June 14, 1927. 1,632,097

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TRANSFORMER WINDING

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Fig. 1.

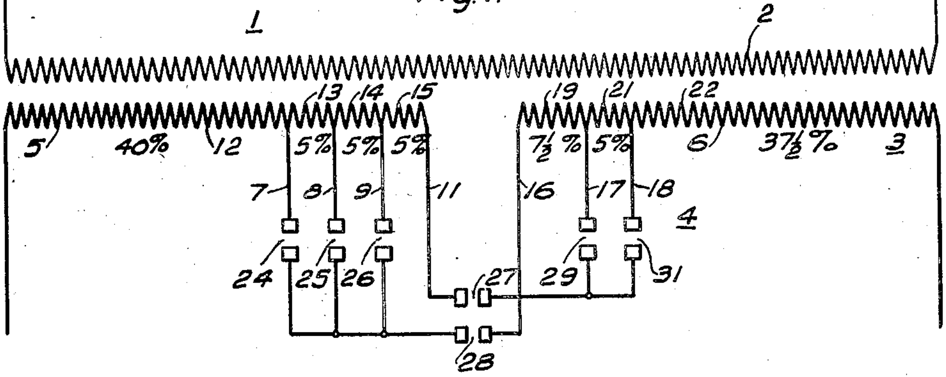


Fig. 2.

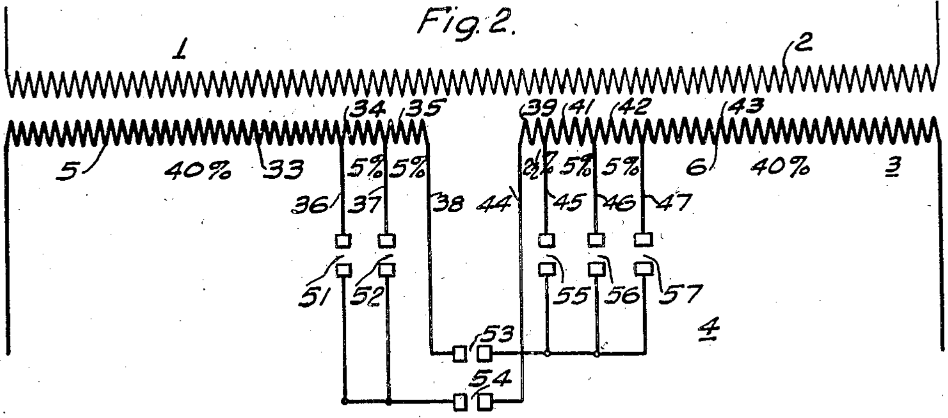
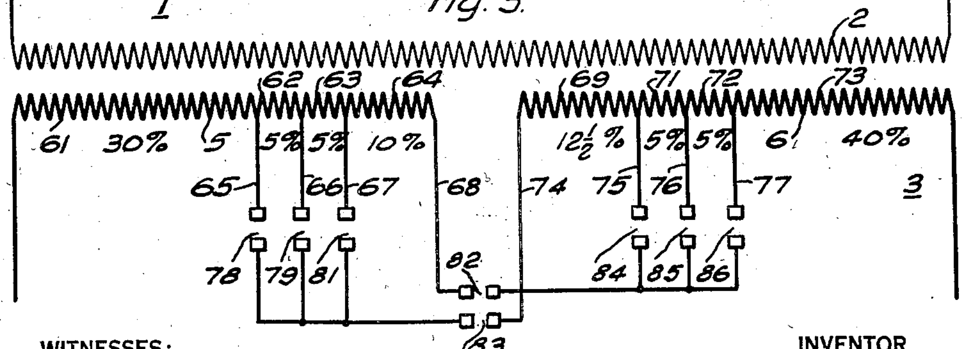


Fig. 3.



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UNITED STATES PATENT OFFICE.

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TRANSFORMER WINDING.

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My invention relates to electrical apparatus and particularly to windings especially designed for the operation of tap changing.

One object of my invention is to provide a winding for tap-changing operations that shall comprise a plurality of standard sections having a definite number of turns and a section having a different number of turns to be interchanged with the standard sections for securing intermediate voltages.

Another object of my invention is to provide an electrical winding to supply variable voltages that shall include a section, the number of turns of which shall differ from the number of turns in the majority of the sections of the winding by a factor that bears a relation to one-half the number of turns of the majority of the sections, that may be connected in circuit with the other sections in sequence, in order that the voltage supplied by the entire transformer may be varied in steps corresponding to the midpoints of the majority of the winding sections.

