Jan. 29, 1963 H. MOERLEIN 3,076,136

CONSTANT VOLTAGE TRANSFORMER

Filed Aug. 25, 1958

Fig-1

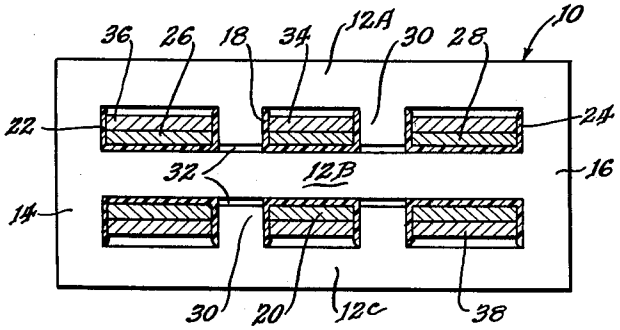


Fig-2

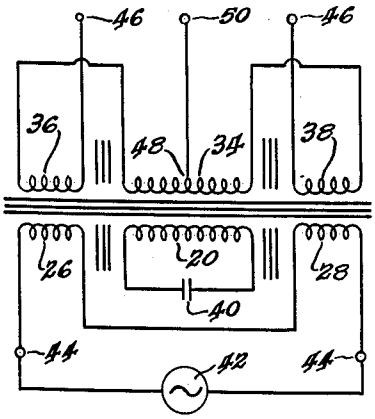


Fig-4

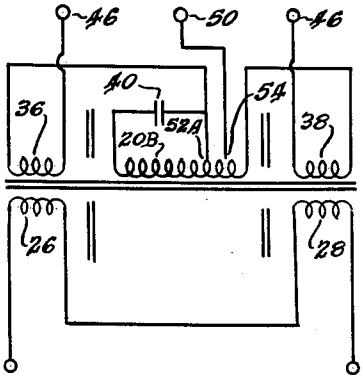


Fig-3

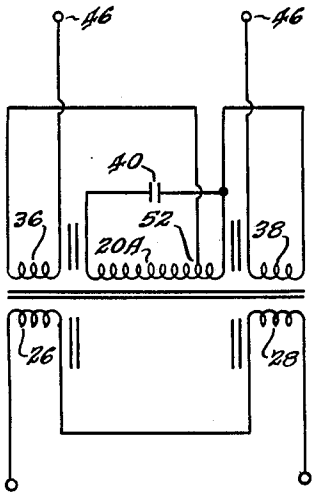
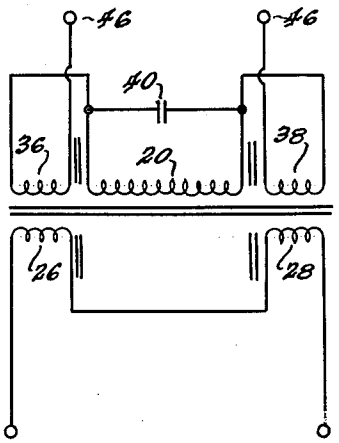


Fig-5



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CONSTANT VOLTAGE TRANSFORMER

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The present invention relates to constant voltage transformers.

Prior to the present invention, a constant voltage transformer existed in which a primary and secondary winding were disposed about a common ferromagnetic core having a magnetic shunt between the coils, and a capacitor was connected in parallel with the secondary winding. The secondary winding and capacitor were designed to resonate at the frequency of an alternating current source connected to the primary, and the output of the transformer was coupled to the secondary winding, generally by means of an auto-transformer connection and in series with a bucking coil magnetically coupled to the primary winding.

It is one of the objects of the present invention to provide an improved constant voltage transformer. Specifically, it is an object of the present invention to provide a constant voltage transformer with an improved wave form over that obtainable by the prior art devices. Further, it is an object of the present invention to provide a constant voltage transformer with a higher volt-ampere capacity per unit of volume. Also, it is an object of the present invention to provide a constant voltage transformer which maintains its potential output for loads with impedances greater than a threshold value and produces negligible output for loads with impedances below the threshold value.

