No. 676,267. Patented June 11, 1901.

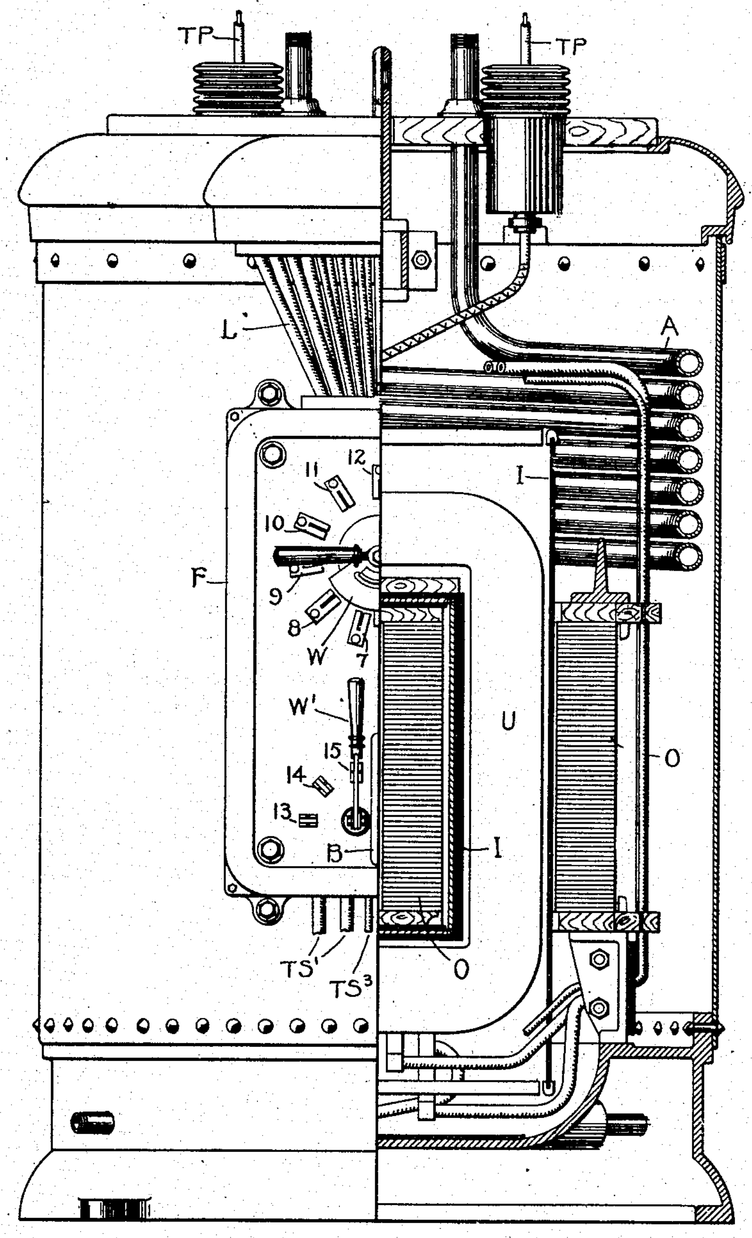
W. S. MOODY.

TRANSFORMER.

(Application filed Feb. 23, 1901.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.



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3 Sheets—Sheet 2.

Fig. 2.

