

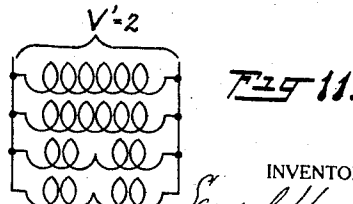
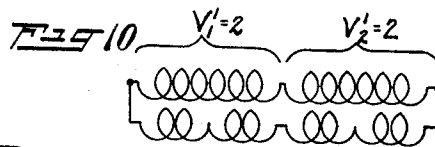
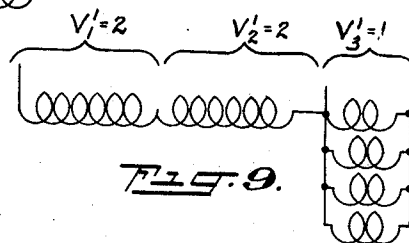
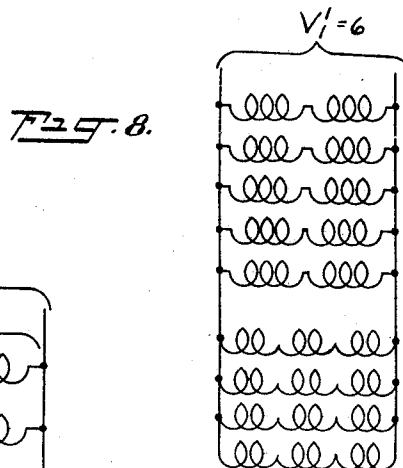
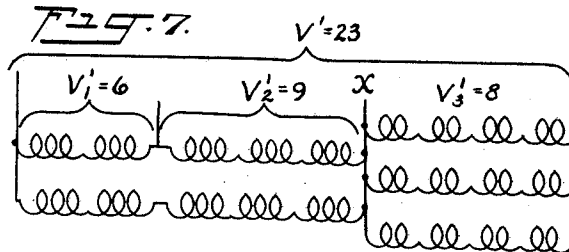
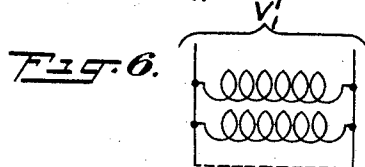
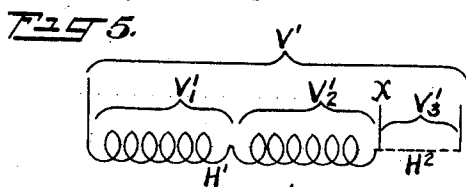
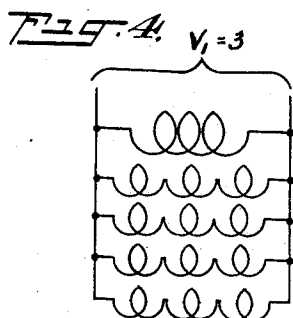
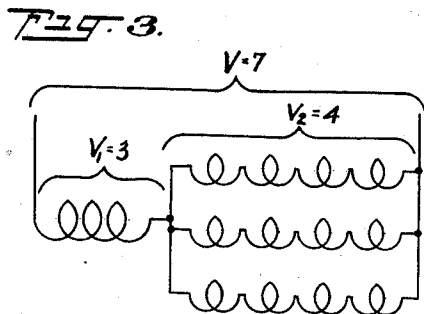
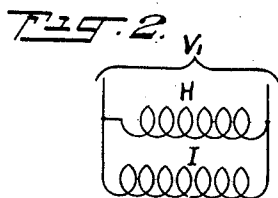
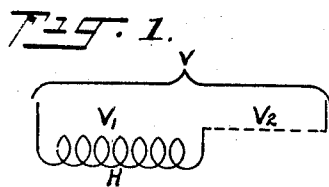
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S. HORELICK

1,740,093

TRANSFORMER

Filed Feb. 1, 1924



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TRANSFORMER

Application filed February 1, 1924. Serial No. 689,981.

My invention relates to electric transformers, particularly adapted for use with different applied voltages.

