July 18, 1967 S. G. VARGO 3,332,050

AUTO-TRANSFORMER OF CORE-FORM TYPE HAVING TAPPED WINDING DISPOSED BETWEEN AXIALLY SPACED SECTIONS OF HIGH AND LOW VOLTAGE WINDINGS

Filed May 12, 1965 3 Sheets-Sheet 1

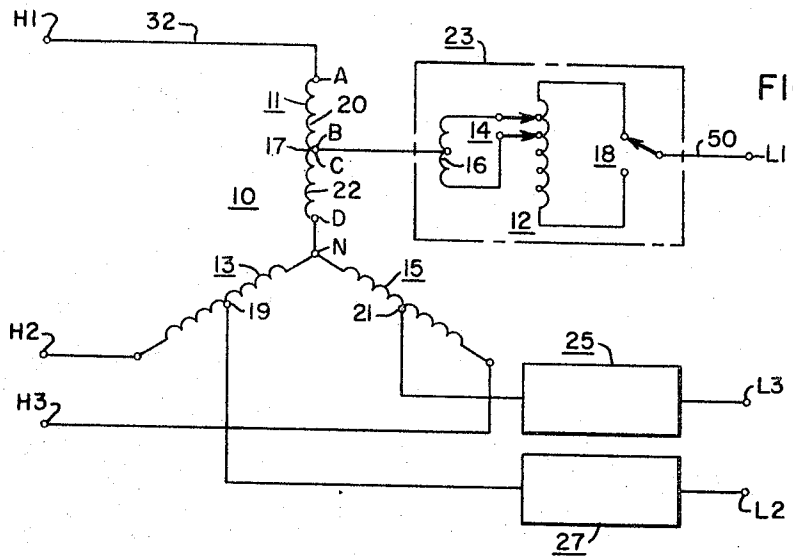


FIG. 1.

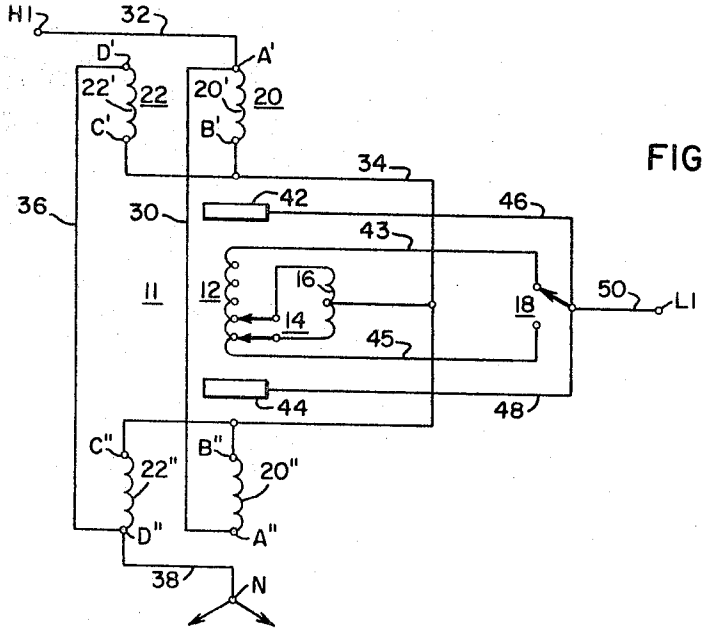


FIG. 2.

WITNESSES:
Bernard R. Giegucz
James F. Young

INVENTOR
Stephen G. Vargo
BY
Donald R. Lackey
ATTORNEY

July 18, 1967 S. G. VARGO 3,332,050

AUTO-TRANSFORMER OF CORE-FORM TYPE HAVING TAPPED WINDING DISPOSED BETWEEN AXIALLY SPACED SECTIONS OF HIGH AND LOW VOLTAGE WINDINGS

Filed May 12, 1965 3 Sheets-Sheet 2

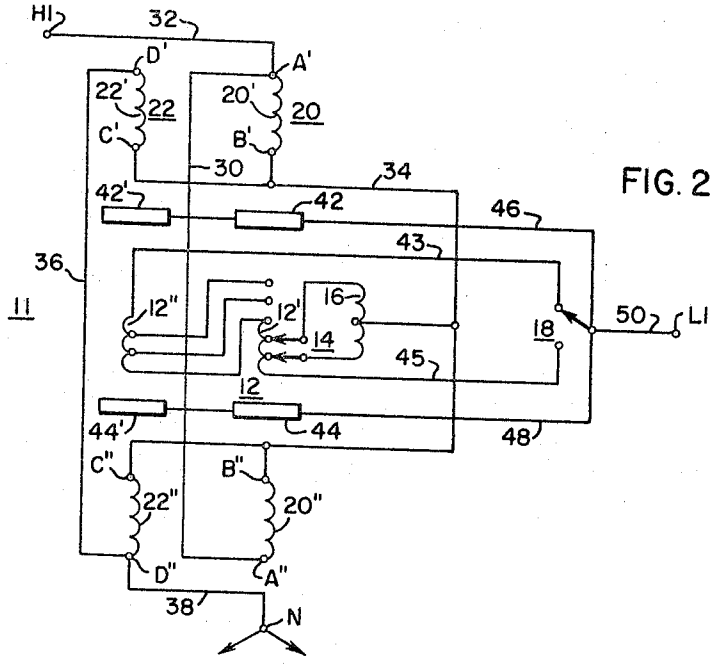


FIG. 2A.

