

[54] **DUAL-VOLTAGE TRANSFORMER WITH COORDINATED FUSING**

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[51] Int. Cl. **H02h 7/04**

[58] Field of Search **317/15, 14 R, 14 A, 317/14 C, 40 A; 323/49; 336/145, 146, 147**

[56] **References Cited**

UNITED STATES PATENTS

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Primary Examiner—J. D. Miller

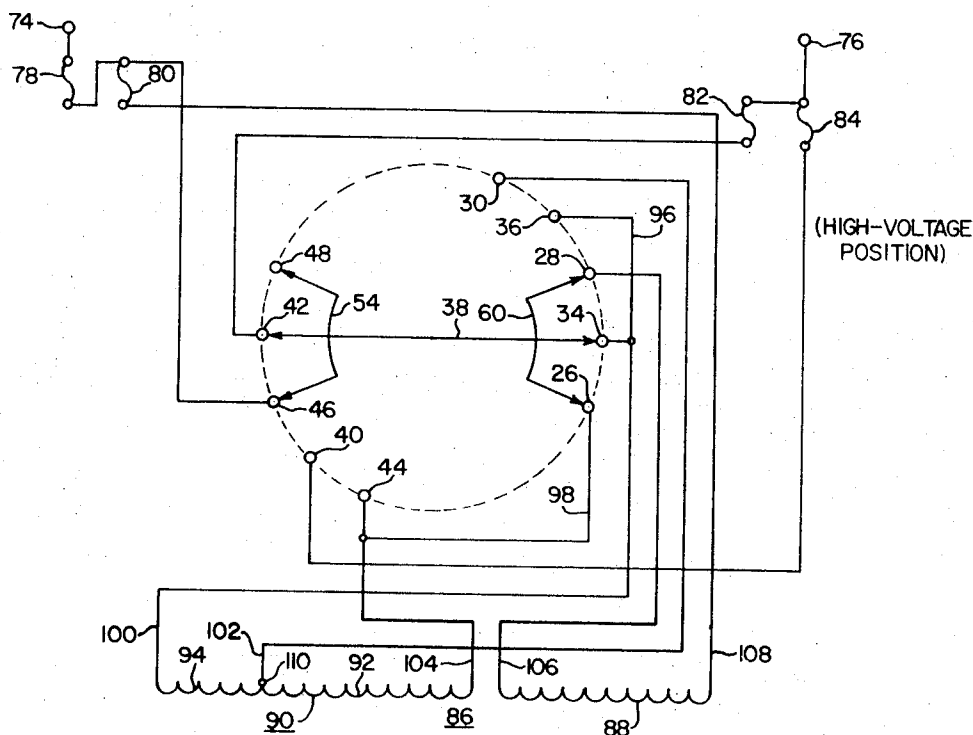
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[57] **ABSTRACT**

Transformer apparatus having two high-voltage and two low-voltage fuses, a dual-voltage winding assembly, and a two-position rotor switch which connects the fuses and the winding assembly to line terminals. When the switch is in the high-voltage position, all of the turns of the winding assembly are connected in series and to the line terminals through the high-voltage fuses and through one low-voltage fuse. When the switch is in the low-voltage position, some of the turns of the winding assembly are connected in parallel with each other and to the line terminals. In the low-voltage position, the total line current flows through the low-voltage fuses and one-half of the total line current flows through one of the high-voltage fuses.

