Jan. 1, 1929.

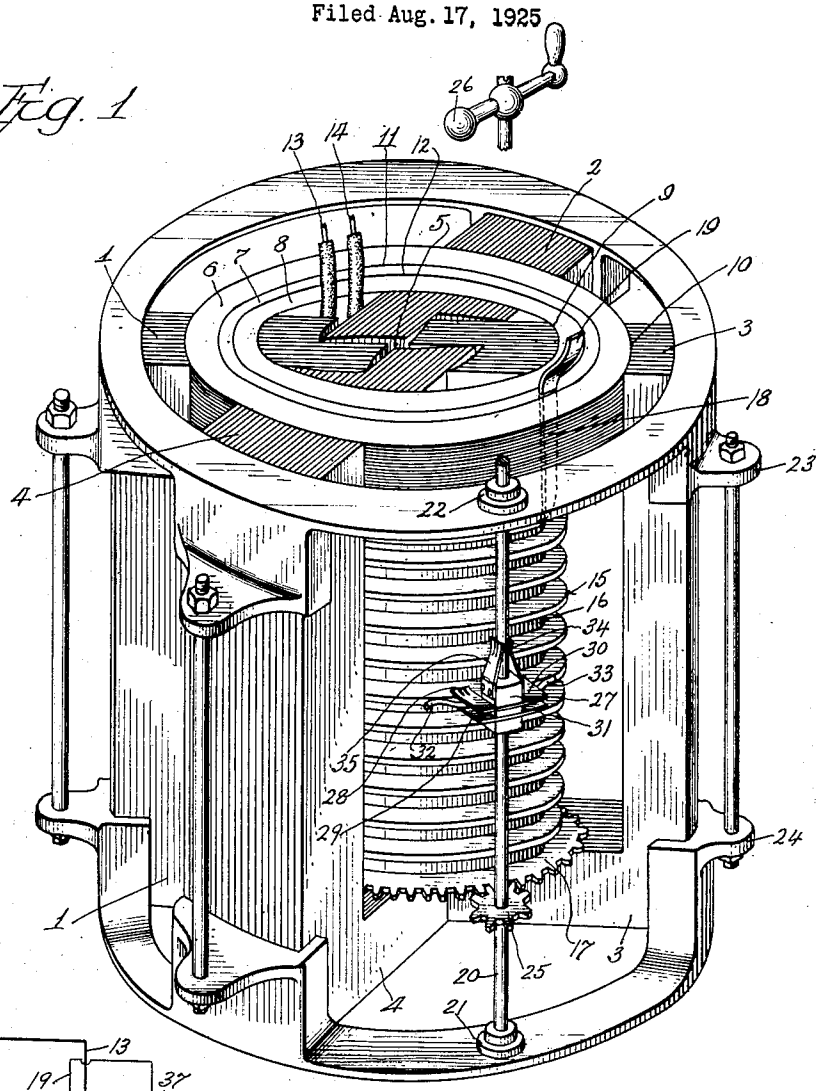
1,696,964

M. MORRISON

TRANSFORMER DEVICE

Filed Aug. 17, 1925

Fig. 1



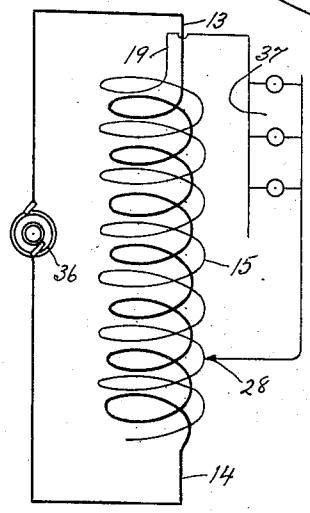


Fig. 2

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UNITED STATES PATENT OFFICE.

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TRANSFORMER DEVICE.

Application filed August 17, 1925. Serial No. 50,718.

My present invention relates to improvements in devices for voltage regulation and especially to those devices of a class commonly called voltage regulators, the functions of which in the electrical field are well-known and understood by those familiar with the art.