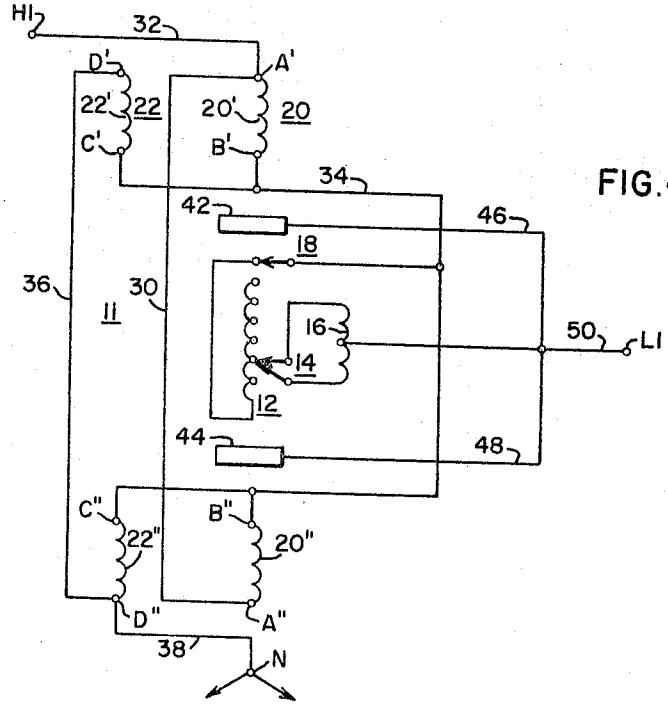


FIG. 4.

July 18, 1967 S. G. VARGO 3,332,050

AUTO-TRANSFORMER OF CORE-FORM TYPE HAVING TAPPED WINDING DISPOSED BETWEEN AXIALLY SPACED SECTIONS OF HIGH AND LOW VOLTAGE WINDINGS