It is a common occurrence in practice to provide a transformer which will be readily adapted for use not only on the circuit for which it may be intended at the time, but also for possible use on a circuit of different voltage, or for use on the same circuit with an increased or lowered voltage. For example, a plant may have in use one circuit in which transformation from 22,000 volts to a lower voltage is being carried out and then have in use another circuit in which transformation from 33,000 volts to a lower voltage is being carried out, or it may be intended to increase the applied voltage in a 22,000 volt system to a 33,000 volt system. In either case in purchasing a transformer, it is desirable to have one which can readily be used on either the higher or lower voltage, while deriving the same voltage from the secondary winding of the transformer in each case. In this instance it has been common to provide a primary winding with a sufficient number of turns adapted to receive 33,000 volts for securing the desired secondary voltage; and to provide a 2/3 tap on the primary winding so that when used on the 22,000 volt circuit, connection will be made to one terminal of the winding and to the 2/3 tap, thus giving the same secondary voltage as before. In such a case, however, the ampere capacity of 2/3 of the primary winding must be 50% greater than the remaining third of the winding to provide for use on the 22,000 volt circuit. But when the transformer is used on the 33,000 volt circuit, this excess ampere capacity in two-thirds of the winding is unnecessary and not economically used; and when the transformer is used on the 22,000 volt circuit, one-third of the winding is out of circuit and is not used at all.

It is thus evident that the provision of a transformer of this character requires a larger space and more expense in the windings, as well as increase in the size of the core, than would be the case if the transformer were adapted for use on only one of the two above mentioned voltages; yet the conven-

ience and the saving in expense over the purchase of two transformers has been sufficiently great to warrant the practice above described.

The main object of my invention is to provide a transformer which will answer the above requirements of being adapted for use with a plurality of primary voltages and which will have a high efficiency in operation when used with either of the voltages for which it is intended. Another object is to reduce the size of the transformer compared with the size previously required. Another object is to provide a transformer which will be more economical in cost of construction compared with transformers of this type previously used. Another object is to provide means for conveniently connecting the windings so that the transformer will be adapted for use with the particular voltage desired at any time, and to also provide convenient means for changing the connections so as to be adapted for use with another voltage. Other objects and advantages of my invention will be understood from the following description and accompanying drawings which disclose preferred embodiments of my invention.

In applicant's Patent 1,576,280, March 9, 1926, is disclosed and claimed how certain broad aspects of these objects may be attained. I will now describe a method which may be employed in providing a transformer in accordance with my present invention which is adapted for use with voltages having certain ratios as will appear hereinafter, and more particularly in which coil sections adapted to work at unequal voltages respectively are preferably employed.

Fig. 1 represents a partial diagram of a transformer winding adapted for use with an impressed voltage V . Fig. 2 represents the same winding adapted for use with a lower impressed voltage V_1 . The winding in Fig. 1 comprises a single coil H in series with which is a group of coils the arrangement of which is as yet undetermined. I have arbitrarily assumed that the voltage impressed on the coil H in the arrangement shown in Fig. 1 is V_1 volts. The remainder of the winding

of Fig. 1 will receive V_2 volts such that $V_1 + V_2 = V$. In the arrangement shown in Fig. 2 the coil H is connected directly across the low voltage line and will in this case also have impressed upon it V_1 volts. The winding in Fig. 2 is completed by coil I connected directly across the low voltage line. If $V_2 = 1/2 V_1$ the winding of Fig. 1 may be completed by dividing the coil I into two equal sections and connecting these sections in parallel with each other and in series with the coil H. Similarly if $V_2 = 1/3 V_1$ the arrangement of Fig. 1 could be completed by dividing the coil I into three equal parts and connecting them in parallel. If

$$V_2 = \frac{1}{N} V_1$$

the coil I should be divided into N equal parts. This may be expressed by the following equation:

$$\frac{V_1}{N} = V_2 \text{ or } N = \frac{V_1}{V_2} \quad (1)$$

Thus if V_2 were 11,000 and V_1 22,000 as in the case illustrated in Figs. 1 to 7 of applicant's Patent 1,576,280 hereinbefore referred to

$$N = \frac{22,000}{11,000} = 2$$

It will be noted that the coils A and A' or said Figs. 1 to 7 may be considered one coil as the same are always connected in series.

Equation (1) gives a solution when $\frac{V_2}{V_1}$ reduces to a whole number or to a fraction with one as the numerator. In other cases it will be necessary to divide the coil I into a number of sections which is the least common multiple of V_2 and V_1 . Assuming that this least common multiple is $V_2 \times V_1$, that is, cannot be reduced to simpler terms, the coil I may be divided into $V_2 \times V_1$ equal sections and these sections arranged in V_1 parallel groups, each comprising V_2 sections connected in series, for the Fig. 1 arrangement and arranged in V_2 parallel groups each comprising V_1 sections in series, for the Fig. 2 arrangement.