5 Claims, 6 Drawing Figures



3 Sheets-Sheet 1

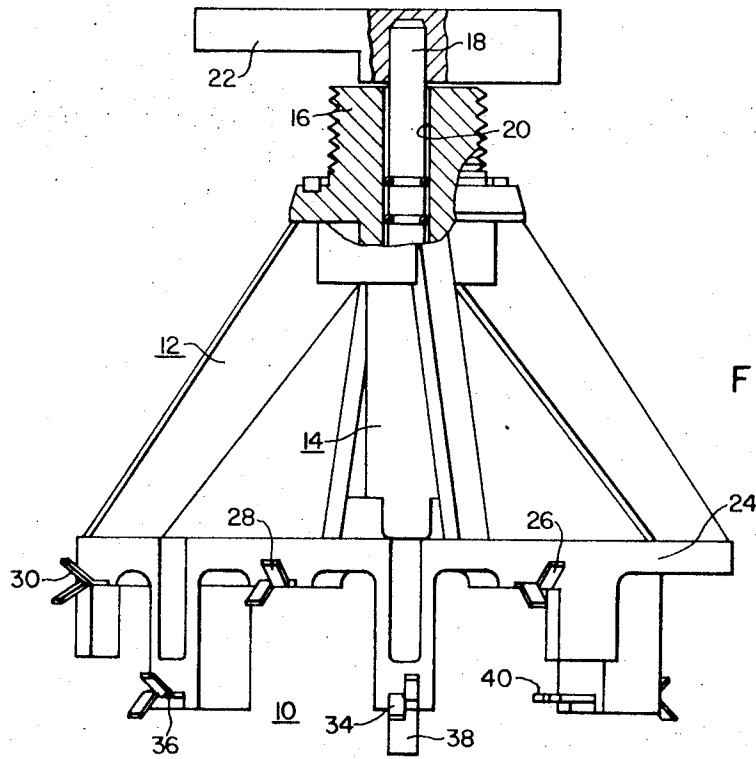


FIG. 1.

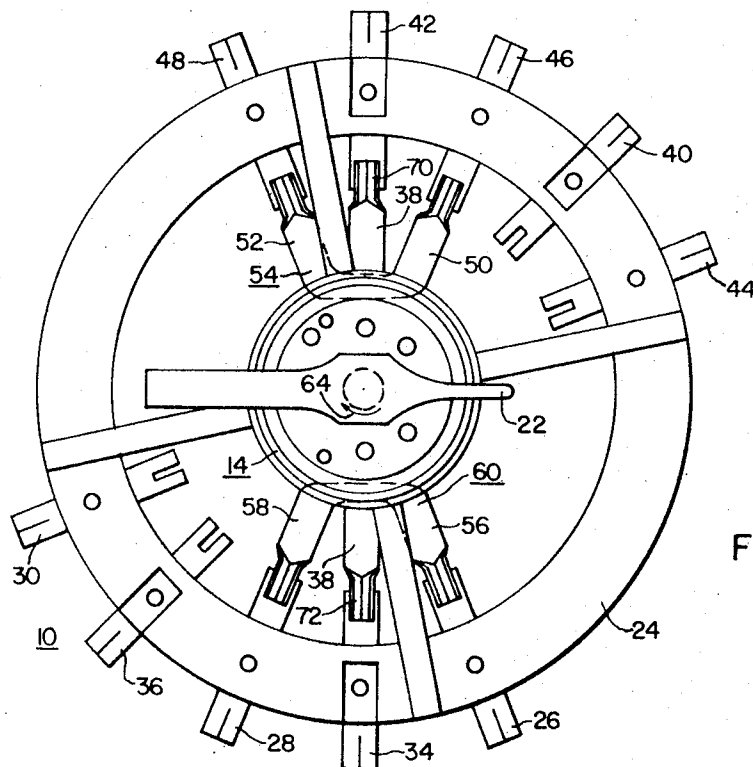


FIG. 2.