In the operation of changing the taps of transformers, load compensators and the like, it is a customary practice to divide the winding into a plurality of sections by connecting conductors at different points in the windings. By varying the connections between the different conductors it is possible to vary the voltage supplied by the entire transformer. In such constructions, however, the number of voltages available depends upon the number of conductors connected to the windings. Where a large number of voltage variations are desired, the number of such conductors becomes excessive.

I propose to increase the number of voltage steps available without increasing the number of conductors connected to the winding by providing one winding, the number of turns of which differs from that of the majority of the windings by a factor that is proportional to one-half the number of windings of the majority of the sections. By connecting the latter winding in a predetermined sequence with the other sections of the winding, as hereinafter described, it is possible to increase the number of voltage steps available without increasing the number of conductors connected to the different windings.

In the accompanying drawings, Figure 1 is a diagrammatic view of circuits and apparatus embodying my invention.

Figure 2 is a similar view of a modified form of my invention, and

Figure 3 is a similar view of another form of my invention.

Referring to Fig. 1, my invention comprises a transformer 1 having the usual primary winding 2 and a subdivided secondary winding 3 that is provided with suitable mechanism 4 for varying the connections of its component windings in order to supply the variable-voltage steps. The secondary winding 3 comprises two divisions 5 and 6 that are inter-connected through the mechanism 4. The subdivision 5 is divided, by conductors 7, 8, 9 and 11, into major sections 12, 13, 14 and 15, respectively. The sections 13, 14, and 15 have the same number of turns and may be considered as standard sections and are hereinafter referred to as such.

Winding 6 is divided, by conductors 16, 17 and 18, into sections 19, 21 and 22, respectively. The section 19 is shown as having one and one-half times the number of turns contained in each of the standard sections 13, 14, 15 and 21. The major section 22 corresponds to the major section 12 of subdivision 5.

Conductors 7, 8, 9, 11, 16, 17 and 18 are connected to circuit interrupters 24, 25, 26, 27, 28, 29 and 31, respectively. The several circuit interrupters constitute portions of the mechanism 4. The circuit interrupters 24, 25 and 26 are in parallel circuit to each other and in series relation to the circuit interrupter 28, while the circuit interrupters 29 and 31 are in parallel circuit to each other and in series relation to the circuit interrupter 27. It is to be understood that, in a practical embodiment of my invention, suitable mechanism must be included in the mechanism 4 to operate the several circuit interrupters 24 to 31, inclusive, but, inasmuch as such mechanism constitutes no part of the present invention, a showing thereof has been omitted from the drawings.

By way of a practical illustration of my invention, it may be assumed that the several sections of the winding 3 are proportioned as follows: Section 12 comprises 40% of the total number of turns in winding. Section 13 comprises 5% of the total number of turns in winding. Section 14 comprises 5% of the total number of turns in winding. Section 15 comprises 5% of the total number of turns in winding. Section 19 comprises 7½% of the total number of turns in winding. Section 21 comprises 5% of the total number of turns in winding. Section 22 comprises 37½% of the total number of turns in winding.

Inasmuch as the entire current traversing the secondary winding 3 always traverses sections 12 and 22, their influence upon the voltage supplied by the winding 3 is constant and may be omitted from further discussion of the invention.

With only the circuit interrupters 26 and 28 in their closed positions, the active portion of secondary winding 3 comprises the sections 12, 13, 14, 19, 21 and 22, and the transformer is supplying its rated or normal voltage. The number of turns in the active sections 13, 14, 19 and 21 may be considered to have a numerical value of 22½% of the total number of active turns in the entire transformer.

In order to reduce the voltage supplied by the winding 3, the circuit interrupters 27 and 29 are closed, in addition to the circuit interrupters 26 and 28, after which the circuit interrupters 26 and 28 are opened. During the time that the four circuit interrupters are in their closed positions, a circulating current traverses the sections 15 and 19 by reason of the different numbers of turns therein. The circulating current is of such short duration, and the connected sections are physically so separated by a space constituting a high-reactance path that the winding 3 is not injured.

When the circuit interrupters 26 and 28 have been opened, the active portion of the winding 3 comprises the sections 12, 13, 14, 15 and 21. The numerical value of the turns in the sections 13, 14, 15 and 21 is 20% of the total winding of the transformer. By the foregoing operations, the section 15 is added to the winding 3 and section 4 is removed therefrom, whereby the number of effective turns in the winding 3 is decreased by 2½% or an amount equivalent to one-half the effect of one of the standard sections 13, 14, 15 or 21.

To further reduce the voltage supplied by the winding 3, circuit interrupters 25 and 28 are closed after which the circuit interrupters 27 and 29 are opened, with the result that the effective portion of the winding 3 comprises the sections 12, 13, 19, 21 and 22. The numerical total of the turns in the sections 13, 19 and 21 is 17½% of the total number of turns of the winding 3. By the last operation, sections 14 and 15 are removed from active duty, and section 19 is added, thereby reducing the number of effective turns in the winding by 2½%.