Among the objects of my present invention are: first, to provide a useful voltage regulator which can be constructed for a fraction of the cost of its kilo-volt-ampere rated equivalent in practical present day regulators; second, to provide a simple practical regulator suitable to replace the pole type regulator and which is more compact, much less expensive to construct and operate and having more suitable electrical characteristics than its predecessors; third, to provide a voltage regulator which has a minimum phase angle between the primary and secondary voltages for any percentage of voltage regulation and at any load; fourth, to provide a voltage regulator with a higher electrical efficiency than the practical regulators of the prior art. Further and other objects will appear from the specification and drawings of this application, but my invention will be most particularly characterized by the claims hereof.

In the drawing, Fig. 1 is a perspective view of a simple form of my regulator which has been removed from its case, and Fig. 2 is a simple form of circuit which I may use with this regulator.

The circuit, shown in Fig. 2 is not the preferred form in all cases, as in particular embodiments an autotransformer connection between the primary and secondary is employed as this increases the material-economy in my apparatus considerably and, therefore, in the specification and claims the term "primary" or "secondary" means that part of the circuit acting as a primary or as a secondary and in the light of the above may mean partly or wholly the same circuit.

I am aware that prior attempts have been made to build induction regulator substitutes by constructions which, on their face, appear to be strikingly similar to that hereinafter described, but upon investigation will be found to lack the essential element of my invention, as will be pointed out.

In the prior art attempts to construct induction voltage regulator substitutes have been made by employing simple transformer cores with conductor helices mounted upon them to act as secondaries, and these helices have been revolved about their axes, but the effort in these attempts to produce regulators has failed to result in anything practical because of the fact that no successful method has been discovered for taking care of the non-variable end of the helices. One end of the helix has a sliding brush upon it and the other end has to have a continuous connection to it, and the lack of a successful means of providing a practical continuous connection with this latter mentioned end is responsible for the failure of these devices.

Short-circuited slip rings and the like are entirely impractical as they introduce a variable resistance in the circuit which has to be compensated for by inserting an additional resistance in the circuit, and the losses, voltage drop and other inherent undesirable characteristics of this construction make the device very inefficient and ineffective as a practical regulator. In some cases the regulator constructed by this principle might in reality, due to temperature distribution in the resistors, show a decreased voltage by turning it in a direction to give it increased voltage, to say nothing of the many other disadvantageous operating characteristics of such devices.

Referring to Fig. 1 of the drawings, 1, 2, 3 and 4 comprise the wings of a distributed core transformer as will be recognized by those familiar with the art. At 5 is the central part of the core which extends through the windings, hereinafter described, in the common way ordinarily employed in the art.

The substance or essence of my present invention lies in the means that I employ for taking care of the non-variable end or ends of the conductor or conductors in my rotatable circuit, and I have discovered that in order to produce a practical operative regulator of this type, it is necessary to bring one or more of the movable electrical conductors through the magnetic field in a manner whereby the said conductor cuts the magnetic circuit such that the total magnetic flux, between the non-variable end of the helix after it is brought through the field and the brush point on the said helix, is continuously increased or decreased depending upon the direction of the rotation of the said helix.

This is contrasted with the regulators in

the prior art of this type by the fact that none of their conductors cut the magnetic circuit. Further and other differentiating characteristics will be set up in the claims.

Instead of the iron core of the regulator being a multiplicity of continuous lapped-joint circuits as commonly employed in related devices of the prior art, I interpose an interruption in the magnetic circuit and bring one or more of the electrical conductors through at the surface of interruption of the magnetic circuit. This core and conductor arrangement may be constructed in many different ways, one of which may consist of three concentric hollow cylindrical elements, 6, 7 and 8, Fig. 1. These three parts are built up of a series of concentric circular punchings, the laminæ of which are by necessity located in planes at right angles to the laminæ of core parts 1, 2, 3 and 4, but the short-circuiting of any eddy currents at the butt of the joints, such as at 9 and 10, is obviated by the grinding to accurate fits of the adjacent surfaces of the joints and then insulating them with very thin but effective material.

It will be appreciated that due to the fact that this invention is to replace a very expensive and comparatively electrically inefficient piece of apparatus, great margins of electrical labor and material economy are afforded so that the joints, such as those located at 9 and 10, are not necessarily worked at the magnetic density of a distribution transformer, but at a much lower value and, therefore, by providing low magnetic density, ground fits and insulating material at these points, high eddy current losses and high exciting currents are not introduced at these locations in the magnetic circuit.

