July 29, 1930. R. STROHSCHNEIDER 1,771,551

ADJUSTABLE TRANSFORMER

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Fig. 9.

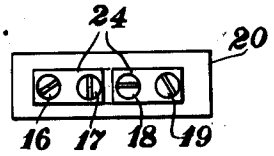


Fig. 10.

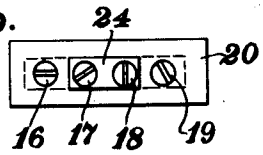


Fig. 3.

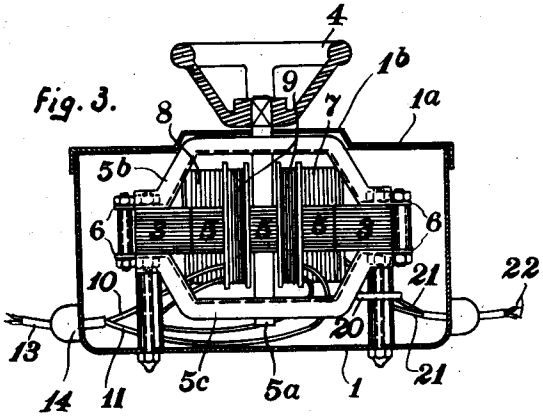


Fig. 2.

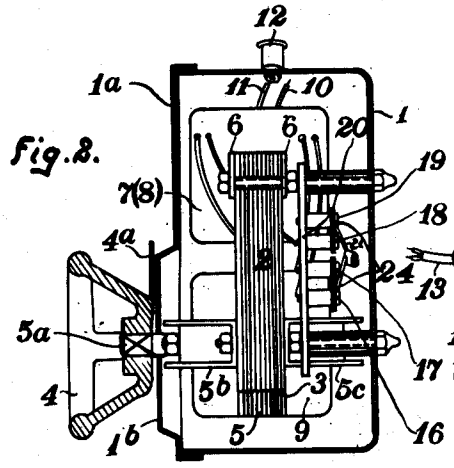


Fig. 1.

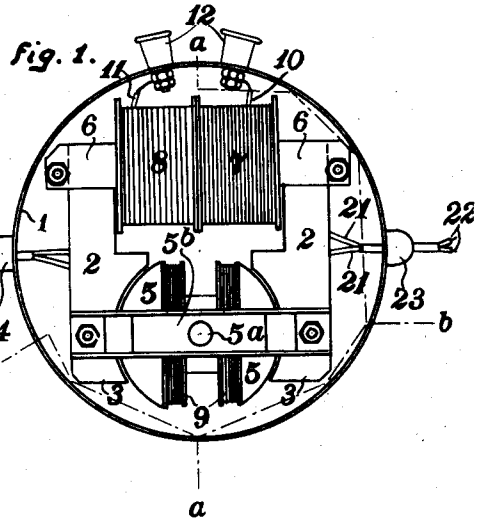


Fig. 4.

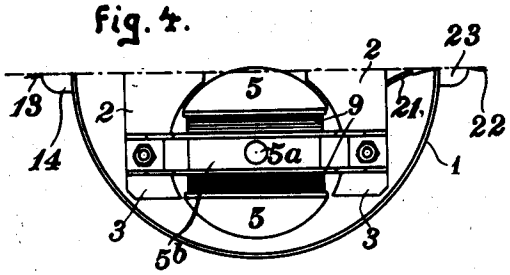
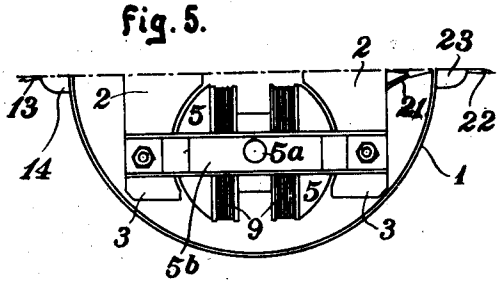


Fig. 5.



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Fig. 6.