These and further objects of the present invention will become readily apparent upon a further reading of this disclosure, particularly when viewed in the light of the drawings, in which:

FIGURE 1 is a sectional view of a constant voltage transformer constructed according to the teachings of the present invention;

FIGURE 2 is a schematic electrical circuit diagram of the constant voltage transformer illustrated in FIGURE 1; and

FIGURES 3, 4, and 5 are schematic electrical circuit diagrams of other constant voltage transformers which constitute additional embodiments of the present invention.

As illustrated in FIGURE 1, the constant voltage transformer has a ferromagnetic core 10 which forms a closed magnetic circuit and includes three equally spaced parallel strips 12A, 12B, and 12C. The strips are joined together at their ends by end bars 14 and 16 which are disposed normal to the strips 12A, 12B, and 12C. The core 10 is preferably constructed of a plurality of thin laminations of iron or other ferromagnetic material held together in a stack to minimize eddy current losses.

A bobbin or coil form 18 is disposed about the central strip 12B centrally between the end bars 14 and 16, and a first coil 20 is wound about the strip 12B on the bobbin 18. A second bobbin 22 is disposed about the strip 12B adjacent to the end bar 14, and a third bobbin 24 is disposed about the strip 12B adjacent to the end bar 16. Primary coils, referred to herein as second and third coils and designated 26 and 28, are wound about the bobbins 22 and 24, respectively. A high reactance magnetic leakage path is disposed between the coil 20 and the coil 26, and a second high reactance leakage path is disposed between the coil 20 and the coil 28. Each of the high reactance leakage paths is formed by ferromagnetic shunt members 30 extending from the strips 12A and 12C toward the strip 12B. The shunt members 30 terminate a short distance from the strip 12B to form air gaps 32.

The air gaps could equally well be remote from the strip 12B except for ease of manufacture.

A secondary winding or fourth coil 34 is disposed about the first coil 20 on the bobbin 18, and bucking windings or fifth and sixth coils are disposed about the coils 26 and 28, respectively, and designated 36 and 38.

As indicated in FIGURE 2, a capacitor 40 is connected in parallel with the coil 20 forming a circuit which will resonate over a narrow frequency range. The second and third coils 26 and 28 are connected in series, and are adapted to be connected to an alternating current source 42, such as a power line, through input terminals 44. The bucking windings 36 and 38 are connected in series opposition to the fifth coil 34, and the bucking coils 36 and 38 are also connected to output terminals 46. The fifth coil 34 has a center tap 48 which is also connected to an output terminal 50.

The frequency of the alternating current source 42 is selected to resonate the coil 20 and condenser 40. As current begins to flow through the coil 26 and 28, these coils are magnetically coupled to the coil 20. As the flux through the coils 26 and 28 increases from zero, the flux threading the coil 20 tends to increase in nearly direct proportion. Due to the reluctance of the air gaps 32, only a slight amount of flux leaks through the shunts formed by the air gaps 32 and the shunt members 30. When the magnetic flux linking the coil 20 to the coils 26 and 28 reaches a critical value, the coil 20 and the condensate 40 resonate resulting in a definite amount of current flow through the coil 20 and condenser 40. The current flowing through the coil 20 produces a magnetic flux in the portion of the strip 12B of the core 10 passing through the coil 20 which greatly exceeds the flux in any other portion of the strip 12B. As a result, an increase in the current flowing through the coils 26 and 28 primarily increases the leakage flux through the shunt members 30, and to a much lesser extent the magnetic flux linking the coil 20. In other words, the coefficient of coupling between the primary coils 26 and 28 and the coil 20 tends to vary inversely with the current flowing through the coils 26 and 28 under these conditions. The coil 20, therefore, approaches a constant voltage source in spite of variations in the current flowing through the coils 26 and 28.

The winding 34 is coupled to the coil 20 and thereby connects the output terminals 46 to the coil 20. If a load connected between the output terminals 46 presents a reduced impedance, greater coupling between the primary coils 26 and 28 and the coil 20 is achieved so that the potential developed across the winding 34 falls only slightly. At the same time, the flux flowing through the bucking coils 36 and 38 is reduced, further tending to maintain the potential between the output terminals 46 constant. By proper design of the bucking coils 36 and 38, the output potential of the transformer can be made to remain substantially constant over wide variations in input voltage and load impedance. Further, if the output terminals are short circuited, the impedance reflected across the coil 20 falls to cause the coil 20 and capacitor 40 to cease oscillating. Under these conditions, the current flowing through the coils 26 and 28 is limited to a very low value, and the transformer in effect has an automatic maximum output current limitation. This sharp collapsing point is due to the tight coupling between the resonant coil 20 and secondary coil 34, which is in turn achieved by the loose coupling between coil 20 and coils 26 and 28.

