No. 620,365. Patented Feb. 28, 1899.

N. ROWE.

MEANS FOR AND METHOD OF ELECTROMOTIVE FORCE REGULATION.

(Application filed Jan. 27, 1898.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1.

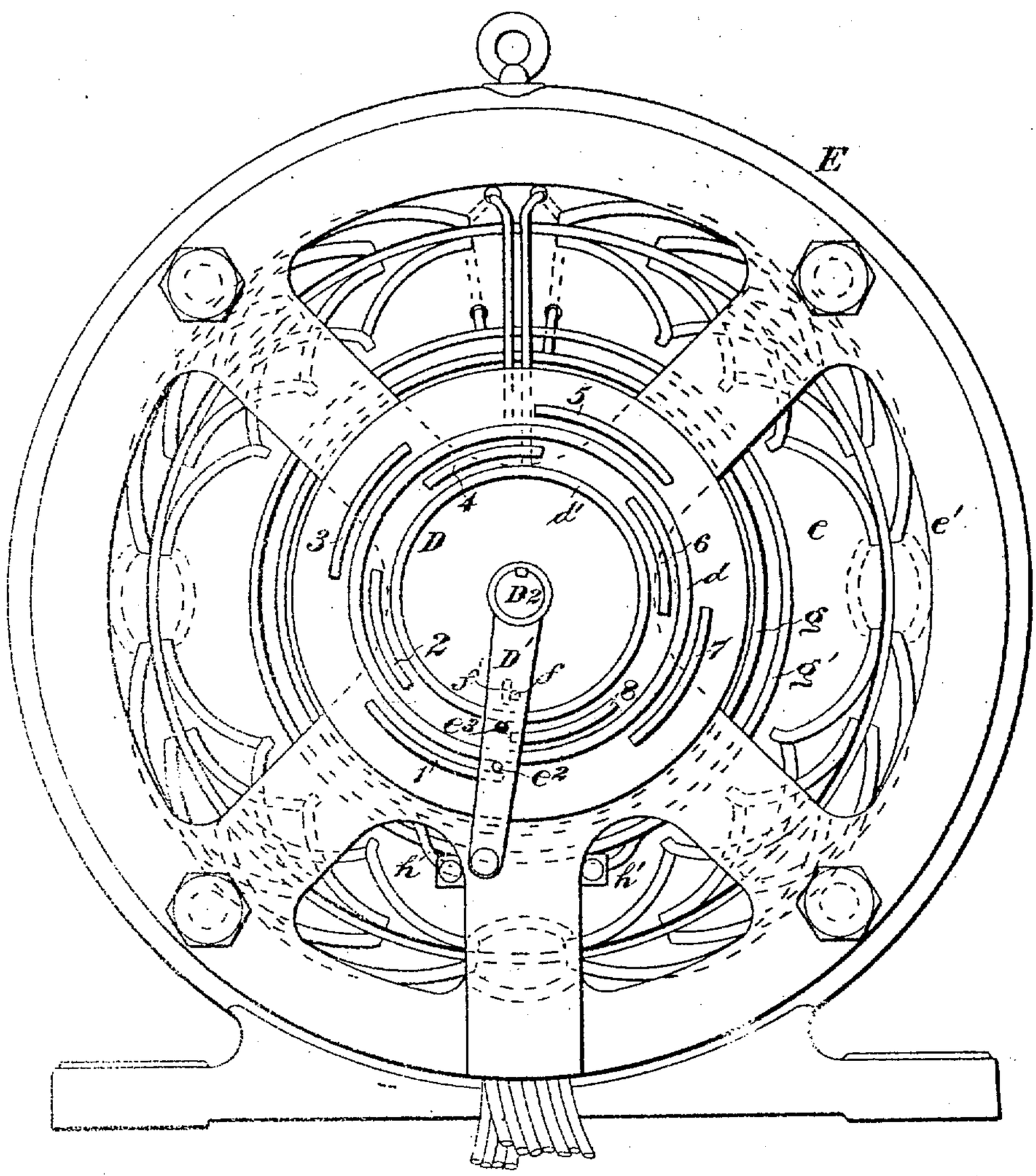

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Fig. 2.