Figs. 3 and 4 represent a transformer adapted for voltages having the ratio 7 to 3. In this case

$$\frac{V_2}{V_1} = \frac{4}{3}$$

That portion of the winding to the right of Fig. 3 is therefore divided into $4 \times 3 = 12$ sections. These are arranged in the manners shown in Figs. 3 and 4 to complete the winding.

In the above cases it has been assumed that the portion H of the winding consists of a single coil adapted to receive the lower voltage V_1 in both high and low voltage arrangement. In certain cases it is possible to

reduce the total number of coil sections and also the number of turns by employing, instead of the coil H, a plurality of coil sections which are grouped according to one arrangement for the high voltage connection and according to a different arrangement for the low voltage connection. In Figs. 5 and 6 such an arrangement is shown in which the transformer is adapted for a higher voltage V' and a lower voltage V'_1 . In Fig. 5 the winding is divided into three portions in series with one another, these portions receiving respectively V'_1 volts, V'_2 volts and V'_3 volts. V'_1 is here assumed to be equal to V'_2 and the coil H' of Fig. 5 is composed of two equal sections arranged in series in Fig. 5 and in parallel in Fig. 6. The voltage point X of the transformer circuit of Fig. 5 is chosen so that the relationship between the voltages $V'_1 + V'_2$ and V'_1 is a simple one namely 2 to 1. If the voltage point X can be chosen so that at the same time the relationship between the voltages V'_1 and V'_3 is also a simple one, the number of coil sections of the portion H₂ of the winding and the total number of turns will be small and these sections will be connected in series with the portion H' and connected to each other in accordance with one arrangement in Fig. 5 and connected in parallel with the portion H' and connected to one another according to the different arrangement in Fig. 6.

As illustrating the advisability in certain cases of employing the method just given, let it be supposed that we wish to design a transformer adapted for impressed voltages of 23 and 6. If the method described in connection with Figs. 1 and 2 were adopted the single coil corresponding to the coil H and adapted to receive an impressed voltage of 6 volts would be employed. The remainder of the winding would then have to consist of 102 sections arranged in six parallel groups of 17 sections in series each, for the high voltage arrangement and 17 parallel groups of this section in series each for the low voltage arrangement. The number of turns is very much reduced by adopting a voltage point X of Fig. 7 which differs in potential from one terminal of the transformer by 15 volts and from the other terminal by 8 volts. In this figure it will be seen that $V'_2 + V'_1$ bears the relation to V'_1 of 5 to 2. As a result of this arrangement the entire winding consists of but 22 coil sections as against 103 by the former method with a consequent reduction in the number of turns.

It will be noted that in all of the specific examples above described, I make use of parallel circuits carrying different currents.

In certain cases it may be advisable to form more than two groups of coil sections with sections of each group differing from sections of another group. The extension of this

method to the design of a transformer adapted for three or more external voltages will be evident. Figs. 9 to 11 show the simple case of a transformer adapted for impressed line voltages of 5, 4 and 2. Here the ratio of V'_1 to V'_2 is a simple one as is also the ratio of V'_1 to V'_3 .

The method underlying the foregoing examples of arrangements of coil sections and selection of relative voltages may be generalized as follows. For convenience referring to Figs. 7 and 8, it will be noted that the coil section voltage to the left of point x is represented by the factor 3 which is a factor of the external voltage V'_1 . The coil section voltage factor 3 goes into the group voltage $V'_1 + V'_2$, five times, and into the external voltage V'_1 (Fig. 8) twice. Thus there are 10 coils and there may be two parallel paths of 5 coils each as in Fig. 7 or five parallel paths of 2 coils each as in Fig. 8. It will be obvious that the total number of coils in a given major group is therefore equal to the product of the voltage across that group and the lowest external voltage, divided by the square of the coil section voltage.

It will be understood that my invention is advantageously adapted to various types of transformers and different forms of construction and also to polyphase transformers as well as single phase and to single phase transformers connected in polyphase circuits. When used on polyphase circuits the windings may be connected in delta, star or otherwise as desired.

It will be obvious that the coil sections or groups of coil sections, or both, may be provided with special terminals and connecting means for connecting the sections and groups in various arrangements, in a manner similar or equivalent to that shown in Figs. 6 and 7 of applicant's patent hereinbefore referred to.

I claim:

1. A transformer for different voltages comprising windings sub-divided into sections, certain of said sections having different resistance and a different number of turns from other of said sections, and means for connecting said sections in different series and parallel arrangements, each section in all arrangements receiving the same current.