Filed May 12, 1965 3 Sheets-Sheet 3

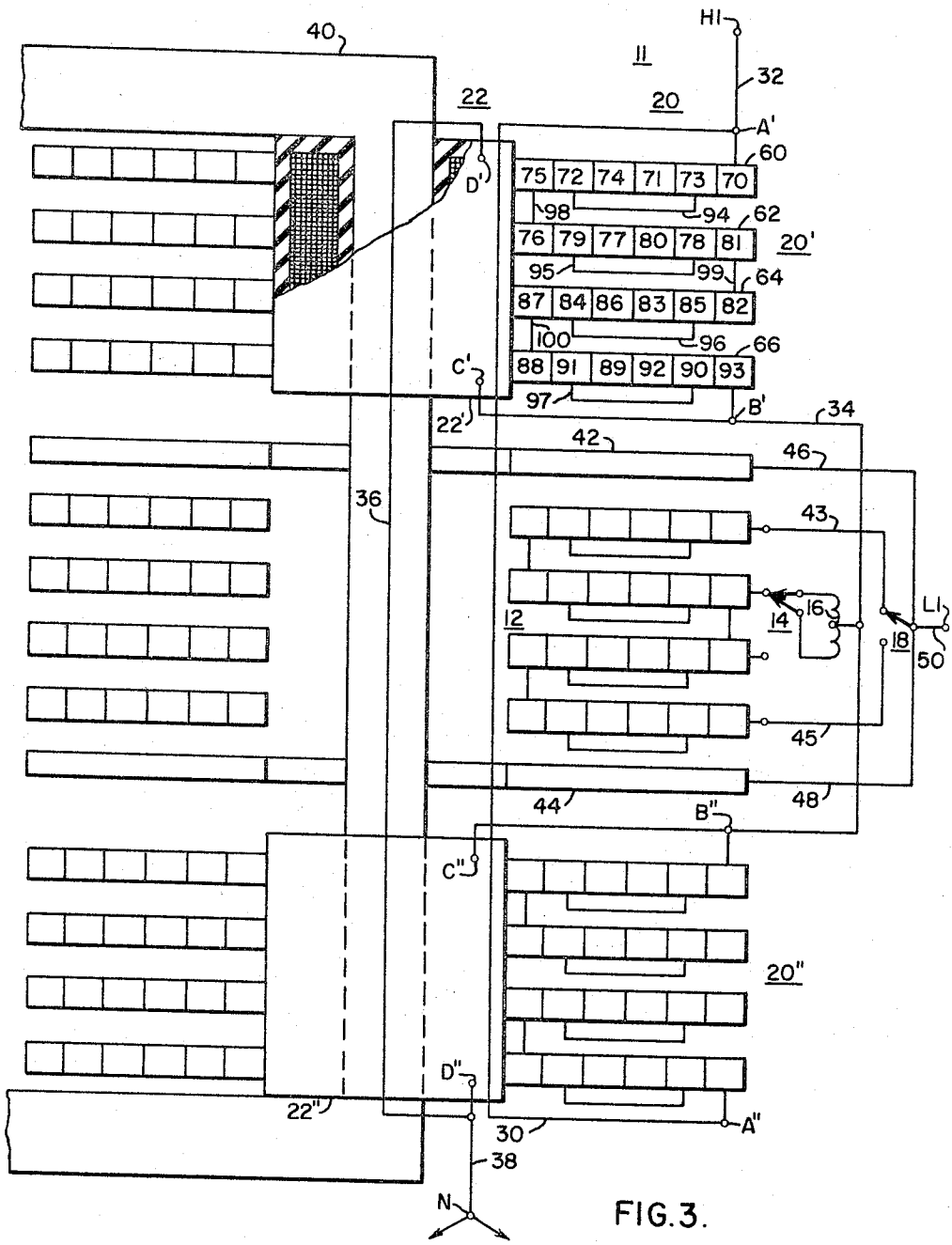


FIG. 3.

United States Patent Office

3,332,050

Patented July 18, 1967

3,332,050

AUTO-TRANSFORMER OF CORE-FORM TYPE HAVING TAPPED WINDING DISPOSED BETWEEN AXIALLY SPACED SECTIONS OF HIGH AND LOW VOLTAGE WINDINGS

Stephen G. Vargo, Campbell, Ohio, assignor to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Filed May 12, 1965, Ser. No. 455,282
8 Claims. (Cl. 336—148)

ABSTRACT OF THE DISCLOSURE

An auto-transformer having concentrically wound high and low voltage windings which are each divided into axially spaced sections. A tapped winding is disposed between the spaced sections, and the inner ends of the spaced sections are connected in common and to the low voltage line terminal through the tapped winding and a tap changer associated with the tapped winding. Static shields are disposed between the tapped winding and the adjacent spaced sections, which are also connected to the low voltage terminal.

It is common in high voltage electrical power systems to step the voltage down by utilizing an auto-transformer. The voltage appearing at the low voltage lead is made adjustable by utilizing a load tap changer. If the auto-transformer is of the shell form type, in which a major portion of the magnetic circuit envelops the windings, and the windings are formed of a plurality of serially connected stacked or superposed pancake or disc coils, the load tap changer may be connected directly in the low voltage circuit by an arrangement well known in the art, since voltage surges are distributed throughout the windings in a substantially uniform manner. If the auto-transformer is of the core form type, wherein the windings envelop a considerable portion of the magnetic circuit, and the high and low voltage winding portions are concentrically disposed instead of stacked, a more difficult problem is presented due to the fact that surge voltages are not distributed uniformly across the conventional core form winding structure. Thus, in order to prevent excessively high voltages, due to surge voltages and consequent oscillations, from being applied to the load tap changer and the tapped winding section, it is common practice to isolate the tapped winding section and load tap changer from the main auto-transformer circuit through a two winding series transformer. One of the windings of the series transformer is connected serially with the low voltage line, and the other winding is connected to the tapped winding through a load tap changer.

It would be desirable to provide an auto-transformer construction which would allow the load tap changer to be connected directly in the main auto-transformer circuit, with said auto-transformer having winding portions in which voltage surges would be distributed in a substantially uniform manner, and which would therefore minimize voltage oscillations which occur when a surge voltage changes from a capacitive to an inductive distribution. Thus, the requirement of isolating the tapped winding portion and load tap changer would be eliminated, allowing the tapped winding portion and load tap changer to be connected directly in the auto-transformer circuit. Thus, the additional floor space and expense of the series transformer would be eliminated. This would lower the losses of the core-form auto-transformer installation, making them competitive with the losses of a shell-form auto-transformer installation, and the cost of the core-form auto-transformer installation would be reduced below that of the comparable shell-form auto-transformer installation.

Accordingly, it is an object of the invention to provide a new and improved auto-transformer of the core-form type having concentrically disposed high and low voltage winding portions.

Another object of the invention is to provide a new and improved auto-transformer of the core-form type, in which the low voltage winding connection is adjustable.

A further object of the invention is to provide a new and improved auto-transformer of the core-form type which distributes voltage surges in a substantially uniform manner across the winding portions, and which minimizes voltage oscillations due to surge voltages.

Still another object of the invention is to provide a new and improved auto-transformer of the core-form type which has electrical characteristics which allow a tapped winding and load tap changer to be connected directly to the main auto-transformer circuit.

