end legs 7. The ends 17 and 18 of secondary winding coils 15 and 16 are connected to a ground, which connection is preferably made to the core 2, as at 19. The other ends 20 and 21 of secondary winding coils 15 and 16 are respectively adapted to be connected to operate an arc discharge device 22, as shown in Fig. 3. Secondary winding coils 15 and 16 are connected in additive voltage relationship in order to provide the requisite open circuit voltage for starting arc discharge device 22, which may be a luminous tube such as a neon tube.

It will be readily seen that in the embodiment of Fig. 1, the secondary winding coil 16 is more loosely coupled to the primary winding 12 than is the other secondary winding coil 15. Thus, if the secondary winding coils 15 and 16 were provided with an equal number of turns, secondary winding coil 16 would have a higher inductive reactance and thus the short circuit current in the more closely coupled secondary winding coil 15 with its end 20 short circuited to ground would be higher than the short circuit current in the more loosely coupled secondary winding coil 16 with its end 21 short circuited to ground. In order to make these short circuit currents more equal, the more closely coupled secondary winding coil 15 is provided with more turns than the more loosely coupled secondary winding coil 16. It has been found that with the more closely coupled secondary winding coil 15 having between approximately 10 and 30 percent more turns than the more loosely coupled secondary winding coil 16, the short circuit current of coil 15 is reduced to approximately the value of the short circuit current of coil 16. It of course will be readily apparent that the optimum design in which the short circuit currents would be equal will differ with each transformer design, however, the determination of the relationship of the turns of the two secondary windings to achieve complete equality of short circuit currents is well within the skill of the art.

Referring now to Fig. 2, in which like elements are indicated by like reference numerals, there is shown a slightly different physical arrangement in which secondary winding coil 16 is wound over secondary winding coil 15. Here again, secondary winding coil 16 is more loosely coupled to primary winding 12 than is secondary winding coil 15.

A comparison will now be made between the high reactance transformer of the type shown in Fig. 1 having an equal number of turns in the secondary winding coils and a high reactance transformer constructed in accordance with this invention. A transformer having a primary winding coil with approximately 474 turns and secondary winding coils each having approximately 11,000 turns when connected as shown in Fig. 3, provided an open circuit voltage of 5,000 volts with 115 volts, 60 cycles applied to the primary coil. With the more closely coupled secondary winding coil 15 short circuited to ground, the short circuit current in coil 15 was 66.6 milliamperes while the short circuit current when the more loosely coupled secondary winding coil 16 was short circuited to ground was 45.0 milliamperes. This shows that with an equal number of turns, on secondary winding coils 15 and 16, the short circuit current in the more closely coupled secondary winding coil is much higher than the short circuit current in the more loosely coupled secondary winding coil. A transformer constructed in accordance with this invention was then tested again having a primary winding with approximately 474 turns connected to a 115 volt, 60 cycle source of alternating current. The open circuit secondary voltage of this transformer was again 5,000 volts, however, the more closely coupled secondary winding coil 15 had approximately 12,100 turns while the more loosely coupled secondary winding coil 16 had approximately 9,950 turns. The ratio of coil turns was thus 1 to 1.22, or

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coil 15 had 22 percent more turns than coil 16. With this construction, the short circuit current of the closely coupled secondary winding coil 15 was found to be 56.4 milliamperes while the short circuit current of the more loosely coupled secondary winding coil 16 was found to be 48.0 milliamperes. It is thus seen that while the short circuit current of the more loosely coupled secondary winding coil 16 has been increased only 3 milliamperes, the short circuit current of the more closely coupled secondary winding coil has been reduced over 10 milliamperes. The short circuit currents of the two coils could be made substantially equal by slightly increasing the number of turns on the more closely coupled secondary winding coil 15 and slightly decreasing the number of turns on the more loosely coupled secondary winding coil 16. In the particular example given, the short circuit current of the more closely coupled secondary winding coil 15 was reduced a sufficient amount to permit substantial savings in copper and iron while the open circuit secondary voltages of each secondary winding coil were still within 15 percent of one-half the overall open circuit secondary voltage, thus permitting the transformer to still be referred to as a midpoint grounded secondary device.