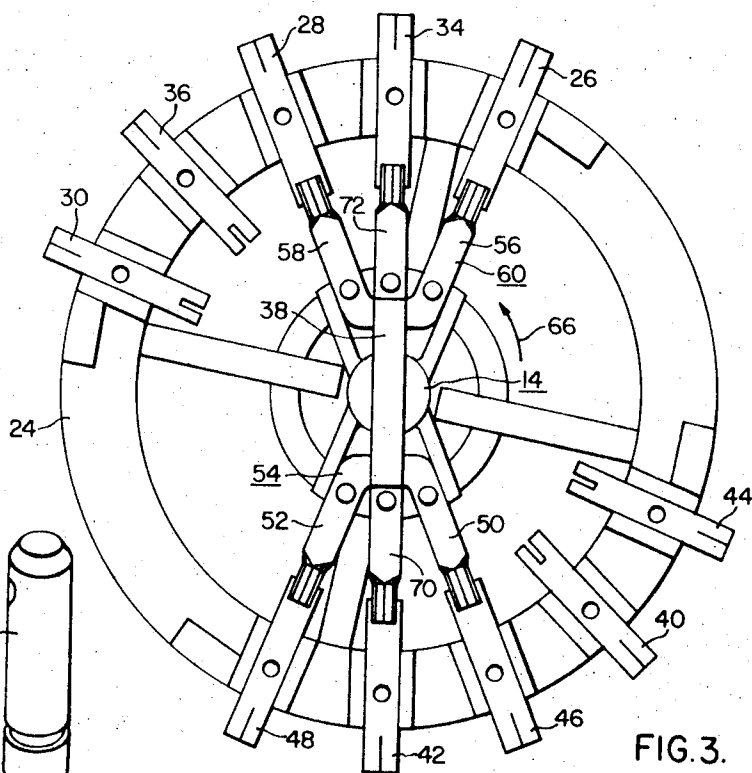


FIG. 3.

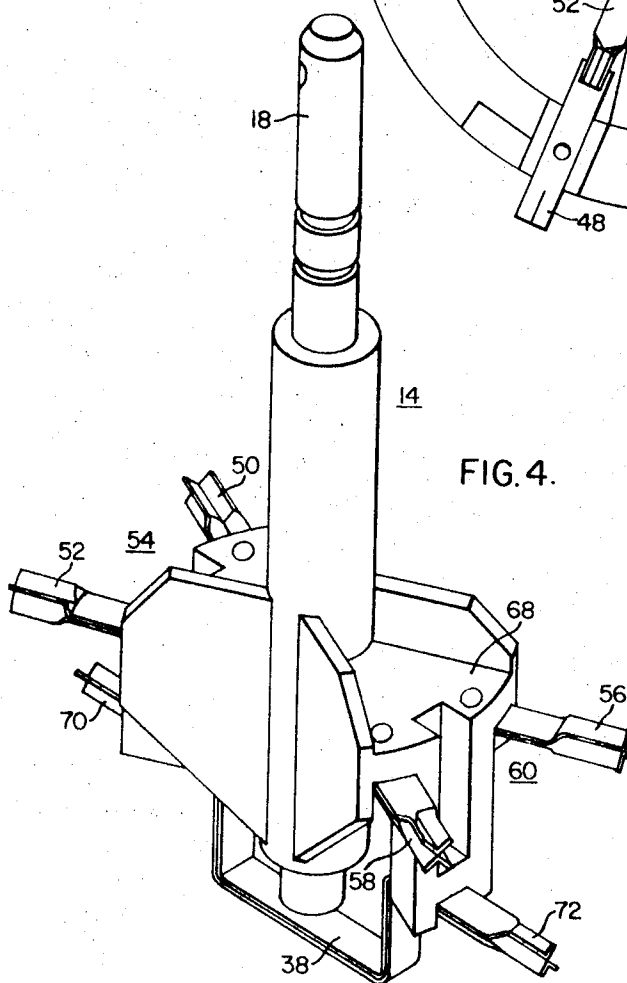


FIG. 4.