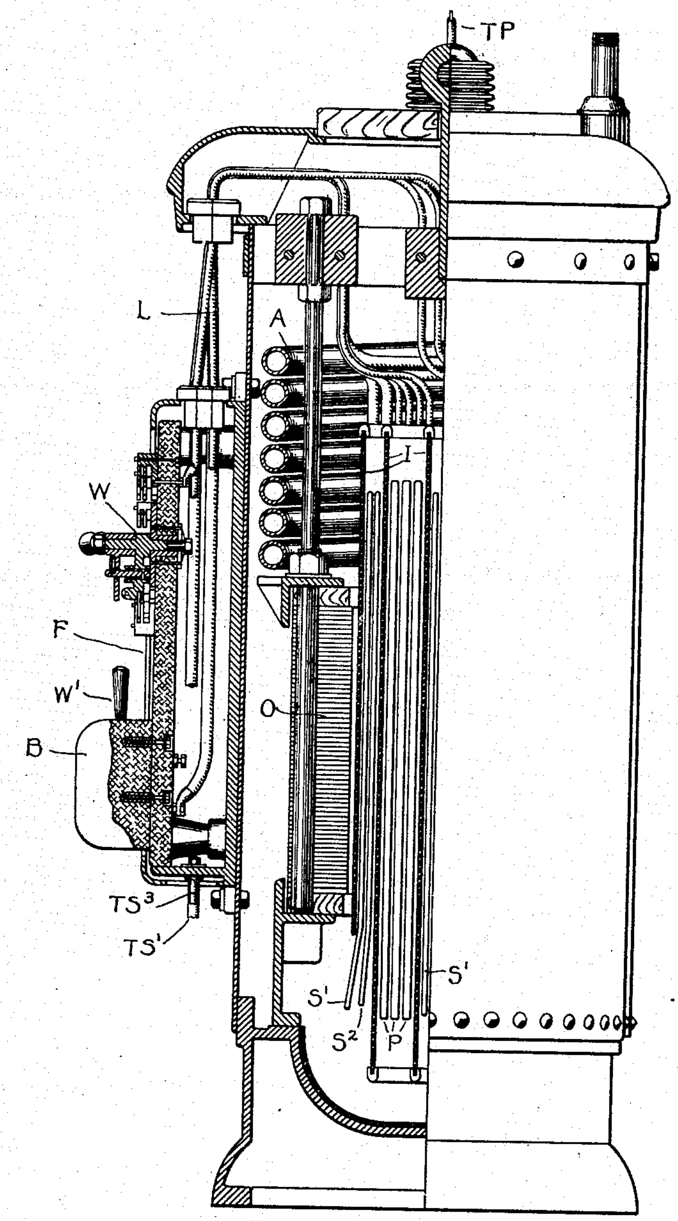

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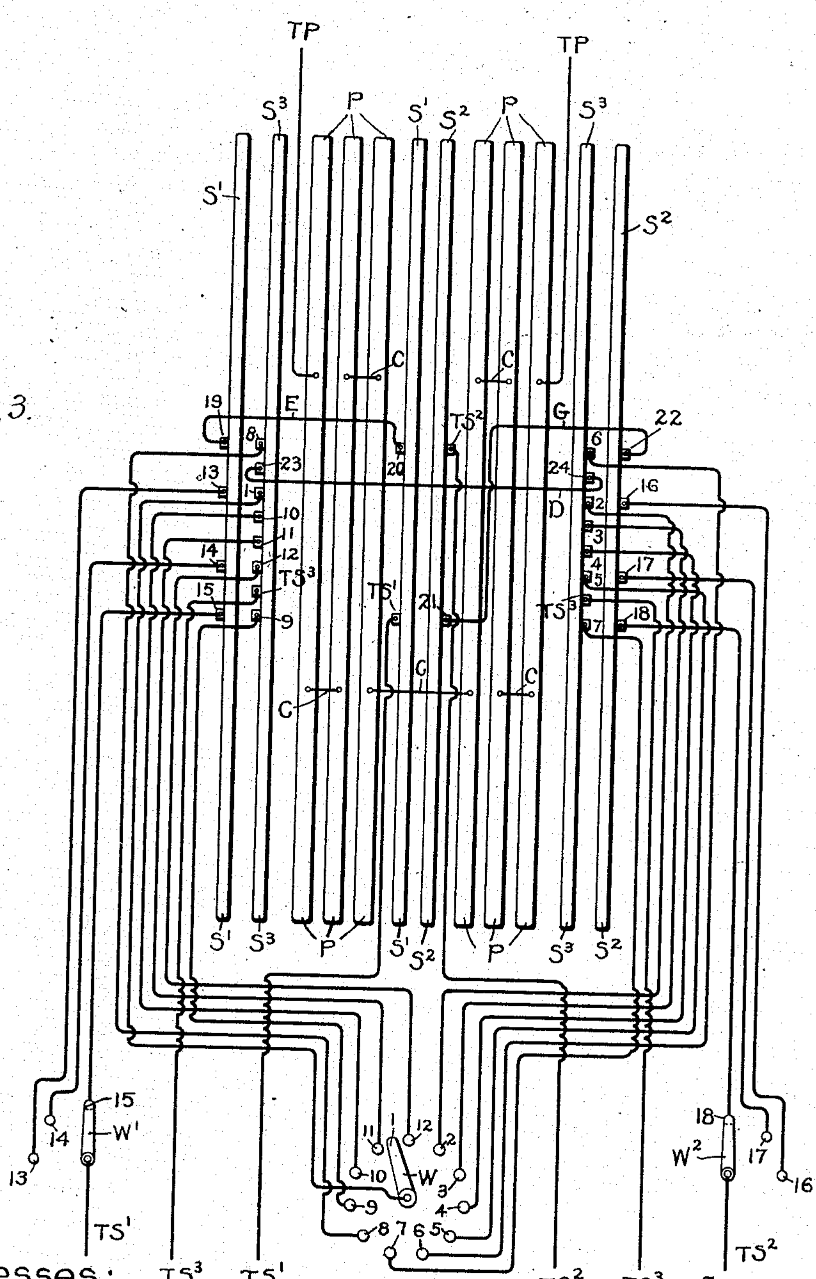
Fig. 3.