Since the concentric cylindrical parts 6, 7 and 8 are not necessarily long with respect to their geometrical axis, they may be ground to fit unusually close at the boundary surfaces of their joints 11 and 12.

It is desired to specifically point out that the concentric circular part 7 may be omitted in the case of the very small and inexpensive regulators and an air gap employed in its place. This avoids the grinding of the adjacent surfaces of parts 6 and 8, further lessening the expense of my device. In an embodiment omitting part 7, I usually increase the geometric-axial dimension of 7 and 8, reducing the air gap density which would otherwise be at 7.

In the present embodiment, the central part of the core 5 is wound with a stationary primary coil mounted upon the core, the ends of which coil are indicated by leads 13 and 14, Figs. 1 and 2, the coil being a continuous conductor between these two ends, as illustrated in the latter figure.

Concentric with this aforesaid primary coil is a secondary coil 15, Figs. 1 and 2. This coil is composed principally of a flat copper strip which is wound edgewise in helical form and separated by a helical strip of insulating material 16, as illustrated in Fig. 1. About one-half of the copper strip 15 is exposed externally such that satisfactory electrical contact may be made with it, as will be hereinafter described.

These two helices 15 and 16 are fixed together integrally and may be rotated about their geometrical axis, which axis is the same as that of the internal core part 5. The integral structure composed principally of 15 and 16 is insulated from the primary winding of the device and from the core by suitable insulating material.

The lower end of this rotatable structure has mounted upon it a gear wheel 17 which is fixed to move with the said structure and such as to drive it rotatably about this aforementioned geometrical axis. This gear wheel is preferably made of insulating material though a metallic wheel may be used if split such as to not form a short circuit about the magnetic field. In this case, certain other precautions have to be taken into consideration which are merely points of mechanical skill and do not enter into the invention proper.

The lower end of helix 15, as illustrated in Figs. 1 and 2, is free and the upper end of the said helix is brought out from the internal coil proper 15, through the field of the magnetic circuit at 18 and into a clear field external of the magnetic circuit as illustrated at 19. This terminal 19 may be as heretofore inferred brought out through a closely fitting solid concentric cylindrical part 7, or the part 7 may be removed from the device. In either case, the terminal 19 in the present embodiment travels around in a cylindrical path between parts 6 and 8 and coaxial with the helix, if it be rotated, as will be understood by those familiar with the art.

The shaft 20 is provided with insulator-bearings 21 and 22 such that the shaft 20 may revolve about its axis, at the same time being electrically insulated from core clamps 23 and 24 which serve to hold the magnetic core-structure together and preserve the air gap relations heretofore described.

Onto shaft 20 is fixed a pinion 25 which rotates with the said shaft and is engaged with the gear wheel 17 such that when the shaft 20 is rotated the helix 15 and the other parts integral therewith rotate about the geometrical axis of the said helix. A suitable driving means such as 26 may be employed to turn the shaft 20.

Upon shaft 20 is mounted a block structure 27 which resembles a bearing in operation in that part 27 is free to slide axially upon the shaft 20, and further the said shaft

is free to rotate within the said block without necessarily disturbing its angular position. Upon block 27 is mounted four parts, 28, 29, 30 and 31, which resemble switch clips in appearance and make contact upon the upper and lower plane surfaces of the helix 15. Parts 28 and 29 are formed such as to cause them to tend to press together, giving good electrical contact upon the aforesaid plane surfaces. The clips 28 and 29 and the clips 30 and 31 have the helix 15 clasped between them like the blade in a closed knife switch. Block 27 is further provided with guides 32 and 33 which hold the aforesaid clips in their proper position and further prevent the block and its integral parts from rotating with the shaft 20, when it is revolved. Positive electrical contact between clips 28 and the shaft 20 is maintained by additional spring contacts 34 and 35 or, in some cases a flexible lead is provided instead of these latter mentioned clips 34 and 35. In the former case, electrical contact with the helix is made by connecting to shaft 20, and in the latter case connecting directly to block 27.