2. A stationary induction apparatus adapted to be employed with a plurality of different external voltages comprising a winding formed of a plurality of coil sections, said sections, when the apparatus is arranged for use with a higher voltage, being arranged in two groups which are connected in series at a point in the winding having such a potential that the voltages between said point and the terminals of the apparatus bear simple relations to a lower of the external voltages, there being coil sections upon opposite sides of said point of different current carrying

capacities and different numbers of turns and means for changing the series parallel relationships of the coil sections of said groups to adapt the winding for use with different external voltages, each coil section being adapted to work at its full capacity and each turn of the winding receiving substantially the same voltage in all arrangements.

3. A stationary induction apparatus adapted to be employed with a plurality of different external voltages comprising a winding formed of a plurality of coil sections, said sections, when the apparatus is arranged for use with a higher voltage, being arranged in two groups which are connected in series at a point in the winding having such a potential that the voltages between said point and the terminals of the apparatus are different from and bear simple relations to a lower of the external voltages, there being coil sections upon opposite sides of said point of different current carrying capacities and different numbers of turns and means for changing the series parallel relationships of the coil sections of said groups to adapt the winding for use with different external voltages, each coil section being adapted to work at its full capacity and each turn of the winding receiving substantially the same voltage in all arrangements.

4. A stationary induction apparatus adapted to be employed with a plurality of different external voltages comprising a winding formed of a plurality of coil sections, said sections, when the apparatus is arranged for use with a higher voltage, being arranged in two groups which are connected in series at a point in the winding having such a potential that the voltages between said point and the terminals of the apparatus bear simple relations to a lower of the external voltages, there being coil sections upon opposite side of said point of different current carrying capacities and different numbers of turns and means for changing the series parallel relationships of the coil sections of one of said groups to adapt the winding for use with different external voltages, each coil section being adapted to work at its full capacity and each turn of the winding receiving substantially the same voltage in all arrangements.

5. A stationary induction apparatus adapted to be employed with a plurality of different external voltages comprising a winding formed of a plurality of coil sections, said sections, when the apparatus is arranged for use with a higher voltage, being arranged in groups which are connected in series, a predetermined number of the individual coil sections of a given group being of a different current carrying capacity than coil sections of another group and being adapted to work at a voltage which is a factor of said lower external voltage and of the voltage across said given group, the working voltage of a

predetermined number of coil sections in another of said groups being different from that of said coil sections of said given group and also a factor of said lower external voltage and of the voltage across said other group, and means for changing the relationships of the coil sections of said groups to adapt the winding for use with different external voltages, each coil section being adapted to work at its full capacity in all arrangements.

6. A stationary induction apparatus adapted to be employed with a plurality of different external voltages comprising a winding formed of a plurality of coil sections, said sections, when the apparatus is arranged for use with a higher voltage, being arranged in two groups which are connected in series at a point in the winding having such a potential that the voltages between said point and the terminals of the apparatus bear simple relations to a lower of the external voltages, there being coil sections upon opposite sides of said point of different current carrying capacities, a predetermined number of the individual coil sections on one of said sides being adapted to work at a voltage which is a factor of said lower external voltage, a predetermined number of the individual coil sections on the other of said sides being adapted to work at a voltage different from that of said first mentioned side and which voltage is a factor of said lower external voltage and of the voltage across the group of coil sections of which said last named coil sections form a part, and means for changing the relationships of the coil sections of said groups to adapt the winding for use with different external voltages, each coil section being adapted to work at its full capacity and each turn of the winding working at substantially the same voltage in all arrangements.

7. A stationary induction apparatus adapted to be employed with at least two different external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with a higher of said external voltages being arranged in two major groups the ratio of the voltages across said groups being non-integral with either voltage as the numerator of said ratio, and the voltage across one of said groups bearing a simple relation to a lower of said external voltages.

8. A stationary induction apparatus adapted to be employed with at least two different external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with a higher of said external voltages being arranged in two major groups the ratio of the voltages across said groups being non-integral with either voltage as the numerator of said ratio, and the voltage across one of said groups bearing a simple relation to all of the lower of said external voltages.

9. A stationary induction apparatus adapt-

ed to be employed with at least two different external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with a higher of said external voltages being arranged in two major groups the ratio of the voltage across said groups being non-integral with either voltage as the numerator of said ratio, and the voltage across each of said groups respectively bearing a simple relation to a lower of said external voltages.

10. A stationary induction apparatus adapted to be employed with at least two different external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with a higher of said external voltages being arranged in two major groups the ratio of the voltage across said groups being non-integral with either voltage as the numerator of said ratio, and the voltage across each of said groups respectively bearing a simple relation to all of the lower of said external voltages.