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UNITED STATES PATENT OFFICE.

WALTER S. MOODY, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, OF NEW YORK.

TRANSFORMER.

SPECIFICATION forming part of Letters Patent No. 676,267, dated June 11, 1901.

Application filed February 23, 1901. Serial No. 48,389. (No model.)

To all whom it may concern:

Be it known that I, WALTER S. MOODY, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Transformers, (Case No. 1,373,) of which the following is a specification.

This invention relates to transformers which have a plurality of secondary windings adapted for different kinds of service; and it consists in the relative disposition of the primary and different secondary windings, such that each of the latter will be kept within the desired limit as to reactive drop with a minimum expenditure of insulation-spaces between the windings.

The invention further consists in a novel means of regulating within wide limits the potential of a secondary which is connected with a circuit requiring close regulation.

It is well known that the reactance between a primary and secondary is dependent upon their relative positions. This principle was applied by Ekstrom in Patent No. 508,688 to a transformer having secondaries connected in multiple to a single work-circuit when he placed the secondaries so that each was exposed to equal inductive effects of the primary, thereby equalizing the work done by the different secondaries, preventing excessive heating of any one of them, and avoiding short-circuiting of the translating devices in the work-circuit through secondary windings doing less work than others. He accomplished this result by arranging the primary and secondary windings alternately, whereby equal inductive effects were obtained. It may be stated that the single coils of the single secondaries of an ordinary transformer are frequently alternated or intermixed to greater or less degrees in order to control the reactance as desired; but there is a serious objection to extensive intermixing of the windings because it entails a great waste of most valuable space occupied by insulation between the divided portions of the coils, and hence also a consequent increased cost for insulation. In the present case the different secondaries are connected with different work-circuits and it is not necessary that they be so thoroughly intermixed with the primary coils that they should be exposed to equal inductive effects. I have taken advantage of this fact to devise a transformer in which there is as little intermixing as possible, while at the same time each secondary winding is so disposed by intermixing with the primary that the desired inductive effect is obtained. For example, one of the secondary windings is connected to a machine for converting the alternating current into direct current for a railway or to any other desired power-circuit, while another secondary is connected directly to a lighting-circuit, which may be provided also with small house-to-house step-down transformers. In such case, since excessive reactance between the lighting secondary and the primary winding will seriously affect the automatic regulation of the lighting-circuit, while a like excess is not objectionable in the power-circuit and, in fact, often produces better regulation in the case of a converter, it is possible by my invention to avoid the excessive reactance between the primary and the lighting secondary by increasing the reactance between the primary and the secondary which is connected to the power-circuit and without waste of insulation-space. In accordance with my invention also a third secondary for such a circuit as one adapted for induction-motors on an ungrounded circuit may be embodied in the same transformer with the described railway and lighting secondaries.

The advantages of a single-transformer structure adapted to supply current for several different purposes are obvious, and since this is accomplished by this invention in a simple, economical, and efficient manner the importance of the improvement will be appreciated.