In FIGURES 1 and 2, the means provided for coupling the output to the resonant circuit is a double wound coil, that is, the winding 34 is wound over and about the resonant coil 20. The output can also be auto-coupled to

the resonant winding, as illustrated in FIGURES 3, 4, and 5. In these figures, the primary coils 26 and 28, and the bucking coils 36 and 38 are identical to those shown in FIGURE 2, and have thus been designated by the same reference numerals.

In FIGURE 3, the first or resonant coil has been designated 20A, and the coil is provided with a tap 52 near one end thereof. A capacitor which is identical to the capacitor 40 of FIGURE 2 and uses the same designation is connected between the ends of the coil 20A. The tap 52 of the coil 20A is connected to one terminal of the winding 36, while the end of the coil 20A nearest to the tap 52 is connected to one end of the winding 38. In this manner, the bucking windings 36 and 38 are connected in series opposition with the portion of the coil 20A between the tap 52 and the end adjacent thereto.

In FIGURE 4, the first or resonant winding is designated 20B and is provided with a tap 52A closer to one end thereof than the other end. The capacitor 40 is connected between the tap 52A and the remote end of the coil 20B. The tap 52A is also connected to one end of the bucking coil 36, and the adjacent end of the coil 20B is connected to one end of the bucking coil 38. In the transformer of FIGURE 4, the resonant portion of the coil 20B is between the tap 52A and the end of the coil remote therefrom, and the portion of the coil 20B between the tap 52A and the adjacent end thereof is connected in series opposition with the bucking coils 36 and 38. FIGURE 4 also illustrates a tap 54 on the coil 20B centrally between the tap 52A and the adjacent end of the coil 52B. The tap 54 forms a center tap for the output terminals 46 in the same manner as the tap 50 of FIGURE 2.

As illustrated in FIGURE 5, the output terminals 46 of the transformer may be directly connected to the first, or resonant winding 20 through the bucking coils 36 and 38, thereby eliminating the need for auto-coupling or a coupling winding. In this construction, the bucking coils 36 and 38 are connected in series opposition to the first or resonant coil 20 itself.

It is also to be understood that other modifications can also be employed to couple the output terminals 46 to the first or resonant winding 20, such as the well known auto-coupling circuits not here disclosed. Further, a center tap may be provided in the output circuit in the manners conventionally known to the art.

In one particular construction of the embodiment illustrated in FIGURES 1 and 2, the first winding 20 has 25,000 turns and the capacitor 40 is 2 microfarads. The core 10 has strips 12A, 12B, and 12C with cross sectional areas of 1.025 square inches. Under these conditions with an input voltage of 115 volts alternating at sixty cycles per second, the potential measured across the resonant winding 20 is approximately 600 volts. The combined bucking voltage across the windings 36 and 38 is selected to be approximately 10 volts to produce a stable output voltage for variations in input voltage of ten percent within approximately 0.1 percent.

It is also to be noted that the split primary and double magnetic shunt construction here disclosed results in a transformer producing an improved wave form. Cancellation of odd harmonics resulting from this construction greatly contributes to this result.

The constant voltage transformer here disclosed achieves the objects of the invention described above. The transformer may be modified without departing from the scope of the present invention, and the teachings of the present invention are clearly applicable to devices other than those specifically disclosed. It is, therefore, intended that the present invention be not limited by the foregoing disclosure, but rather only by the appended claims.

The invention claimed is:

1. A constant voltage device comprising an alternating current source of constant frequency, and a transformer having a ferromagnetic core forming a closed magnetic circuit, a first coil disposed about the core, a capacitor connected in parallel with the first coil to form a resonant electrical circuit therewith at the frequency of the alternating current source, second and third coils disposed about the core adjacent to opposite ends of the first coil and connected in series, said coils being electrically connected to the alternating current source, a first high leakage reactance magnetic shunt disposed between the first and second coils, a second high leakage reactance magnetic shunt disposed between the first and third coils, and means for coupling a load to the first coil.