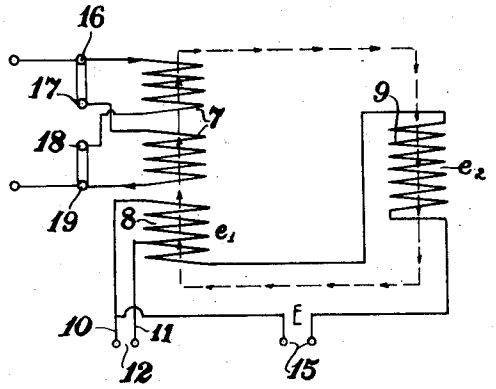


Fig. 7.

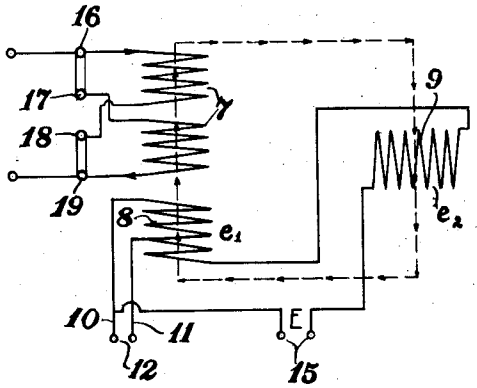
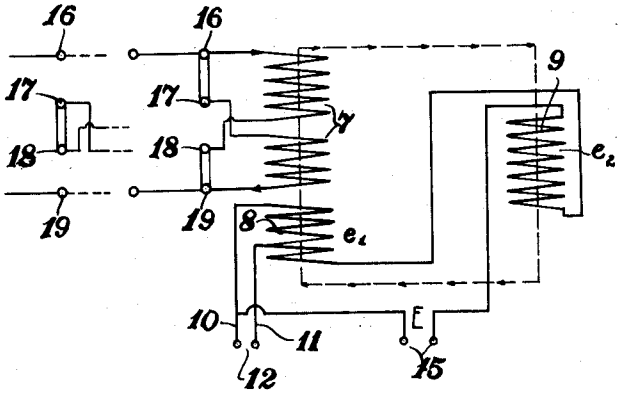


Fig. 8.



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UNITED STATES PATENT OFFICE

ROBERT STROHSCHNEIDER, OF NUREMBERG, GERMANY

ADJUSTABLE TRANSFORMER

Application filed April 26, 1928, Serial No. 273,094, and in Germany February 24, 1927.

This invention relates to an adjustable transformer more particularly for low voltage apparatus which require a variable voltage supply, such as for instance electric toys, machines of small size, or the like.

Hitherto, in order to obtain a variable voltage, the secondary winding of the transformer has been tapped so as to supply the required voltage, and the tapping points have been connected to corresponding contacts used in conjunction with a sliding arm. This arrangement has the great disadvantage that the tappings themselves cannot be constructed in such a manner as to prevent a short-circuit. There is always a danger of a short-circuit in the case of open contacts which lie next to one another. It is not possible to insulate by simple means the tapping contacts whilst avoiding an interruption of the current if it is desired to ensure permanent reliable operation of the transformer when the same is operated by an inexperienced person.

A second arrangement, which is just as unsatisfactory, consists in this that an adjustable resistance is connected to a transformer having a fixed ratio of transformation, which resistance varies the voltage whilst consuming electric energy. This arrangement has in addition to the disadvantage that energy is uselessly consumed, the great disadvantage that the resistance becomes very hot and that the person in charge of the apparatus may thereby suffer.

The object of the invention is to provide an adjustable transformer in which these disadvantages are avoided.

The invention consists in this that the secondary of the transformer consists of two windings connected in series with one another, one of the windings being mounted on the stationary core of the primary winding, whilst the other winding is mounted on a rotatable core (armature). By thus arranging the secondary winding, the current in the primary winding is transformed in the stationary part of the secondary winding to a desired voltage. In addition thereto, a definite voltage is induced in the rotary part of the secondary winding. By rotating the armature, the voltage induced in the rotary part of the secondary winding can be varied from a positive maximum value to nil and from nil to a negative maximum, that is to say, a change in the voltage and in the direction of the current can be obtained by induction. These values of the voltage combine as regards their values and direction with the voltage which is induced in the fixed part of the secondary winding.