To further reduce the voltage of the winding 3, the circuit interrupters 27 and 31 are closed, after which the circuit interrupters 25 and 28 are opened. The effective sections of the secondary winding 3 are then sections 12, 13, 14, 15 and 22. The numerical total of the turns in sections 12, 14 and 15 is 15% of the total number of turns in the winding 3. By this step, sections 14 and 15 are added to the effective portion of winding 3, and sections 19 and 21 are removed therefrom, with the result that the number of effective turns in the winding is reduced by 2½%.

To further reduce the voltage supplied by the winding 3, the circuit interrupters 24 and 28 are closed, after which circuit interrupters 27 and 31 are opened. The effective portion of the winding is thus constituted by the sections 12, 19, 21 and 22. The numerical total of the number of turns in the sections 19 and 21 is 12½% of the total of the number of turns in the entire winding 3. In this step, the sections 13, 14 and 15 are removed from the active portion of winding 3, and the sections 19 and 21 are substituted therefor, with a net loss of 2½% in the number of active turns in the winding 3. In order to raise the voltage of the winding 3, the foregoing steps are taken in a reverse order.

Accordingly, by utilizing the section 19 in different combinations with sections 13, 14, 15 and 21, it is possible to secure a series of voltage gradations between the normal operating voltage of the transformer and 90% of the normal voltage, in steps that correspond to the mid-points of the standard sections 13, 14, 15 and 21.

Fig. 2 illustrates a modified form of my invention in which the sub-division 5 comprises sections 33, 34 and 35 and accompanying connections 36, 37 and 38, respectively, and the sub-division 6 comprises sections 39, 41, 42 and 43 that are defined by conductors 44, 45, 46 and 47, respectively. Conductors 36, 37, 38, 44, 45, 46 and 47 are connected to circuit interrupters 51, 52, 53, 54, 55, 56 and 57, respectively.

The ratios between the number of turns in the entire winding 3 to the number of turns in the several sections may be considered to be as follows: Section 33 comprises 40% of the number of turns in winding 3. Section 34 comprises 5% of the number of turns in winding 3. Section 35 comprises 5% of the number of turns in winding 3. Section 39 comprises 2½% of the number of turns in winding 3. Section 41 comprises 5% of the number of turns in winding 3. Section 42 comprises 5% of the number of turns in winding 3. Section 43 comprises 40% of the number of turns in winding 3.

By comparing section 39, in this form of my invention, with section 19 in Fig. 1, it will be observed that, in the former section one-half the number of turns in a standard section are taken from the standard section while, in the latter section, one-half the number of turns are added to the number of the turns in the standard section.

When the circuit interrupters 53 and 55 are in their closed positions and the other circuit interrupters are in their open positions, the transformer is operating at its normal voltage, and the winding 3 includes the active sections 33, 34, 35, 41, 42 and 43. To lower the voltage of the winding 3, circuit interrupters 52 and 54 are closed, after which circuit interrupters 53 and 55 are opened, whereby section 35 is removed from the active portion of the winding 3, and section 39 is added thereto, with a net reduction of 2½% in the number of active turns in the winding 3.

The next step in reducing the voltage of the winding 3 is to close circuit interrupters 53 and 56 and then open circuit interrupters 52 and 54. This operation removes sections 39 and 41 from the effective portion of the winding and adds section 35, with the result that the number of active turns of the winding 3 is reduced by 2½%.

To reduce the effective number of turns in the winding 3 to 92½% of the normal number of turns, circuit interrupters 51 and 54 are closed, after which circuit interrupters 53 and 56 are opened. By this operation, sections 34 and 35 are removed from the active portion of the winding 3, and sections 39 and 41 are added thereto, with a net reduction of 2½% in the number of active turns in the winding 3.

To further reduce the number of active turns in the winding 3, the circuit interrupters 53 and 57 are closed, and the circuit interrupters 51 and 54 are opened, which operation inserts sections 34 and 35 in the active part of the winding 3 and removes sections 39 and 41 and 42, with a net reduction of 2½% in the number of active turns.

Refering to Fig. 3, the subdivision 5 comprises sections 61, 62, 63 and 64 that are defined by conductors 65, 66, 67 and 68, respectively, and the subdivision 6 comprises sections 69, 71, 72 and 73 that are defined by conductors 74, 75, 76 and 77, respectively. Conductors 65, 66, 67, 68, 74, 75, and 76 and 77 are connected to circuit interrupters 78, 79, 81, 82, 83, 84, 85 and 86, respectively.