This transformer is especially adapted for use in small towns, where the current may be supplied by a high-tension line from a generator operated by water-power.

A further improvement consists in means for the regulation within wide limits of a secondary which is connected with a circuit requiring close regulation, such as the lighting-circuit, whereby excessive leakage flux is avoided. Hitherto all the turns that were cut out during the regulation were located in one place, thus causing an excessive leakage flux between the primary and the remaining turns. This leakage has been a serious disadvantage and a source of considerable energy loss. My improvement consists in cutting out in a substantially symmetrical manner the portions of the secondary which are intermixed with the primary. In the present case the portions of the lighting secondary, which are intermixed with the primary and the other two secondaries, are symmetrically cut out, so that a portion of the lighting secondary located in one space always receives substantially the same inductive effect as any other portion of the same secondary which is located in a different place.

Of the drawings, Figure 1 is a front elevation of a transformer constructed in accordance with my invention, a part of the casing being cut away to show the interior parts. Fig. 2 is a side elevation of the same, a part of the casing being cut away, as in Fig. 1; and Fig. 3 is an end elevation of all the windings, all the other parts of the transformer being removed except the connections, which are shown diagrammatically.

In Fig. 1 the windings U are shown in elevation wound upon the laminated core O, as is customary, and separated from the core by insulation I. The core O is mechanically supported, as shown, in any suitable manner. The organic portions of the transformer are immersed in oil, with which the casing is filled, in accordance with the patent to Thomson, No. 428,648. The oil absorbs the heat generated in the windings of the metallic casing and dissipates a portion of the heat thus absorbed. The coil of pipe A through which is maintained a water-circulation coöperates with the casing to carry off the heat from the oil. The primary leads T P are taken to the top or cover of the casing, as shown, while a plurality of leads L from various portions of the different secondaries are led from beneath the cover to the rear of an insulating face-plate F, which is secured to the front of the transformer-casing. Switches for the respective secondaries are mounted on the plate F, and all the secondary leads are taken out to the work-circuits from the lower part of the plate F. These secondary leads are six in number in the present case, as there are three different secondaries.

In Fig. 2 the windings are shown in end elevation, three sections of the primary P being located between two strips of insulation and a section of each of the secondaries S′ and S^2 being located in an insulated compartment on one side of the primary group shown and the other section of the secondary S′ being located in an insulated compartment on the other side of the primary group. The remainder of the coils are hidden from view in this figure. The plate F is shown in section, disclosing the space behind it. A few of the bunch L of leads from the various sections of the different secondaries are shown connected to the various contacts of the switches. The dial-switch W of Figs. 1 and 2 has a large number of contacts adapted to control the lighting-circuit, which requires closer regulation than the power-circuits. There are two switches W′ and W^2, Fig. 3, mounted on the lower part of the face-plate F and separated from each other by an insulating-barrier B. The switch W′ controls a railway converter-circuit and the switch W^2 controls a non-grounded power-circuit for induction-motors or the like. In Figs. 1 and 2 only half the number of leads is shown extending from the lower part of the plate F. Of these the two lettered T S′ are the terminals of the converter-circuit leading from the switch W′, and the third, T S^3, is one terminal of the lighting-circuit leading from the switch W.

The invention is best shown in Fig. 3, which is an end view of the coils alone, as partially shown in Fig. 2, but with all other parts removed except the connections, which are shown in diagram. The primaries P are bunched in two groups of three sections, each of the sections being connected in series by the connections C and the end sections being connected with the leads T P to the transformer. There are three secondaries in this transformer, as above noted. The central switch W and its different contacts are connected to different portions of a secondary S^3, which is adapted to supply a lighting-circuit with a potential of about two thousand four hundred volts. This winding is divided into two sections, one of which is located to the left of the left-hand group of primaries and the other of which is located at the right of the right-hand group of primaries, so that there is equal reactance between the primaries and each section of this secondary. The left-hand switch W′ controls a secondary S′, which may be connected to a converter-circuit and adapted to supply potential thereto of from three hundred to four hundred volts. One section of the secondary S′ is located at the extreme left in Fig. 3 and farther removed from the primary P than the section of the secondary S^3, which is located immediately to the right of the section of S′. Another section of the secondary S′ is located just to the right of the left-hand group of primaries P. Hence the secondary S′ as a whole is farther removed from the primary than the lighting-secondary S^3 as a whole, and therefore there is greater reactance between the primary and the power secondary than there is between the primary and the lighting secondary.