Briefly, the present invention accomplishes the above cited objects by dividing each of the concentrically wound high and low voltage windings of a core-form auto-transformer into two spaced sections. The winding sections are separated to allow a tapped winding section to be disposed between the two spaced high voltage sections or, the tapped winding section may be divided into two portions, with one part disposed between the two high voltage sections and the other part disposed between the two spaced low voltage sections. The ends of the high and low voltage winding sections which are adjacent the space between the windings, are connected in common, with the common connection being connected to the load tap changer and tapped winding section through means for preventing excessive current flow when the load tap changer bridges two tapped positions. The ends of the tapped winding section are connected to a reversing switch, with the reversing switch selector being connected to the low voltage line. Static shields are disposed between the two high voltage winding sections and the centrally disposed tapped winding section, and they are connected to the low voltage line in order to subject the tapped winding to a uniform potential and thus a uniform electrostatic field. Further, the individual turns of which the tapped winding and the high voltage winding sections are wound, are interconnected with one another in a manner which produces a high series capacitance, which aids in distributing surge voltages uniformly across the high voltage winding portions and tapped winding portion, and substantially reduces voltage oscillations which are produced when the initial or capacitive voltage distribution across a winding is not the same as the final or inductive voltage distribution.

Further objects and advantages of the invention will become apparent as the following description proceeds and features of novelty which characterize the invention will be pointed out in particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the invention, reference may be had to the following detailed description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a basic schematic diagram of an auto-transformer having adjustable low voltage connections;

FIG. 2 is a schematic diagram illustrating the winding arrangement of an auto-transformer constructed according to the teachings of one embodiment of the invention;

FIG. 2A is a schematic diagram illustrating a modification of the winding arrangement shown in FIG. 2;

FIG. 3 is a functional, elevational view of a core-form auto-transformer having concentrically wound high and low voltage winding portions, constructed according to

the teachings of the embodiment of the invention shown in FIG. 2; and

FIG. 4 is a schematic diagram illustrating the winding arrangement of an auto-transformer constructed according to the teachings of another embodiment of the invention.

Referring now to the drawings, and FIGURE 1 in particular, there is illustrated a basic schematic diagram of a three-phase auto-transformer **10**, having high voltage terminals H1, H2 and H3, which are adapted for connection to a three-phase alternating potential source (not shown). Three-phase auto-transformer **10** includes phase windings **11**, **13** and **15**, each disposed in inductive relation with a magnetic core (not shown). Each of the phase windings **11**, **13** and **15** has one end connected in common at the neutral N, and the other end connected to line terminals H1, H2 and H3 respectively. Each phase winding **11**, **13** and **15** also has a low voltage winding tap **17**, **19** and **21**, respectively, which is in turn connected to means **23**, **25** and **27** respectively, for adjusting the voltage appearing at the low voltage line terminals L1, L2 and L3. Since means **23**, **25** and **27** for adjusting the low voltage which appears at line terminals L1, L2 and L3, are similar, only means **23** is shown. Means **23** includes a tapped winding portion **12**, which may be disposed in inductive relation with the same magnetic core as phase winding **11**, a reversing switch **18** connected between the line terminal L1 and the ends of the tapped winding portion **12**, a load tap changer **14** connected to tapped winding section **12**, and means for limiting the current when the selectors of the load tap changer **14** are bridging a portion of the tapped winding **12**, such as a preventive auto-transformer **16**. Preventive auto-transformer **16** is connected between the tap **17** on phase winding **11** and load tap changer **14**.

If auto-transformer **10** is of the shell form type, it would only be necessary to dispose the tapped winding portion **12** between the stacked high and low voltage winding sections **20** and **22** of phase winding **11**, and dispose static shields between the tapped winding portion **12** and the adjacent winding sections **20** and **22**, which shields may be connected to the line terminal L1. The substantially uniform surge voltage distribution characteristics and consequent reduction in voltage oscillations of a shell form type transformer makes this arrangement practical. This arrangement is not suitable for auto-transformers of the core-form type, however, because the conventional concentric winding structure has an uneven surge voltage distribution across the winding, which would subject the load tap changer **14** and tapped winding portion **12** to excessively high voltages, and also to high oscillatory voltages produced when the surge voltage distribution across the winding changes from a capacitive to an inductive distribution. As hereinbefore stated, when core form auto-transformer constructions were utilized in the prior art, it was necessary to resort to a separate series transformer to isolate the tapped winding and load tap changer, which adds considerably to the cost and losses of a core-form auto-transformer system.

This invention teaches a core form auto-transformer structure having a winding arrangement which allows the basic schematic diagram of FIG. 1 to be followed. In order to more clearly understand the changes in the winding arrangement taught by this invention, the ends of the high and low voltage winding sections **20** and **22** of phase winding **11** are given letters, with the ends of high voltage section **20** being lettered A and B, and the ends of low voltage winding section **22** being lettered C and D. It will be noted that the ends of the high and low voltage winding sections **20** and **22** having the letters B and C are actually at the same potential.

FIGS. 2, 2A and 3 illustrate schematically and functionally a core form auto-transformer having concentric high and low voltage windings, constructed according to the teachings of this invention. Like components in the various figures are given like reference numerals, in order to aid in understanding how the basic schematic diagram has been changed.