It will now be readily apparent that this improved construction by reducing the short circuit current of the more closely coupled secondary winding coil permits the design of unbalanced, midpoint grounded secondary winding type high reactance transformers having smaller wire in the more closely coupled secondary winding coil thus permitting savings in both copper and iron. It will also be readily seen that this improved construction provides the same operating characteristics in a smaller, more compact, and less expensive device.

While I have illustrated and described particular embodiments of this invention, further modifications and improvements will occur to those skilled in the art. I desire that it be understood, therefore, that this invention is not limited to the forms shown and I intend in the appended claims to cover all modifications within the spirit and scope of this invention.

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

1. A high reactance transformer for starting and operating an arc discharge device comprising a core formed of magnetic material, a primary winding on said core adapted to be connected to a source of alternating current, a first secondary winding coil on said core loosely coupled to said primary winding, and a second secondary winding coil on said core more loosely coupled to said primary winding than said first secondary winding coil, one end of each of said secondary winding coils being connected to a ground, leads for respectively connecting the other ends of said secondary winding coils to an arc discharge device, said secondary winding coils being connected in additive voltage relationship, said first secondary winding coil having more turns than said second secondary winding coil whereby the short circuit currents of each of said secondary winding coils when the other coil is open circuited are approximately equal.

2. A high reactance transformer for starting and operating an arc discharge device comprising a core formed of magnetic material, a primary winding on said core adapted to be connected to a source of alternating current, a first secondary winding coil on said core loosely coupled to said primary winding, and a second secondary winding coil on said core more loosely coupled to said primary winding than said first secondary winding coil, one end of each of said secondary winding coils being connected to a ground, leads for respectively connecting the other ends of said secondary winding coils to an arc discharge device, said secondary winding coils being connected in additive voltage relationship, said first secondary winding coil having at least 10 percent more turns than said second secondary winding coil whereby the

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device, said secondary winding coils being connected in additive voltage relationship, said first secondary winding coil having more turns than said secondary winding coil whereby the short circuit currents of each of said secondary winding coils when the other coil is open circuited are approximately equal.

11. A high reactance transformer for starting and operating an arc discharge device comprising a core formed of magnetic material, a primary winding on said core adapted to be connected to a source of alternating current, a first secondary winding coil on said core spaced from said primary winding, said core having a high reluctance magnetic shunt for leakage flux disposed between said primary winding and said first secondary winding coil, and a second secondary winding coil wound over said first secondary winding coil, one end of each of said secondary winding coils being connected to a ground, leads for respectively connecting the other ends of said secondary winding coils to an arc discharge device, said secondary winding coils being connected in additive voltage relationship, said first secondary winding coil having at least 10 percent more turns than said second secondary winding coil whereby the short circuit currents of each of said secondary winding coils when the other coil is open circuited are approximately equal.

12. A high reactance transformer for starting and operating an arc discharge device comprising a core formed

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of magnetic material, a primary winding on said core adapted to be connected to a source of alternating current a first secondary winding coil on said core spaced from said primary winding, said core having a high reluctance magnetic shunt for leakage flux disposed between said primary winding and said first secondary winding coil, and a secondary secondary winding coil wound over said first secondary winding coil, one end of each of said secondary winding coils being connected to a ground, leads for respectively connecting the other ends of said secondary winding coils to an arc discharge device, said secondary winding coils being connected in additive voltage relationship, said first secondary winding coil having 10 to 30 percent more turns than said second secondary winding coil whereby the short circuit currents of each of said secondary winding coils when the other coil is open circuited are approximately equal.

References Cited in the file of this patent

UNITED STATES PATENTS

1,777,256	Daley et al. -----	Sept. 30, 1930
1,786,422	Daley -----	Dec. 30, 1930
2,183,355	Mauerer -----	Dec. 12, 1939
2,382,638	Keiser et al. -----	Aug. 14, 1945

FOREIGN PATENTS

415,803	Italy -----	Nov. 2, 1946
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