The arrangement described is that embodied in a commercially-operative transformer which has a difference in reactance between the two windings just described of about twenty-five per cent. This difference can be increased, if desired, by so intermixing the windings to a greater degree that the distance between the primary and the power secondary as a whole is still further increased with respect to the distance between the primary and the lighting secondary as a whole. Such a result could be obtained, for example, if the two sections between the primary groups were connected to the secondary S^3 and the two sections, one on each end, constituted the power secondary. The result obtained is not only a positive advantage to the automatic regulation of the lighting-circuit, but inasmuch as the power-circuit in this case is connected to a converter the increased reactance between the primary and the power-circuit is of great advantage with respect to the regulation of the rotary. In fact, if this excessive reactance were not obtained in this manner it would be advisable to insert some artificial reactance in the converter-circuit. It is apparent that the above result is accomplished with a minimum intermixing of the windings and consequent saving in the valuable space which would otherwise be filled with insulation between the sections.

The means for regulating the lighting-circuit S^3 will now be described.

The switch-piece W is provided with a contact end 1, which is connected to a corresponding terminal of a portion of the section S^3 which is located at the left of the left-hand primary group. The contact T S^3 is also provided for another portion of the same section and is connected to the left-hand lead T S^3, which is connected to one terminal of the lighting-circuit. Other contacts 8 to 12 are also provided on the same section to divide up the section into parts of varying size, which are cut in and out of circuit by the movement of the switch W along the corresponding contacts 8 to 12 of the dial. Finally, a contact 23 is provided for the same section, and a lead D connects this contact with a contact 24 on the section of the secondary S^3 which is located at the right of the right-hand primary group. A contact T S^3 is provided on the same section, which contact is connected with the right-hand lead T S^3 which is connected to the other terminal of the lighting-circuit. The same section S^3 is provided also with contacts 2 to 7, which divide the section into portions of varying size and which are connected to the corresponding contacts 2 to 7 of the dial-switch. When the switch W is revolved, a portion of the turns of one of the sections of the secondary S^3 will be cut out, and then in addition a portion of the turns of the other section will be cut out, so that there will at no time be a great difference between the reactance between the primary and one section and the reactance between the primary and the other section. The turns of the secondary as a whole are thus cut out symmetrically and excessive leakage flux is avoided.

The secondary S', which is adapted to be connected to a converter, is regulated by the switch W', the movement of which over the switch-contacts 13, 14, and 15 cuts out portions of the turns of the section at the extreme left. The switch W' is connected to one lead T S' of the converter-circuit, while the other lead T S' is taken from a point T S' on the section located at the right of the left-hand group of primaries. The regulation of this secondary S' is not required to be as close as that of the lighting secondary S^3. The number of turns which are cut out is at no time very great, and hence it is not necessary to employ the method used in regulating the lighting secondary S^3. Furthermore, since few turns of the left-hand sections of the secondary S' are ever cut out, there is consequently little change in the reactance between such left-hand section and the left-hand section of the secondary S^3. The symmetrical regulation of the secondary S^3, in addition to preventing excessive leakage flux between the primary and the lighting secondary, prevents excessive leakage flux between the primary and the adjoining power secondary. As the power-circuit does not require as close regulation, the cutting out of the turns of the lighting secondary section does not seriously affect it, and, in fact, its regulation is benefited by the uniform minimum reactance between the lighting secondary and the primary.