11. A stationary induction apparatus adapted to be employed with a plurality of external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with the highest of said external voltages being arranged in two major groups, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, one of said major groups being composed of two minor groups of coil sections, the voltage across said one of said major groups bearing a simple relation to the voltage across one of said minor groups.

12. A stationary induction apparatus adapted to be employed with a plurality of external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with the highest of said external voltages being arranged in two major groups, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, one of said major groups being composed of two minor groups of coil sections, the voltage across one of said major groups bearing a simple relation to the voltage across each of said minor groups.

13. A stationary induction apparatus adapted to be employed with a plurality of external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with the highest of said external voltages being arranged in two major groups, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, one of said major groups being composed of two minor groups of coil sections,

the voltage across said one of said major groups bearing a simple relation to the voltage across one of said minor groups, the voltage across the other of said major groups bearing a simple relation to the voltage across said one of said minor groups.

14. A stationary induction apparatus adapted to be employed with a plurality of external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with the highest of said external voltages being arranged in two major groups, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, one of said major groups being composed of two minor groups of coil sections, the voltage across said one of said major groups bearing a simple relation to the voltage across each of said minor groups, the voltage across the other of said major groups bearing a simple relation to the voltage across one of said minor groups.

15. A stationary induction apparatus adapted to be employed with at least two different external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with a higher of said external voltages being arranged in two major groups the ratio of the voltage across said groups being non-integral with either voltage as the numerator of said ratio, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, said coil section voltages being respectively factors of a lower of said external voltages.

16. A stationary induction apparatus adapted to be employed with at least two different external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with a higher of said external voltages being arranged in two major groups the ratio of the voltages across said groups being non-integral with either voltage as the numerator of said ratio, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, said coil section voltages being respectively factors of all of the lower of said external voltages.

17. A stationary induction apparatus adapted to be employed with a plurality of external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with the highest of said external voltages being arranged in two major groups, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, said coil section voltages being re-

spectively factors of a lower of said external voltages, one of said major groups being composed of two minor groups of coil sections, the voltage across said one of said major groups bearing a simple relation to the voltage across one of said minor groups.

18. A stationary induction apparatus adapted to be employed with a plurality of external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with the highest of said external voltages being arranged in two major groups, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, said coil section voltages being respectively factors of a lower of said external voltages, one of said major groups being composed of two minor groups of coil sections, the voltage across one of said major groups bearing a simple relation to the voltage across each of said minor groups.

19. A stationary induction apparatus adapted to be employed with a plurality of external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with the highest of said external voltages being arranged in two major groups, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, said coil section voltages being respectively factors of a lower of said external voltages, one of said major groups being composed of two minor groups of coil sections, the voltage across said one of said major groups bearing a simple relation to the voltage across one of said minor groups, the voltage across the other of said major groups bearing a simple relation to the voltage across said one of said minor groups.

20. A stationary induction apparatus adapted to be employed with a plurality of external voltages, comprising a winding formed of a plurality of coil sections, said sections when the apparatus is arranged for use with the highest of said external voltages being arranged in two major groups, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, said coil section voltages being respectively factors of a lower of said external voltages, one of said major groups being composed of two minor groups of coil sections, the voltage across said one of said major groups bearing a simple relation to the voltage across each of said minor groups, the voltage across the other of said major groups bearing a simple relation to the voltage across one of said minor groups.

21. A stationary induction apparatus adapted to be employed with at least two

different external voltages, comprising a winding formed of a plurality of coil sections, said sections when arranged for use with the highest of said external voltages being arranged in two major groups, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, the coil section voltages of the respective groups being factors of the lowest of said external voltage and of the respective voltages across said major groups, the number of coil sections in the respective major groups being equal to the product of the lowest of said external voltages and the respective group voltage, divided by the square of the coil section voltage of the respective group.

22. A stationary induction apparatus adapted to be employed with at least two different external voltages, comprising a winding formed of a plurality of coil sections, said sections when arranged for use with the highest of said external voltages being arranged in two major groups, the coil sections of one of said major groups being adapted to work at a voltage different from that of the coil sections of the other major group, the coil section voltages of the respective groups being factors of the lowest of said external voltage and of the respective voltages across said major groups, the number of coil sections in the respective major groups being equal to the product of the lowest of said external voltages and the respective group voltage, divided by the square of the coil section voltage of the respective group, the coil sections in the respective major groups being connected in such series parallel arrangement that the number of parallel paths in the respective groups is equal to the lowest external voltage divided by the respective coil section voltage.

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