When the circuit interrupters 82 and 84 are closed and the other circuit interrupters are open, the winding 3 comprises sections 61, 62, 63, 64, 71, 72 and 73.

The numerical values of the several sections are:—Section 61 comprises 30% of the total number of turns in winding. Section 62 comprises 5% of the total number of turns in winding. Section 63 comprises 5% of the total number of turns in winding. Section 64 comprises 10% of the total number of turns in winding. Section 69 comprises 12½% of the total number of turns in winding. Section 71 comprises 5% of the total number of turns in winding. Section 72 comprises 5% of the total number of turns in winding. Section 73 comprises 40% of the total number of turns in winding.

To reduce the voltage of the transformer, circuit interrupters 83 and 79 are closed, after which circuit interrupters 82 and 84 are opened. This operation adds section 69 to the active portion of the winding 3 and removes 63 and 64, with a net reduction of 2½% of the number of active turns in the winding.

The second operation is to close the circuit interrupters 82 and 85 and open circuit interrupters 79 and 83. This operation adds sections 63 and 64 to the active part of winding 3 and removes sections 69 and 71 therefrom, with a net reduction of 2½% of the number of active turns in the winding.

To reduce the number of turns in the winding to 92½% of the normal value, circuit interrupters 78 and 83 are closed, and circuit interrupters 82 and 85 are opened, with the result that sections 69 and 71 are inserted in the active portion of the winding 3, and sections 62, 63 and 64 are removed therefrom.

The final step in reducing the voltage of the winding 1 is to close circuit interrupters 82 and 86, after which circuit interrupters 78 and 83 are opened. This operation adds sections 62, 63 and 64 to the active part of winding 3 and removes sections 69, 71 and 72 therefrom, with a net reduction of 2½% in the number of active turns in the winding 3. To raise the voltage of the winding, the foregoing steps are repeated in a reverse order.

In this form of my invention, the section 64 contains a number of turns, which is a product of the number of turns of a standard section and a whole number, while the number of turns in section 69 is the product of the number of turns in the standard section and a mixed-number that is evenly divisible by one-half. The difference in the number of turns between sections 64 and 69 is equal to one-half the number of turns in the standard sections 62, 63, 71 and 72.

According to my invention, a plurality of intermediate voltages, or one-half steps, are available for increasing or decreasing the voltage supplied by a winding, by utilizing a winding whose number of turns is the product of the number of turns in a standard section and a mixed number that is evenly divisible by one-half. That winding is connected to the standard windings in such sequence that each successive connection differs from the preceding connection by the inclusion or exclusion of a number of turns that is equal to one-half the number of turns in a standard section. That section may be a standard section with an addition of one-half its number of turns, as in Fig. 1, or a subtraction of one-half the number of turns, as in Fig. 2, or the result may be secured by any two co-operating windings which differ from each other by one-half the number of turns in a standard section, as in Fig. 3.

It is to be understood that such changes as may be deemed necessary to function in accordance with my invention may be made within the scope of the appended claims.

I claim as my invention:

1. An electrical winding comprising a plurality of divisions, one of which comprises a standard section having a definite number of turns, the other division comprising a section the number of turns of which is the product of the number of turns in the standard section and a number evenly divisible by one-half, and means for controlling connections of the several divisions and sections to vary the voltage of the winding in steps corresponding to changes of one-half the number of the turns in the first named section.

2. An electrical winding comprising a plurality of divisions, one of which comprises a standard section having a definite number of turns and a second section the number of turns in which is the product of the number of turns in the standard section and a whole number, another division comprising a section the number of turns in which differs from the second section by one-half of the number of turns in the standard section, and means for controlling connections of the several divisions and sections to vary the voltage of the winding in steps corresponding to changes of one-half the number of turns in the first named section.

3. An electrical winding comprising a plurality of divisions, one of which comprises a standard section having a definite number of turns, one of the divisions comprising a section the number of turns in which is the product of the number of turns in the standard section and a whole number, another of the divisions comprising a winding the number of tu.ns in which is the product of the number of turns in the standard section and a number evenly divisible by one-half, and means for controlling connections of the several divisions and sections to vary the voltage of the winding in steps corresponding to changes of one-half the number of turns in the first named section.

4. An electrical winding comprising a plurality of divisions, one of which comprises a standard section having a definite number of turns, one of the divisions comprising a section the number of turns in which is the product of the number of turns in the standard section and a whole number, another of the divisions comprising a winding the number of turns in which differs from the number of turns in the second named section by one-half the number of turns in the standard section, and means for controlling connections of the several divisions and sections to vary the voltage of the winding in steps corresponding to changes of one-half of the number of turns in the first named section.

In testimony whereof, I have hereunto subscribed my name this 28th day of May, 1926.

JOHN F. PETERS.