By rotating the rotary armature, it is thus possible to obtain directly within predetermined limits the voltages which are required. The desired steps can be obtained entirely without any interruption and in a manner which is ideal. The advantages of such a transformer consist in this that it can be constructed by simple means in such a way as to avoid any possibility of short-circuiting, that no energies are uselessly consumed and that no heating takes place, and further, that in consequence of the absence of any heating paths and other parts which are subjected to wear, it can be constructed so as to be very robust, self-contained, and very reliable in its operation.

One mode of carrying the invention into effect is illustrated by way of example in the accompanying drawings, in which:

Figure 1 is a plan view of a transformer built in a casing, the lid of the latter and the controlling wheel being removed,

Figure 2 shows a transformer in section along the line *a*—*a* in Figure 1,

Figure 3 shows a transformer in section along the line *b*—*b* in Figure 1, as seen in the direction of the arrow A,

Figure 4 shows a portion of Figure 1, viz, the rotary part of the transformer wherein the armature carrying a portion of the secondary winding is turned through an angle of 90° with respect to the position illustrated in Figure 1.

Figure 5 is a part view of the transformer similar to Figure 4 with that difference that the armature has been turned through an angle of 180° with respect to the position illustrated in Figure 1.

Figures 6, 7 and 8 are diagrams intended to explain the electric transformer phenomena and the values of the voltages for dif-

ferent positions of the armature, the diagram illustrated in Figure 6 corresponding to the armature position shown in Figure 1, the diagram in Figure 7 corresponding to the armature position shown in Figure 4, and the diagram in Figure 8 corresponding to the armature position illustrated in Figure 5.

Figures 9 and 10 show the connecting plate by which the ends of the subdivided primary winding are connected together.

Referring the the drawings, 1 is a cylindrical casing in which there is mounted a U-shaped iron core 2, the poles 3 of which surround an armature 5 arranged to be rotated by a hand-wheel 4, the connecting part 6 of which core carries a primary winding 7 and a fixed secondary winding 8. The casing 1 is closed by a lid 1^a, the projecting part 1^b of which is traversed by the spindle 5^a of the armature, the hand-wheel 4 being mounted on the said spindle. The armature spindle 5^a is mounted in stirrup-like bearings 5^b and 5^c which connect together the two poles 3 of the iron core. The hand-wheel 4 is provided with an index 4^a adapted to move along a graduated scale. The core 5 carries a winding 9 which is connected in series with the stationary secondary winding 8. Further, the stationary secondary winding 8 has two tappings 10 and 11 which are respectively connected to two contact sockets mounted in an insulated manner on the casing 1. The ends of the two parts of the secondary winding 8, 9, are assembled together to a single strand 13 and leave the casing 1 through a socket 14. The strand 13 leads to a contact plug 15 (Figs. 6, 7, and 8). The primary coil 7 is also divided into two parts and the ends thereof are connected to the terminals 16 and 18, 17 and 19 of a connecting plate 20 (Figs. 9 and 10). The leads 21 coming from the supply circuit 22 (Fig. 2), after passing through a socket 23 provided in the casing 1, are connected to the terminals 16 and 19. The terminals 16, 17, 18 and 19 are connected together by a continuous lead strip 24 (Figs. 9 and 10) before the transformer is sent out from the factory. The two parts of the primary winding can thus be connected together in series or parallel, by the user, by removing a portion or portions of the lead strip 24 or simply severing the lead strip, as hereinafter described.

The operation of the transformer is as follows:

Let us assume that the rails of a toy railway are supplied with alternating current, the voltage of which has to be regulated between 6 and 24 volts. Let us also assume that the manufacturer of the transformer has to take into consideration that the supply circuit of some of his consumers has a voltage of 110 volts and of other consumers 220 volts.

If the purchaser desires to connect the transformer to a supply circuit of 110 volts, then that portion of the connecting strip of lead 24, which connects the terminals 17 and 18 together is removed or severed (Fig. 9), whereby the two parts of the primary coil are connected in parallel with one another (Figs. 6 and 7). If the transformer is to be connected to a supply circuit of 220 volts, the strips of lead between the terminals 16 and 17 on the one hand and 18 and 19 on the other hand are removed or severed (Fig. 10), whereby the two parts of the primary coil are connected in series with one another, as shown to the left of Figure 8.