In general, the high voltage and low voltage winding sections, **20** and **22** respectively, of phase winding **11**, are each divided into spaced, parallel connected sections, with high voltage section being divided into sections **20'** and **20''**, and low voltage winding section being divided into sections **22'** and **22''**. The two spaced, parallel connected high voltage sections **20'** and **20''** are connected in series circuit relation with the two spaced, parallel connected low voltage sections **22'** and **22''**.

More specifically, high voltage winding section **20** is divided into section **20'**, having ends A' and B', and section **20''** having ends A'' and B''. Ends A' and A'' of high voltage section **20** are connected to one another, and to line terminal H1 through conductors **30** and **32**, respectively. Ends B' and B'' of high voltage section **20** are connected together, to complete the parallel connection of high voltage sections **20'** and **20''**, through conductor **34**.

Low voltage winding section **22** is wound in concentric relation with high voltage section **20**, and is divided into section **22'** having ends C' and D', and section **22''** having ends C'' and D''. Ends D' and D'' are connected to one another, and to the neutral N through conductors **36** and **38**, respectively. The remaining ends, C' and C'' of low voltage winding sections **22'** and **22''** are connected to one another, and also to ends B' and B'' of high voltage winding section **20'** and **20''** through conductor **34**. The winding sections **20** and **22** are all wound in a direction relative to a magnetic core **40** (see FIG. 3) which causes the magnetomotive force produced by current flow therethrough to be additive.

The tapped winding portion **12** is disposed in inductive relation with magnetic core **40**, in the space provided between the high voltage winding sections **20'** and **20''**. The ends of tapped winding portion **12** are connected to the reversing switch **18**, through conductors **43** and **45**, which extend the tapped voltage range of the system, and reversing switch **18** is connected to the line terminal L1.

The common connection of the various winding sections **20'**, **20''**, **22'** and **22''** through conductor **34** is connected to the load tap changer **14**, and tapped winding portion **12**, through means **16** for reducing current flow when the selectors of the load tap changer **14** are connected to adjacent taps on tapped winding portion **12**. Means **16** may be a preventive auto-transformer, as shown, resistor means, or any other suitable impedance means.

In order to provide a uniform electrostatic field across tapped winding portion **12**, and aid in reducing or eliminating voltage oscillations upon voltage surges, static shielding members **42** and **44** are disposed in the column which includes high voltage winding sections **20'** and **20''** and tapped winding portion **12**, with static shielding member **42** being disposed between high voltage winding section **20'** and one end of tapped winding portion **12**, and static shielding member **44** being disposed between high voltage winding section **20''** and the other end of tapped winding portion **12**. Static shielding members **42** and **44** may be formed in any suitable manner, such as disposing metallic foil over pressboard washers, and are electrically connected to the reversing switch **18** and low voltage line terminal L1 through conductors **46**, **48** and **50**. Thus, with a uniform static field impressed across tapped winding portion **12**, there is substantially no electrostatic potential difference across the tapped section, and thus very little potential across the turns, even when a surge voltage is applied to line terminal L1. It is important to note that all of the conductors **34**, **43**, **45**, **46** and **48**, which are brought out from the various winding sections and electrostatic shielding members are at substantially the same potential, thus reducing the amount of electrical insulation required between the conductors.

In order to achieve a substantially uniform surge voltage distribution across the high voltage winding sections

20' and 20", as well as across the tapped winding portion 12, it is necessary that the turns of the windings be arranged in a manner which increases their series capacitance. FIG. 3 illustrates an arrangement and connection of the various coils which make up the winding sections. This arrangement, and others that may also be utilized, are described in detail in U.S. Patent 3,090,022, issued May 14, 1963 to G. M. Stein, and assigned to the same assignee as the present application.

Since the high voltage winding sections 20' and 20" and tapped winding portion 12 may all be formed in the same manner, only winding section 20' will be described. In general, winding section 20' comprises a plurality of pancake coils 60, 62, 64 and 66, which are spaced axially apart from one another in a stacked arrangement and connected in series circuit relation. Each of the pancake coils 60, 62, 64 and 66 includes at least first and second conductors spirally wound together about a common central axis, to form first and second coil sections, whose turns are interleaved with one another in substantially the same plane. For example, if it is assumed that the turns of pancake coil 60 are wound outwardly from the innermost turn, the consecutively wound turns of the first coil section would be indicated at 75, 74 and 73, and the consecutively wound turns of the second conductor would be indicated at 72, 71 and 70. Thus, the turns of the two coil sections which make up pancake coil 60 are interleaved with one another. The turns of the coil sections which make up each of the pancake windings 60, 62, 64 and 66 are connected in series circuit relation with one another, with the end of the innermost turn of one of the coil sections in each of said pancake coils being connected to the end of the outermost turn of the other of said coil sections by interconnecting conductors 94, 95, 96 and 97. Thus, the instantaneous direction of current from line terminal H1 would be through turns 70, 71 and 72, through conductor 94 to turn 73, and then through turns 74 and 75.