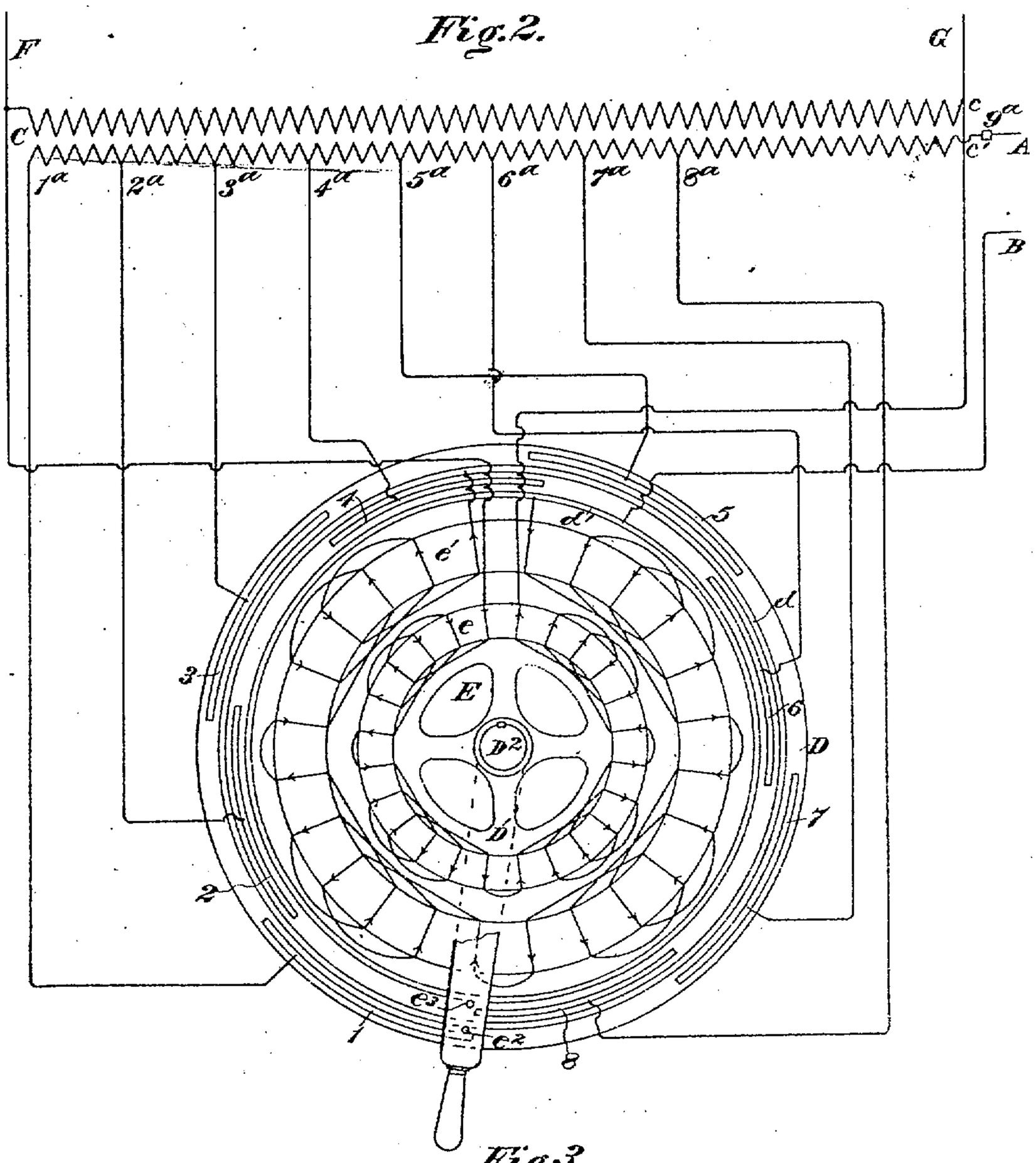
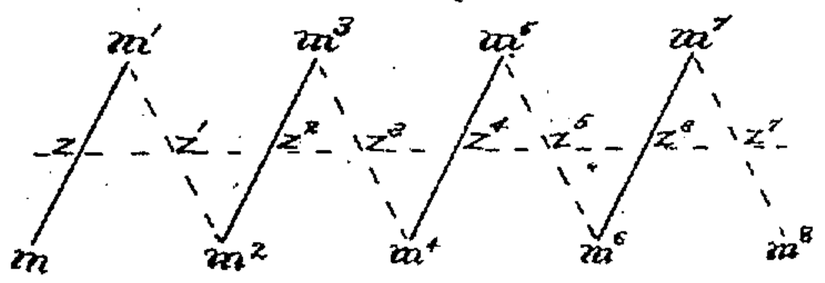