When the transformer is connected to the supply circuit, a magnetic flux passes through it, as is indicated by the rectangles illustrated in the dotted lines in Figures 6, 7 and 8, the strength of the flux corresponding to the calculated output of the transformer. This magnetic flux induces in the fixed secondary coil 8 a voltage of $e_1=15$ volts. It also induces in the armature coil 9 an electromotive force $e_2=9$ volts, which has the same direction as the electromotive force produced in the stationary coil 8 when the armature assumes the position illustrated in Figures 1 and 6. However, the voltage E at the terminals 15 corresponds to the sum of the voltages e_1 plus e_2 in the two windings 8 and 9, that is to say 15 plus 9 volts=24 volts. In this position the voltage at the terminals 15 is equal to the sum of the voltages induced in all the windings of the coils 8 and 9.

By turning the armature 5, the turns of the armature coil 9 are gradually removed in a sliding manner from the inductive action, so that when the armature reaches the position illustrated in Figures 4 and 7, the inductive effect on the turns of the coil 9 is nil, and thus the total voltage E at the terminals 15 gradually drops from 24 volts to 15 volts.

By further turning the armature 5, the turns of the armature coil 9 are again brought into the zone of the inductive action but now the electromotive force which is induced in the coil 9 is in opposite direction to the electromotive force in the fixed coil 8 and therefore the voltage at the terminals 15 is equal to the difference between the voltages in the fixed coil 8 and the armature coil 9. The voltage difference E reaches its maximum value when the armature assumes the position illustrated in Figures 5 and 8. In this case, the whole of the electromotive force induced in the armature coil 9 is in opposite direction to the electromotive force in the coil 8, so that in this position the voltage E at the terminals 15 is equal to 15 volts minus 9 volts, that is to say, 6 volts.

In all these cases the magnetic flux remains quite constant as regards its output; the same is neither choked nor destroyed and therefore it is possible to obtain the whole

transformer output irrespective of its position. Consequently the efficiency of the transformer is exceedingly high and such as could not hitherto be obtained. By this arrangement the voltage steps can be regulated within any desired limits and with the smallest difference between the various steps.

Constant voltages may also be derived from the apparatus up to the voltage supplied by the stationary coils, and even higher voltages if separate additional windings are provided for the purpose of supplying current to lighting installations provided on the train of an electrically driven toy railway.

Owing to its fine regulation, the transformer is also very useful for laboratory purposes.

What I claim is:

1. An adjustable transformer comprising the combination with an open magnetic core and a primary winding on said core of a magnetic armature arranged so as to be capable of closing said magnetic core, a two part secondary winding comprising a coil on the magnetic core and a coil on said armature connected in series with the coil on the magnetic core, said secondary winding being adapted to co-operate with the primary winding so as to produce a secondary output voltage equal to the algebraic sum of the voltages induced in the two coils, said armature being rotatable through at least 180° so as to enable the voltage induced in the movable coil of the secondary winding to be varied continuously from a maximum value acting in the same direction as the voltage induced in the coil mounted on the magnetic core to a maximum value acting in opposition to the voltage induced in the latter coil, as and for the purposes set forth.

2. An adjustable transformer comprising the combination with a U-shaped magnetic core and a primary winding on said core, of stirrup-like bearings mounted on said core so as to connect the limbs of the core, a spindle rotatable in said bearings, a magnetic armature on said spindle arranged between the poles of the magnetic core so as to be capable of closing said core, a two part secondary winding comprising a coil on the magnetic core and a coil on said armature connected in series with the coil on the magnetic core, said secondary winding being adapted to co-operate with the primary winding so as to produce a secondary output voltage equal to the algebraic sum of the voltages induced in the two coils and a casing enclosing the transformer and having a removable lid, as and for the purposes set forth.

3. A transformer comprising the combination with a magnetic core and a secondary winding thereon, of a divided primary winding comprising two parts having the four ends thereof arranged in sequence and a strip of lead capable of being readily severed attached to said ends so as to connect all four ends together and when severed in the middle serves to connect the adjacent ends together in pairs so as to connect the two parts of the primary winding in parallel and when severed between the ends of each pair serves to connect the two parts of the primary winding in series.

In testimony whereof I have signed my name to this specification.

ROBERT STROHSCHNEIDER.