The pancake coils 60, 62, 64 and 66 are connected in series circuit relation with one another by conductors 98, 99 and 100. Thus, the inner turns 75 and 76 are connected together, the outer turns 81 and 82 are connected together, and the inner turns 87 and 88 are connected together. This keeps the interconnection leads between pancake coils as short as possible. Since the instantaneous direction of current flow is opposite in adjacent pancake windings, being from the outer turn to the inner turns in one pancake coil and from the inner turn to the outer turn in the adjacent pancake coil, alternate coils are wound in a direction opposite to the direction in which the intervening coils are wound, thus insuring that the magnetomotive force produced by current flow in the pancake coils is additive.

The specific arrangement of increasing the series capacitance of high voltage and tapped winding sections is for illustrative purposes only, as many different arrangements may be employed. Also, for purposes of simplicity, the winding sections were each illustrated as having four pancake coils, each having six turns, but it is obvious that the winding sections may have any desired number of pancake coils and any desired number of turns per coil.

FIG. 2A is a schematic diagram illustrating a modification of FIG. 2, which enables the axial length of each phase winding to be substantially reduced. More specifically, FIG. 2A illustrates that the tapped winding portion 12 may be divided into two substantially equal sections, 12' and 12", with section 12' being disposed between the spaced high voltage winding sections 20' and 20", and section 12" being disposed between low voltage winding sections 22' and 22". The two sections 12' and 12" of tapped winding portion 12 are concentrically disposed, to achieve the desired reduction in axial length, and they are serially connected, with the taps of the inner section 12" being brought out to the load tap changer 14. Additional static shielding members 42' and 44' may be disposed between the tapped winding section 12" and the low voltage winding sections 22' and 22", and connected to the low voltage terminal L1. Thus, the space between the low voltage winding sections 22' and 22" is utilized to reduce the axial length of the complete phase winding structure.

FIG. 4 is a schematic diagram illustrating another modification which may be made to the schematic diagram of FIG. 2. The arrangement of the auto-transformer windings is the same as shown in FIGS. 2 and 3, but their connection to means 23 for adjusting the voltage appearing at the low voltage terminal L1 is different, although equivalent. For example, instead of connecting the common connection of winding sections 20', 20", 22' and 22" to the preventive auto-transformer 16, their common connection through conductor 34 could just as effectively be connected to the reversing switch 18. Then, line terminal L1 would be connected to the preventive auto-transformer 16.

Thus, there has been shown and described a winding arrangement for an auto-transformer of the core form type which provides a substantially uniform distribution of surge voltages across the windings, and which limits subsequent voltage oscillations, due to the fact that the capacitive and inductive voltage distributions across the windings are substantially the same. The arrangement whereby the concentric high voltage and low voltage windings are divided into two spaced sections, serves to balance surge stresses in the transformer, and the location of the tapped winding portion in the space between the high voltage sections aids in protecting the tapped winding portion and load tap changer from surge voltages. The static shielding members provide a uniform electrostatic field across the tapped winding portion, reducing the potential between taps, even during surge voltages, to a minimum, and also reduces the insulation required by the load tap changer and tapped winding portion. The winding arrangement taught by the invention greatly simplifies the insulating of the electrical leads brought forth from the various winding sections and electrostatic shielding members, as they are all at substantially the same potential. Further, the stress voltage distribution across the high voltage winding sections and tapped winding portion is made substantially uniform by utilizing an arrangement of turns within the various coils which make up the sections, which increases the series capacitance of the windings.

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 matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative, and not in a limiting sense.

I claim as my invention:

1. A transformer comprising a high voltage terminal, a low voltage terminal, a magnetic core member, high and low voltage windings disposed in inductive relation with said magnetic core member, said high and low voltage windings being disposed in concentric relation, each of said high and low voltage windings being divided into first and second spaced sections, each of the first and second spaced sections having inner ends adjacent the space between the sections, and outer ends, the outer ends of said first and second high voltage winding sections each being connected to said high voltage terminal, the outer ends of said first and second low voltage winding sections being connected in common, the inner ends of said first and second high and low voltage winding sections all being connected in common, a tapped winding section, said tapped winding section being disposed in the space between said spaced high and low voltage winding sections, means connecting the common connection of the

inner ends of said first and second high and low voltage winding sections to said low voltage terminal through said tapped winding section, first and second static plate members connected to said low voltage terminal, said first and second static plate members being disposed between said tapped winding portion and said first and second high voltage winding sections, respectively, each of said first and second high voltage winding sections and said tapped winding section having a plurality of stacked pancake coils each having a plurality of turns interconnected in a predetermined arrangement which distributes surge voltages across said winding section in a substantially uniform manner.