Fig. 3.



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MEANS FOR AND METHOD OF ELECTROMOTIVE-FORCE REGULATION.

SPECIFICATION forming part of Letters Patent No. 620,365, dated February 28, 1899.

Application filed January 27, 1898. Serial No. 668,171. (No model.)

To all whom it may concern:

Be it known that I, NORMAN ROWE, a citizen of the United States, residing in Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Means for and Methods of Electromotive-Force Regulation, (Case No. 767,) of which the following is a specification.

My invention relates to alternating-current systems of electrical distribution which embody means independent of the primary source of current for raising and lowering the electromotive force of the work-circuit.

The object of my invention is to provide a method of and means for increasing or decreasing the work-circuit electromotive force gradually over any desired range without undue expense and complication as regards either the structure or operation of the apparatus employed.

Among the methods heretofore proposed for varying the electromotive force in alternating-current work-circuits supplied directly by stationary transformers perhaps the most usual is that which involves varying the active length of either the primary or the secondary transformer-winding by means of suitable switch devices.

In dealing with large transformers and high electromotive forces this method involves the employment of either an excessively large and practically prohibitive number of switch contact-points and corresponding divisions of the transformer-winding or excessively large and abrupt changes in the electromotive force between successive divisions of the transformer-winding. It has also been proposed to vary the work-circuit electromotive force by means of a regulator having two inductively-related windings which may be relatively adjusted in position, so as to magnetically vary the electromotive force. This method fails to satisfactorily meet all the requirements of a normally high voltage circuit in which a wide range of variation is desired, chiefly on account of the size and structure of the regulator which it is necessary to employ for such purpose and the consequent torque to be overcome in operating it.

In order to secure the desired range of regulation advantageously both as regards the character of the apparatus employed and the results effected, I have devised the method and means illustrated in the accompanying drawings, in which—

Figure 1 is a front elevation of the inductive regulator, and Fig. 2 a diagram of the entire apparatus employed. Fig. 3 is a diagram illustrating the action of the inductive regulator.

In the drawings, A and B are the supply alternating-current mains; C, a stationary transformer; D, a stationary switch base or plate; E, an inductive regulator, and F and G the work-circuit mains.

For the purpose of carrying out my invention I have shown the switch-plate D as provided with an outer contact-ring d, an inner contact-ring d', an outer set of contact-segments 1, 3, 5, and 7, and a similar set of inner contact-segments 2, 4, 6, and 8, the segments of each set being spaced apart and alternating, as regards radial position, with those of the other. A switch-arm D′ is suitably fastened to one end of a shaft D^2 at the center of the switch-plate D and is provided with two brushes e^2 and e^3. The brush e^2 is so located as to make contact with ring d at all times and also with each of contact-segments 1, 3, 5, and 7 during a portion of each revolution of switch-arm D′.

The brush e^3 is so located as to make contact with ring d' at all times and with each of contact-segments 2, 4, 6, and 8 during a portion of each revolution of arm D′, the relation of the two sets of segments being such that each brush comes into contact with a corresponding segment just before the other brush breaks contact with its segment. The switch-plate D is also provided with a stop-pin f in position to be engaged by a lug f' on the arm D′ when the latter is in either its first or its last position.