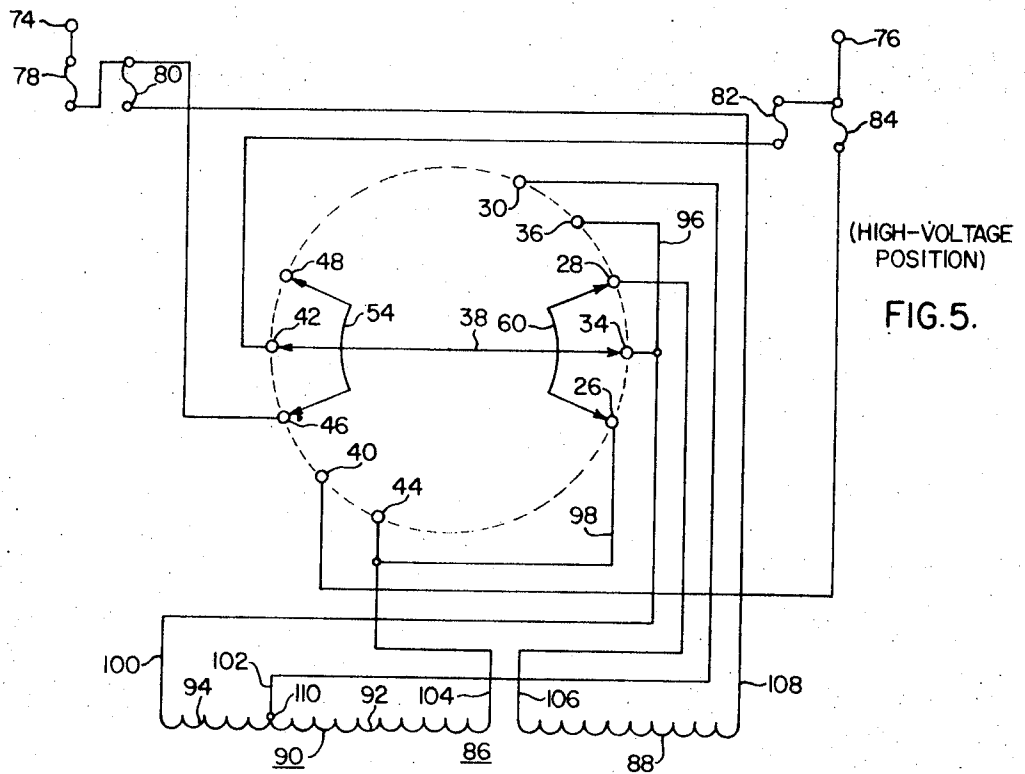


FIG. 5.

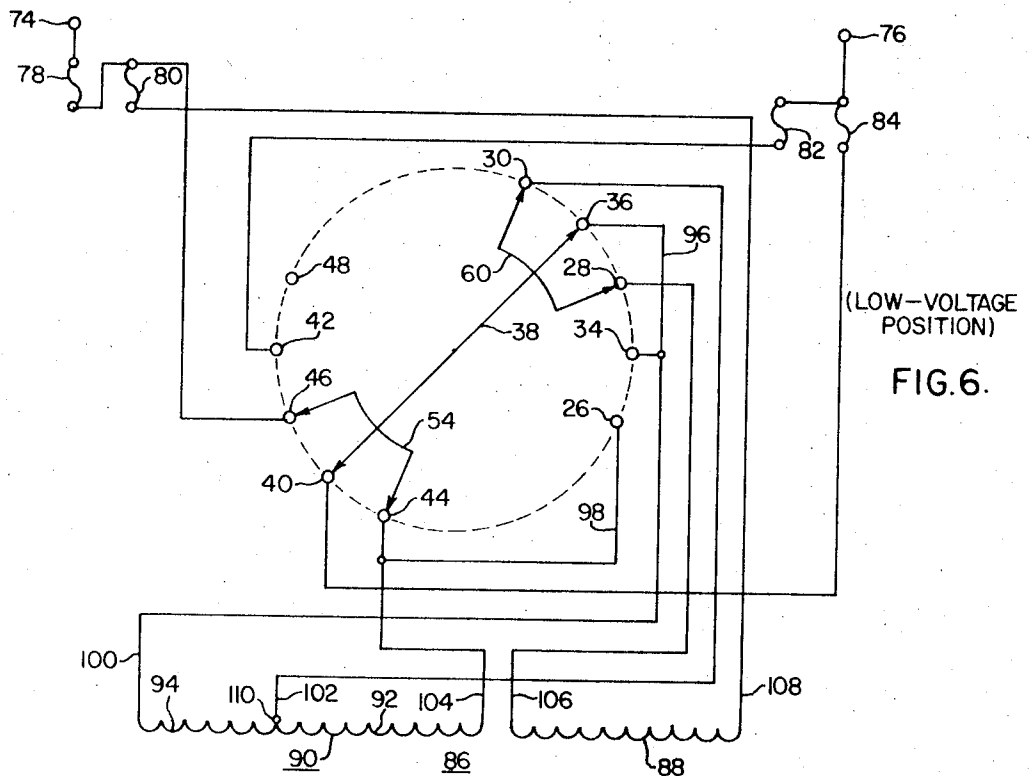


FIG. 6.