2. A transformer comprising a high voltage terminal, a low voltage terminal, a magnetic core member, high and low voltage windings disposed in inductive relation with said magnetic core member, said high and low voltage windings being disposed in concentric relation, each of said high and low voltage windings being divided into first and second spaced sections, each of the first and second spaced sections having inner ends adjacent the space between the sections, and outer ends, the outer ends of said first and second high voltage winding sections each being connected to said high voltage terminal, the outer ends of said first and second low voltage winding sections being connected in common, the inner ends of said first and second high and low voltage winding sections all being connected in common, a tapped winding section having a plurality of taps, said tapped winding section being disposed in the space between said first and second high voltage winding sections, first and second static plate members connected to said low voltage terminal, said first and second static plate members being disposed between said tapped winding section and said first and second high voltage winding sections, respectively, each of said first and second high voltage winding sections and said tapped winding section having a plurality of stacked pancake coils each having a plurality of turns interconnected in a predetermined arrangement which distributes surge voltages across said winding section in a substantially uniform manner, and tap changer means for selectively connecting a tap on said tapped winding section, the common connection of the inner ends of the first and second high and low voltage winding sections being connected to said tap changer means, said low voltage terminal being connected to said tapped winding section.

3. An auto-transformer comprising a high voltage terminal, a low voltage terminal, a magnetic core member, high and low voltage windings disposed in inductive relation with said magnetic core member, said high and low voltage windings being disposed in concentric relation, each of said high and low voltage windings being divided into first and second spaced sections, each of the first and second spaced sections having inner ends adjacent the space between the sections, and outer ends, the outer ends of said first and second high voltage winding sections each being connected to said high voltage terminal, the outer ends of said first and second low voltage sections being connected in common, the inner ends of said first and second high and low voltage winding sections all being connected in common, a tapped winding section having a plurality of taps, said tapped winding section being disposed in the space between said first and second high voltage winding sections, first and second static plate members connected to said low voltage terminal, said first and second static plate members being disposed between said tapped winding section and said first and second high voltage winding sections, respectively, each of said first and second high voltage winding sections and said tapped winding section having a plurality of stacked pancake coils each having at least two conductors spirally wound together and interconnected in a predetermined arrangement which distributes surge voltages across said winding section in a substantially uniform manner, and means for selectively connecting a tap on said tapped winding section, the common connection of the inner ends of said high and low voltage winding sections being connected to said tapped winding section, said low voltage terminal being connected to said tap selecting means.

4. A transformer comprising a high voltage terminal, a low voltage terminal, a magnetic core member, high and low voltage windings disposed in inductive relation with said magnetic core member, said high and low voltage windings being disposed in concentric relation, each of said high and low voltage windings being divided into first and second spaced sections, each of the first and second spaced sections having inner ends adjacent the space between the sections, and outer ends, the outer ends of said first and second high voltage winding sections each being connected to said high voltage terminal, the outer ends of said first and second low voltage winding sections being connected in common, the inner ends of said first and second high and low voltage winding sections all being connected in common, a tapped winding section having a plurality of taps, said tapped winding section being disposed in the space between said first and second high voltage winding sections, first and second static plate members connected to said low voltage terminal, said first and second static plate members being disposed between said tapped winding section and said first and second high voltage winding sections, respectively, each of said first and second high voltage winding sections and said tapped winding section having a plurality of stacked pancake coils each having a plurality of turns interconnected in a predetermined arrangement which distributes surge voltages across said winding sections in a substantially uniform manner, tap changer means for selectively connecting a tap on said tapped winding section, and a reversing switch, the common connection of the inner ends of said first and second high and low voltage winding sections being connected to said tap changer means, said reversing switch being connected to said tapped winding section and to said low voltage terminal.

5. A transformer comprising a high voltage terminal, a low voltage terminal, a magnetic core member, high and low voltage windings disposed in inductive relation with said magnetic core member, said high and low voltage windings being disposed in concentric relation, each of said high and low voltage windings being divided into first and second axially spaced sections, each of the first and second spaced sections having inner ends adjacent the space between the sections, and outer ends, the outer ends of said first and second high voltage winding sections each being connected to said high voltage terminal, the outer ends of said first and second low voltage winding sections being connected in common, the inner ends of said first and second high and low voltage winding sections all being connected in common, a tapped winding section having a plurality of taps, said tapped winding section being disposed in the space between said first and second high voltage winding sections, first and second static plate members connected to said low voltage terminal, said first and second static plate members being disposed between said tapped winding section and said first and second high voltage winding sections, respectively, each of said first and second high voltage winding sections and said tapped winding section having a plurality of stacked pancake coils each having a plurality of turns interconnected in a predetermined arrangement which distributes surge voltages across said winding section in a substantially uniform manner, tap changer means for selectively connecting a tap on said tapped section, and a reversing switch, said reversing switch being connected to said tapped winding section and to the common connection of the inner ends of said first and second high and low voltage winding sections, said

tap changer means being connected to said low voltage terminal.