As the shaft 20 is turned, the helix 15 is revolved with it as will be appreciated from the foregoing explanation, and the block 27 is prevented from rotating but allowed to slide along the shaft in the direction of its axis. The switch clips 28, 29, 30 and 31 form a nut with the lead of the helix as a thread and, therefore, the block 27 and the sliding contacts and other parts integral with it move along continuously in contact with the helix, increasing or decreasing the total linear conductor in circuit between the point of contact of the said switch clips and the terminal 19. The magnetic reluctance between core parts 7 and 8 is arranged such that it is as nearly constant circumferentially as possible so that the normal radial distribution of the magnetic flux between these parts is substantially uniform. This, it will be appreciated, is one of the reasons for interposing these parts between the central core member 5 and the outer wings 1, 2, 3 and 4, for, as will be appreciated by those familiar with the art, the parts 6, 7 and 8 may be entirely removed from the core without completely destroying the inoperativeness of my device though greatly impairing it, as will be more fully appreciated from what appears elsewhere in this specification.

With a fairly constant radial magnetic field between parts 6 and 8, it will be appreciated that the electrical conductor terminal 19, as it revolves in the path in which it is constrained to move, cuts the field of magnetic force within its path such that the total magnetic-flux-turns included between the point of contact of the contactors at 27 and the terminal 19 is continuously increased or decreased by the revolution of the shaft 20 when the device is properly connected up in suitable circuits such as illustrated in Fig. 2, in which 36 is a source of electric potential for supplying the primary of the device with energy, forming a complete primary circuit. The secondary circuit is formed by secondary helix 15 through terminal 19 to a suitable load 37, to a switch-clip point of contact 28, to the helix 15, thus completing the secondary circuit.

Having fully described one embodiment of my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a transformer, a core of magnetic material and a winding thereupon, one terminal conductor of which is brought through the magnetic field of the said core whereby one effective turn of said winding is caused to embrace less than the total flux of the said core.

2. In a transformer, a core of magnetic material and an electrical winding thereupon, one terminal conductor of which is brought through the material of the said core whereby one effective turn of said winding is caused to embrace less than the total flux of the said core.

3. In a transformer, a core of magnetic material and an electrical winding thereupon, one terminal conductor of which is brought through an air gap in the magnetic circuit of the said core whereby one effective turn of said winding is caused to embrace less than the total flux of the said core.

4. In a transformer, a core of magnetic material and a winding thereupon, the electrical circuit of which has one lead-conductor brought through the magnetic field of said core and one lead-conductor brought out free from the influence of said field whereby one effective turn of said winding is caused to embrace less than the total flux of the said core.

5. A transformer device having a core provided with an interruption in its magnetic circuit, a primary circuit disposed about said core, a secondary circuit mounted fixedly-concentric but axially-rotatable about said primary circuit, and a secondary terminal passing through said interruption and rotatable about the axis of the said core.

6. In a transformer, a core of magnetic material, a helical winding embracing the magnetic field of said core, and a terminal for said winding cutting the said field whereby one effective turn of said winding is caused to embrace less than the total flux of the said core.

7. In a transformer, a core of magnetic material having an air gap therein, a winding embracing said core and rotatable thereupon, means for making electrical contact with different portions of said winding and a terminal conductor fixed to said winding,

adapted to rotate therewith, and in said gap in the said core.

8. A transformer device having a core provided with an interruption in the magnetic circuit thereof and rotatable electrical winding thereon, a terminal for said winding which is brought through the magnetic circuit of said core, said terminal and said winding being rotatable with respect to the axis of the said core, a brush adapted to move longitudinally with said axis to contact with any given circumferential location on said winding uninterruptedly, said contact forming a movable second terminal for said winding.

9. In a voltage regulator comprising a core of magnetic material and a winding thereupon rotatable about the axis upon which it is wound, means for rotating said winding, said winding having a major portion embracing said core and a minor portion cutting the path of the magnetic field of said core when rotated.

10. In an induction apparatus, a core of magnetic material having an interruption in the magnetic circuit thereof, and a rotatable electrical winding thereabout, a part of said winding having a constant volt-per-turn ratio for any rotated position of said winding and a part of aforesaid winding having a volt-per-turn ratio dependent upon the position to which said winding is rotated.

August 14, 1925.

MONTFORD MORRISON.