In the transformer shown a third secondary S^2 is embodied in substantially the same manner as the power secondary already described. This secondary is adapted to supply another power-circuit, such as induction-motors or converters for general work on an ungrounded circuit. This third secondary may supply substantially the same potential as the other power secondary, dependent on the number of ampere-turns, as the arrangement is the same as the other secondary with respect to the primary. This third secondary is controlled by the switch W^2, which is connected to a work-circuit lead T S^2 and is moved over the contacts 16, 17, and 18, which are connected to corresponding contacts 16, 17, and 18 on the extreme right-hand section. The other work-circuit lead T S^2 is taken from a point T S^2 on the section S^2 which is located at the left of the right-hand group of primary sections. These two sections of the secondary S^2 are connected by a wire G, leading to terminals 21 and 22 of the respective sections.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. A transformer which has a plurality of secondary windings adapted for supplying work-circuits of different characters, one of which circuits requires a sensitive regulation and hence good inductive effect and low reactance between its secondary and the primary, and the regulation of the other of which circuits may be benefited or at least not badly affected by higher reactances; the primary and secondary windings being divided into sections which are so intermixed that there is a low reactance between the primary and one secondary, but a correspondingly-increased reactance between the primary and another secondary.

2. A transformer which has a plurality of

secondary windings adapted to be connected to independent work-circuits, the primary and secondary windings being divided into sections which are intermixed to obtain the desired inductive effect and reactive drop between the primary and the respective secondaries.

3. A transformer which has a secondary adapted to be connected to a lighting-circuit, and a secondary adapted to be connected to a power-circuit, the primary and secondary windings being divided into sections which are intermixed so as to produce a low reactance between the primary and the lighting secondary, and a correspondingly-increased reactance between the primary and the power secondary.

4. A transformer which has a secondary adapted to be connected to a lighting-circuit, and two secondaries adapted to be connected to two power-circuits respectively, the primary and the secondaries being divided into sections which are intermixed to produce a low reactance between the primary and the lighting-circuit, and a correspondingly-increased reactance between the primary and the power secondaries.

5. A transformer which has a secondary which is adapted to be connected to a lighting-circuit, and a secondary which is adapted to be connected to a power-circuit, the primary and both secondaries being divided into sections which are intermixed to obtain a minimum reactance between the primary and the sections of the lighting secondary, at the expense of a correspondingly-increased reactance between the primary and the sections of the power secondary.

6. A transformer which has a secondary which is adapted to be connected to a lighting-circuit, and a secondary which is adapted to be connected to a power-circuit, the secondaries being divided into sections and so arranged with respect to the primary that the lighting secondary as a whole is in better inductive relation with respect to the primary than the power secondary as a whole.

7. A transformer which has its primary divided into sections which are connected in series and arranged in two groups, of a secondary which is adapted to be connected to a lighting-circuit and is divided into two connected sections, each of which sections is located outside of a group of primaries; a secondary which is adapted to be connected to a power-circuit and is divided into two sections, one of which is located between the primary groups and the other of which is located outside of one section of the lighting secondary; and a secondary which is adapted to be connected to another power-circuit and is divided into two sections, one of which is located between the primary groups and the other of which is located outside of the other section of the lighting secondary.

8. A transformer which has its secondary divided into sections which are located in different positions with respect to the primary, so as to obtain the desired inductive effect, said sections being subdivided, whereby portions of all the sections can be cut in and out, thus causing a minimum leakage flux between the primary and each subdivided secondary section.

9. A transformer which has its secondary divided into sections which are intermixed with the primary to obtain the desired inductive effect, leads from different portions of each of a plurality of secondary sections, and a switch coöperating with said leads to cut out portions of each of said sections.

10. A transformer which has a secondary adapted to be connected to a lighting-circuit requiring sensitive regulation; and a secondary adapted to be connected to a power-circuit; the primary and both secondaries being divided into sections which are so intermixed as to obtain a lower reactance between the lighting secondary and the primary than between the power secondary and the primary; different sections of the lighting secondary being subdivided and provided with leads from the divided portions, whereby the turns of the different sections can be cut out symmetrically with respect to the whole lighting secondary.

11. A transformer which has a plurality of secondary windings adapted for supplying work-circuits of different characters; one of which circuits is not self-regulable and hence requires good inductive effects and low reactance in the transformer; and another of which circuits is self-regulable; the primary and different secondary windings being divided into sections which are so intermixed that there is a low reactance between the primary and one secondary, and a correspondingly-increased reactance between the primary and another secondary.

In witness whereof I have hereunto set my hand this 21st day of February, 1901.

WALTER S. MOODY.

Witnesses:
BENJAMIN B. HULL,
EDWARD WILLIAMS, Jr.