DUAL-VOLTAGE TRANSFORMER WITH COORDINATED FUSING

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates, in general, to electrical inductive apparatus and, more specifically, to dual-voltage distribution transformers.

2. Description of the Prior Art

Dual-voltage transformers are used extensively in electrical power distribution systems. The dual-voltage distribution transformer is installed and connected to the primary line which has a particular voltage rating. When desired by the electric utility company, the voltage rating of the primary line may be raised to increase the efficiency and capacity of the distribution system. It is not necessary to replace dual-voltage distribution transformers by transformer units having a higher rating. The dual-voltage transformers are simply changed to a higher voltage rating by appropriate switching apparatus installed during the manufacturing of the transformer.

Dual-voltage transformers require special techniques in fusing and coil construction. Generally, when the winding voltage rating is switched to its lower value, portions of the winding are connected in parallel. When the winding voltage rating is switched to its higher value, portions of the winding are connected in series. When the voltage ratios are integral multiples, such as exists when the voltage ratings are 2,400 and 7,200 volts, all portions of the winding are used in both rated positions. When the voltage ratios are not integral ratios, such as exist with the voltages 4,800 and 7,200, 4,800 and 7,620, and 4,800 and 8,000 volts, a portion of the winding is not energized in the high voltage position according to many prior art designs. This provides uneconomical use of the winding and increases the size of the transformer.

Since the KVA rating of a dual-voltage transformer is substantially the same for both voltage positions, the winding current at full load is different for each voltage rating. Completely self-protected distribution transformers have protective means, such as fuses, in the primary winding leads. Special fusing techniques must be used in order to maintain the proper clearing time of the fuses in each voltage position.

Some prior art techniques have used compromise fuses which increase the clearing time at the high-voltage rating and which decrease the clearing time at the low-voltage rating as compared to the normal clearing time desired for the transformer. Other prior art arrangements have taught using four fuses. Two of the fuses are appropriately rated for the low-voltage rating and two of the fuses are appropriately rated for the high-voltage rating. This technique provides desirable clearing time for both of the voltage ratings but requires sophisticated switching arrangements.

It is desirable, and it is an object of this invention, to provide a dual-voltage transformer having coordinated fusing and which provides maximum utilization of the winding structure when the voltages do not have an integral ratio.

SUMMARY OF THE INVENTION

There is disclosed herein new and useful dual-voltage transformer apparatus which may be conveniently switched from one voltage rating to another voltage

rating without the loss of coordinated fusing and without the need for a winding assembly having unused turns at one rating. A low-voltage fuse and a high-voltage fuse are connected to each line terminal and to stator contacts on a dual-voltage switch. Stator contacts are also connected to a dual-voltage winding assembly which includes a separate winding section having a predetermined voltage rating and a tapped winding section having a predetermined voltage rating on each side of the winding tap. In general, one portion of the tapped winding has the same voltage rating as the separate winding section. Another portion of the tapped winding has a voltage rating sufficient to provide the desired high-voltage transformer voltage rating when all of the turns of the winding assembly are connected in series, and also sufficient to provide the desired low-voltage transformer voltage rating when the other portion of the tapped winding is connected in parallel with the separate winding section.

The dual-voltage switch includes rotor contacts which may be set in two different positions to interconnect stator contacts on the switch. In the high-voltage position, all of the turns of the winding assembly are connected in series by the dual-voltage switch. Also, the winding assembly is connected to the line terminals through the high-voltage fuses. In the low-voltage position, a portion of the tapped winding is connected in parallel with the separate winding section. Also, the total winding assembly is connected to the line terminals through the low-voltage fuses with one-half of the total line current flowing through a high-voltage fuse.

BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages and uses of this invention will become more apparent when considered in view of the following detailed description and drawings, in which:

FIG. 1 is an elevational view, partly in section of a dual-voltage switch constructed according to this invention;

FIG. 2 is a plan view of the top of a dual-voltage switch constructed according to this invention;

FIG. 3 is a plan view of the bottom of a dual-voltage switch constructed according to this invention;

FIG. 4 is a view of a rotor assembly of a dual-voltage switch constructed according to this invention;

FIG. 5 is a partial schematic diagram of a dual-voltage transformer constructed according to this invention with the dual-voltage switch set in the high-voltage position; and

FIG. 6 is a partial schematic diagram of a dual-voltage transformer constructed according to this invention with the dual-voltage switch set in the low-voltage position.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the following description, similar reference characters refer to similar elements in all figures of the drawings.

Referring now to the drawings, and FIG. 1 in particular, there is shown a dual-voltage switch 10 constructed according to this invention. A dual-voltage switch constructed similar to the switch of this invention, but having different contact arrangements, is disclosed in U.S. Pat. No. 3,624,319 which is assigned to the same assignee as is this invention.

As shown in FIG. 1, the dual-voltage switch 10 includes a stator assembly 12 and a rotor assembly 14. The stator assembly 12 includes a threaded mounting hub 16 which provides means for attaching the switch 10 onto the enclosure of a transformer. The operating shaft 18 of the rotor assembly 14 extends through an opening 20 in the mounting hub 16 and is pinned to an operating handle 22.

A ring-shaped contact deck 24 is constructed of an insulating material and supports a plurality of stator contacts. Stator contacts 26, 28 and 30 are on one level of the contact deck 24 and stator contacts 34, 36 and 40 are on another level of the contact deck 24. Two pairs of movable contacts are attached to the rotor assembly 14 which are not illustrated in FIG. 1. A third contact pair 38 is attached to the rotor assembly 14 as shown in FIG. 1. The contact pair 38 is positioned in the plane containing the upper stator contacts 34, 36 and 40 in such a manner as to be engageable therewith.

FIG. 2 is a view of the top of the dual-voltage switch 10. The stator contacts 44, 46 and 48 are mounted on the contact deck 24 in the same plane and diagonally opposite from the stator contacts 36 and 34, respectively.

Contact pair 54 includes the finger contacts 50 and 52 and a suitable interconnecting member. Contact pair 60 includes the finger contacts 56 and 58 and a suitable interconnecting member. The contact pairs 54 and 60 are positioned in the plane containing the lower stator contacts 26, 28, 30, 44, 46 and 48 in such a manner as to be engageable therewith. The switch 10 is shown in the high-voltage position. Rotation of the rotor assembly 14 in the direction indicated by the arrow 64 moves the switch 10 to the low-voltage position.

FIG. 3 is a view of the bottom of the dual-voltage switch 10 shown in the high-voltage position. The contact pair 38 electrically connects together the stator contacts 34 and 42. The contact pair 54 electrically connects together the stator contacts 46 and 48. The contact pair 60 electrically connects together the stator contacts 26 and 28. When the rotor assembly 10 is rotated in the direction indicated by the arrow 66, the switch 10 is moved to the low-voltage position. In the low-voltage position, the contact pair 38 electrically connects together the stator contacts 36 and 40, the contact pair 54 electrically connects together the stator contacts 44 and 46, and the contact pair 60 electrically connects together the stator contacts 28 and 30.

A view of the rotor assembly 14 is shown in FIG. 4. The rotor assembly 14, including the operating shaft 18 and the contact carrier 68, is constructed of a suitable insulating material. The finger contacts 50, 52, 56 and 58 engage with stator contacts on one level of the contact deck 24. The finger contacts 70 and 72 of the contact pair 38 engage with stator contacts on another level of the contact deck 24.

A schematic representation of a transformer having a dual-voltage switch 10 is illustrated in FIG. 5 with the switch 10 set in the high-voltage position. The line terminals 74 and 76 are connected to suitable protective fuses, such as current-limiting fuses or protective links 78, 80, 82 and 84.