6. A three-phase transformer comprising a magnetic core member, first, second and third high voltage terminals, first, second and third low voltage terminals, first, second and third substantially similar winding phases, each of said winding phases including high and low voltage windings disposed in inductive relation with said magnetic core member, said high and low voltage windings of each winding phase being disposed in concentric relation, each of said high and low voltage windings of each winding phase being divided into first and second axially spaced sections, each of the first and second spaced sections having inner ends adjacent the space between the sections, and outer ends, the outer ends of said first and second high voltage winding sections each being connected to one of said high voltage terminals, the outer ends of said first and second low voltage winding sections being connected in common, with the common connection being connected to similar connections in the remaining winding phases, the inner ends of said first and second high and low voltage winding sections being connected in common, first, second and third tapped winding sections each having a plurality of taps, said tapped winding sections being disposed in the space between said first and second high voltage winding sections, first, second and third pairs of static plate members connected to said first, second and third low voltage terminals, respectively, said first, second and third pairs of static plate members being disposed in said first, second and third phase windings, respectively, at opposite ends of said tapped winding section to separate said tapped winding section from said first and second high voltage winding sections, said first, second and third pairs of static plate members being connected to said first, second and third low voltage terminals, respectively, each of said first and second high voltage winding sections and said tapped winding section having a plurality of stacked pancake coils each having a plurality of turns interconnected in a predetermined arrangement which distributes surge voltages across said winding sections in a uniform manner, and means for selectively connecting a tap in each of said tapped winding sections, the common connection of the inner ends of said first and second high and low voltage winding sections of each of said first, second and third winding phases being connected to said first, second and third winding phases, respectively, through its associated tap selecting means, to provide an adjustable three phase voltage at said low voltage terminals when said high voltage terminals are connected to a three-phase source of alternating potential.

7. A transformer comprising a high voltage terminal, a low voltage terminal, a magnetic core member, high and low voltage windings disposed in inductive relation with said magnetic core member, said high and low voltage windings being disposed in concentric relation, each of said high and low voltage windings being divided into first and second spaced sections, each of the first and second spaced sections having inner ends adjacent the space between the sections, and outer ends, the outer ends of said first and second high voltage winding sections each being connected to said high voltage terminal, the outer ends of said first and second low voltage winding sections being connected in common, the inner ends of said first and second high and low voltage winding sections all being connected in common, a tapped winding portion having a plurality of taps, said tapped winding portion being divided into first and second serially connected sections, said first tapped winding section being disposed in the space between said first and second high voltage winding sections, said second tapped winding section being disposed in the space between said first and second low voltage winding sections, first, second, third and fourth static plate members connected to said low voltage terminal, said first and second static plate members being disposed between said first tapped winding section and said first and second high voltage winding sections, respectively, said third and fourth static plate members being disposed between said second tapped winding section and said first and second low voltage winding sections, respectively, each of said first and second high voltage winding sections and said tapped winding portion having a plurality of stacked pancake coils each having a plurality of turns interconnected in a predetermined arrangement which distributes surge voltages across said winding section in a substantially uniform manner, and means for selectively connecting a tap on said tapped winding portion, the common connection of the inner ends of said first and second high voltage and low voltage winding sections being connected to said low voltage terminal through said tap selecting means to provide an adjustable voltage at said low voltage terminal when said high voltage terminal and the common connection between the outer ends of said first and second low voltage winding sections are connected to a source of alternating potential.

8. A three-phase transformer comprising a magnetic core member, first, second and third high voltage terminals, first, second and third low voltage terminals, first, second and third substantially similar winding phases, each of said winding phases including high and low voltage windings disposed in inductive relation with said magnetic core member, said high and low voltage windings of each winding phase being disposed in concentric relation, each of said high and low voltage windings of each winding phase being divided into first and second axially spaced sections, each of the first and second spaced sections having inner ends adjacent the space between the sections, and outer ends, the outer ends of said first and second high voltage winding sections each being connected to one of said high voltage terminals, the outer ends of said first and second low voltage winding sections being connected in common, with the common connection being connected to similar connections in the remaining winding phases, the inner ends of said first and second high and low voltage winding sections being connected in common, first, second and third tapped winding portions each having a plurality of taps, said tapped winding portions each being divided into two concentrically disposed, serially connected sections disposed in the space between said spaced high and low voltage winding sections, first, second and third static plate means connected to said first, second and third low voltage terminals, respectively, said first, second and third static plate means being disposed in said first, second and third phase windings, respectively, at opposite ends of said tapped winding portions to separate said tapped winding portions from said high and low voltage winding sections, each of said first and second high voltage winding portions and said tapped winding section having a plurality of stacked pancake coils each having a plurality of turns interconnected in a predetermined arrangement which distributes surge voltages across said winding sections in a uniform manner, and means for selectively connecting a tap in each of said tapped winding portions, the common connection of the inner ends of said first and second high and low voltage winding sections in each of said first, second and third winding phases being connected to said first, second and third low voltage terminals, respectively, through its associated tap selecting means, to provide an adjustable three phase voltage at said low voltage terminals when said high voltage terminals are connected to a three-phase source of alternating potential.

No references cited.

LEWIS H. MYERS, *Primary Examiner.*

H. W. COLLINS, *Assistant Examiner.*