2. A constant voltage transformer having a ferromagnetic core forming a closed magnetic circuit, a first coil disposed about the core, a capacitor connected in parallel with the first coil to form a resonant electrical circuit therewith, second and third coils disposed about the core adjacent to opposite ends of the first coil and electrically connected in series, said coils being adapted to be connected to an alternating current source having a frequency equal to the frequency of resonance of the first coil and capacitor, a first high leakage reactance magnetic shunt disposed between the first and second coils, a second high leakage reactance magnetic shunt disposed between the first and third coils, means for coupling a load to the first coil, a fourth coil disposed about the core and magnetically coupled to the second coil, and a fifth coil disposed about the core and magnetically coupled to the third coil, the fourth and fifth coils being electrically connected in series opposition with the means for coupling a load to the first coil.

3. A constant voltage transformer having a ferromagnetic core forming a closed magnetic circuit, a first coil disposed about the core, a capacitor connected in parallel with the first coil to form a resonant electrical circuit therewith, second and third coils disposed about the core adjacent to opposite ends of the first coil and electrically connected in series, said coils being adapted to be connected to an alternating current source having a frequency equal to the frequency of resonance of the first coil and capacitor, a first high leakage reactance magnetic shunt disposed between the first and second coils, a second high leakage reactance magnetic shunt disposed between the first and third coils, a fourth coil disposed about the core and magnetically coupled to the second coil, a fifth coil disposed about the core and magnetically coupled to the third coil, and a sixth coil disposed about the core and magnetically coupled to the first coil, the fourth and fifth coils being electrically connected in series opposition with the sixth coil.

4. A constant voltage transformer comprising the elements of claim 1 wherein the ferromagnetic core comprises three parallel spaced elongated linear strips, a pair of end bars normal to the strips and interconnecting the ends thereof, the first coil being disposed centrally about the center strip, and the second and third coils being disposed about the center strip on opposite sides of the first coil, and shunt members extending from the central strip to the outer strips between the first coil and the second coil and between the first coil and the third coil, each of said shunt members forming an air gap with another portion of the core.

5. A constant voltage transformer comprising a ferromagnetic core having three parallel spaced linear elongated strips, a pair of end bars normal to the strips and interconnecting the ends of the strips, and four shunt members disposed between the center strip and the other two strips, two of said shunt members being disposed between the center strip and each of the other strips and spaced from each other and from the end bars, a first coil disposed about the center strip between the four shunt members, a capacitor connected in parallel with the first coil to form a resonant electrical circuit therewith, second and third coils disposed about the center strip confronting opposite ends of the first coil and elec-

trically connected in series, the magnetic shunts being disposed between the first coil and the second and between the first coil and third coil, said second and third coils being adapted to be connected to an alternating current source having a frequency equal to the frequency of resonance of the first coil and capacitor, a fourth coil disposed about the first coil, a fifth coil disposed about the second coil, and a sixth coil disposed about the third coil, the fifth and sixth coils being connected in series opposition with the fourth coil forming an output circuit.

6. A constant voltage transformer comprising the elements of claim 2 wherein the means for coupling a load to the first coil comprises a tap on said first coil remote from one end thereof, the fourth and fifth coils being connected in series opposition with the portion of the first coil between the tap and the adjacent end of the coil.

7. A constant voltage transformer comprising the elements of claim 2 wherein the means for coupling a load to the first coil comprises means for connecting the fourth and fifth coils in series opposition with the first coil.

8. A constant voltage transformer comprising the elements of claim 2 wherein the first coil is provided with

a tap adjacent to one end thereof and the capacitor is connected between the tap and the end of the coil remote therefrom, the means for coupling the first coil to a load including means for connecting the portion of the first coil between the tap and the adjacent end thereof in series opposition with the fourth and fifth coils.

9. A constant voltage transformer comprising the elements of claim 8 wherein the first coil is provided with a second tap located centrally between the first tap and the adjacent end of the first coil.

10. A constant voltage transformer comprising the elements of claim 5, wherein the fourth coil is provided with a central tap.

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