For a description of this specific embodiment only, it is assumed that the low-voltage rating is 4,800 volts, that the high-voltage rating is 7,620 volts, and that the protective devices 78, 80, 82 and 84 are fuses. Fuses 78

and 84 are constructed to have a clearing time suitable for the low-voltage rating. For example, fuses 78 and 84 may be constructed to clear or interrupt the line current in 2.5 seconds during an overload current condition which is 25 times the normal line current at 4,800 volts. Fuses 80 and 82 are constructed to have a clearing time suitable for the high-voltage rating, such as 6 seconds with 25 times normal line current at 7,620 volts.

A winding assembly 86 includes the separate winding section 88 and a tapped winding section 90 which includes winding portions 92 and 94. The leads from the winding assembly 86 are connected to stator contacts and fuses as indicated by FIG. 5. Jumper leads 96 and 98 electrically connect together the stator contacts 34 and 36, and 26 and 44, respectively. In this specific embodiment, the winding section 88 has a rated voltage of 2,825 volts, the winding portion 92 has a rated voltage of 2,825 volts, and the winding portion 94 has a rated voltage of 1,975 volts. Although not shown, the transformer would normally be associated with another winding and a magnetic core.

Line current flows between the line terminals 74 and 76 through a current path provided by the components of the transformer. Line current flowing into terminal 76 flows through the fuse 82, the stator contact 42, the contact pair 38, and the stator contact 34 to the winding lead 100. No current flows through fuse 84 since stator contact 40 is not connected to any other contact. Therefore, the high-voltage fuse 82 is appropriately connected between the line terminal 76 and the winding assembly 86 when the switch 10 is in the high-voltage position.

Tap lead 102 is connected to stator contact 30 which is not connected to any other contact. The current entering the lead 100 leaves the tapped winding section 90 through a lead 104. This current flows through the jumper lead 98, the stator contact 26, the contact pair 60, the stator contact 28, and a lead 106 to the winding section 88. The lead 108 of the winding section 88 directs the current through the high-voltage fuse 80 and the low-voltage fuse 78 to the line terminal 74.

Fuses 78 and 80 are effectively in series in the high-voltage position shown in FIG. 5. Fuse 78 is the low-voltage fuse and it requires a clearing time of approximately 17 seconds when conducting the high-voltage overload current. Therefore, since fuse 80 has a clearing time of 6 seconds, fuse 78 functions only as a conductor in the high-voltage position of the switch 10.

Since all portions of the winding sections 88 and 90 are electrically connected in series, the voltage rating of the winding assembly 86 is the sum of the individual ratings, or 7,620 volts. Also, since the high-voltage fuses 80 and 82 are properly in the path of the total line current, coordinated fusing is achieved in the high-voltage position.

FIG. 6 is a schematic diagram of a transformer having a dual-voltage switch 10 set in the low-voltage position. Line current enters the line terminal 76 and flows through the low-voltage fuse 84 and the lead 100 to the winding section 90. Line current does not flow through the fuse 82 since the stator contact 42 is not connected to any other contact.

The line current flows through the winding portion 94 and divides at the tap position 110. One-half of the line current flows through the lead 102, the stator contact 30, the contact pair 60, the stator contact 28, the

lead 106, the winding section 88, and the lead 108 to the lower end of the high-voltage fuse 80. The other half of the line current flows through the winding portion 92, the lead 104, the stator contact 44, the contact pair 54, and the stator contact 46 to the upper end of the high-voltage fuse 80. The total line current flows through the low-voltage fuse 78 to the line terminal 74.

The winding section 88 and the winding portion 92, which both have the same voltage rating, are effectively connected in parallel. The overall rating of the winding assembly 86 is the sum of 1,975 volts and 2,825 volts, or 4,800 volts.

One-half of the total line current flows through the high-voltage fuse 80. The high-voltage fuse 80, which has a clearing time of 6 seconds at high-voltage overload currents, has a clearing time of approximately 24 seconds with one-half of the low-voltage overload current flowing therethrough. Thus, fuse 78 which has a clearing time of 2.5 seconds at the low-voltage overload current will clear first.

With the novel arrangements taught by this invention, coordinated fusing can be provided by using a dual-voltage switch and an efficient winding assembly wherein all of the turns of the winding assembly are energized in both voltage positions. 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 of the matter contained in the foregoing description or shown in the accompanying drawings, shall be interpreted as illustrative rather than limiting.

What is claimed is:

1. Electrical inductive apparatus comprising a winding assembly having first and second voltage ratings, first, second, third and fourth protective means, first and second line terminals, electrical switching means having first and second positions, said switching means connecting said winding assembly to said line terminals through said first, second and third protective means to provide the first voltage rating when the switching means is in the first position, and said switching means connecting said winding assembly to said line terminals through said first, second and fourth protective means to provide the second voltage rating when the switching means is in the second position.

2. The electrical inductive apparatus of claim 1 wherein the first and fourth protective means are constructed to interrupt current flowing therethrough at a first predetermined value, the second and third protective means are constructed to interrupt current flowing therethrough at a second predetermined value, the first predetermined value being higher than the second predetermined value.

3. The electrical inductive apparatus of claim 1 wherein the winding assembly includes a first winding section, a tapped second winding section having first and second winding portions, the switching means connects the first winding section and the first portion of the second winding section in parallel circuit relationship with each other and in series circuit relationship with the second portion of the second winding section when the switching means is in the second position, and the switching means connects the first winding section and the first and second winding portions of the second winding section in series circuit relationship when the switching means is in the first position.

4. The electrical inductive apparatus of claim 2 wherein the winding assembly includes a first winding section and a tapped second winding section having first and second winding portions, the switching means connects the winding assembly and the protective means together when the switching means is in its second position to provide a line current path wherein the total line current flows through the first and fourth protective means and through the second portion of the second winding section, and substantially one-half of the total line current flows through the second protective means, the first portion of the second winding section, and the first winding section, and the switching means connects the winding assembly and the protective means together when the switching means is in its first position to provide a line current path wherein the total line current flows through the first, second and third protective means, the first and second portions of the second winding section, and the first winding section.

5. Electrical inductive apparatus comprising a first winding section having a first voltage rating with first and second end terminals, a tapped second winding section having third and fourth end terminals and an intermediate tap terminal, the voltage rating between the first and second end terminals and between the third and tap terminals of the winding sections being equal, first and second line terminals which conduct line current, first, second, third and fourth protective links each having first and second ends, said first and fourth protective links being constructed to interrupt current at a higher value than said second and third protective links, the first terminal of the first protective link being connected to the first line terminal, the second terminal of the first protective link being connected to the first terminal of the second protective link, the first terminals of said third and fourth protective links being connected directly to each other and to the second line terminal, switching means having first and second positions, said switching means including a stator assembly with first, second, third, fourth, fifth, sixth, seventh, eighth and ninth stator contacts mounted thereon, a rotor assembly with first, second and third contact pairs mounted thereon, said first stator contact being connected to said tap terminal, said second stator contact being connected to said fourth end terminal and said fourth stator contact, said third stator contact being connected to said second end terminal, said fourth stator contact being connected to said fourth end terminal, said fifth stator contact being connected to said sixth stator contact, said sixth stator contact being connected to said third end terminal, said seventh stator contact being connected to the second end of said fourth protective link, said eighth stator contact being connected to the first end of said second protective link, said ninth stator contact being connected to the second end of said third protective link, said stator contacts and said rotor contact pairs being arranged to connect together appropriate contacts when the switching means is in its second position to provide a current path wherein the total line current flows through the first protective link and through the portion of the second winding section which is between the fourth end terminal and the tap terminal, and substantially one-half of the total line current flows through the second protective link, the portion of the second winding section which is between the third end

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terminal and the tap terminal, and the first winding section, the switching means connecting the winding sections and the protective links together when the switching means is in its first position to provide a line current

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path wherein the total line current flows through the first, second, and third protective links, the second winding section, and the first winding section.

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