The primary c of the transformer C is provided with leads 1^a, 2^a, 3^a, 4^a, 5^a, 6^a, 7^a, and 8^a at regular intervals extending over a portion of its length, which are respectively connected to the contact-segments 1, 2, 3, 4, 5, 6, 7, and 8. An end lead 9^a constitutes the terminal of the line conductor A. The wind-

ing of the secondary member e' of the regulator E is connected at one end to ring d and at the other end to ring d', the latter of which constitutes the terminal of the line conductor B. The winding of the primary member e of the regulator E is connected across the secondary circuit F G—*i. e.*, in shunt to the secondary c' of transformer C—by means of rings g and g' and brushes h and h'.

As illustrated in Fig. 1 of the drawings, the primary member e of the regulator E supports the rings g and g' and is mounted upon the shaft D^2 of the switch, so as to rotate with it as the switch-arm D′ is revolved. In the construction shown the regulator has eight magnetic poles; but any other number that is found desirable and practicable may be employed by suitably modifying the switching devices.

The operation of my invention is as follows: Assuming that the switch-arm D′ and the member e of the induction-regulator are in the positions indicated in the drawings, so that the regulator produces a maximum inductive effect in opposition to the main-line electromotive force, as is indicated at m in Fig. 3, if the arm D′ and the movable member e of the regulator be turned in a clockwise direction, so as to gradually vary the inductive effect of the primary upon the secondary to and through zero (represented by z in Fig. 3) to a maximum positive value, (indicated at m' in said figure,) the main-line electromotive force will obviously be less than the normal by an amount which gradually decreases from the point m to the point z and will then be gradually increased to an equal amount, (represented by the line $z\ m'$.) When this maximum, corresponding to point 2^a in Fig. 2, is reached, brush e^2 will be in contact with segment 1 and brush e^3 with segment 2 momentarily. In this position the section $1^a\ 2^a$ and the winding of the secondary member e' of the regulator E will be in shunt to the portion of the transformer-primary between leads 2^a and 9^a, and hence there is very little current to be interrupted when at the next instant brush e^2 leaves segment 1. When the brush e^2 leaves segment 1, the section of the transformer-primary c between leads 1^a and 2^a and the winding of the secondary member e' of regulator E are cut out of circuit. This condition will be maintained until brush e^2 reaches segment 3, and during this interval the action of the regulator E is represented by the broken line $m'\ z'\ m^2$, there being no resulting effect upon the line electromotive force.

During the time that brush e^2 is in engagement with segment 3 the inductive action of the regulator is represented by the line $m^2\ e^2\ m^3$ of Fig. 3, the line electromotive force corresponding to lead 3^a being opposed by the regulator E by an amount which decreases until the middle point (indicated by the full-line position of arm D′) is reached, when its effect is *nil*. From this point the line electromotive force is boosted until brush e^2 reaches the end of segment 3, when the regulator effect is represented by point m^3, Fig. 3, and the line electromotive force will be substantially that corresponding to lead 4^a. A further movement of switch-arm D′ will cut out that portion of the transformer-primary between leads 3^a and 4^a. If the movement of the arm D′ be continued until its lug f' comes into contact with the stop-pin f on the switch-plate D, the line electromotive force will be opposed from the point indicated by m^4, Fig. 3, and corresponding to lead 4^a, Fig. 2, to point z^4, corresponding to lead 5^a, and then to point m^5, corresponding to lead 6^a, then opposed from point m^5, corresponding to lead 6^a, to point [illegible], corresponding to lead 7^a, and then boosted to point m^7, corresponding to lead 8^a. It will be seen, therefore, that the line electromotive force is raised by means of progressively-added increments instead of by means of abrupt steps or jumps, as would be the case if sections of the primary of the transformer were successively cut out of circuit without any intermediate variation of potential. It will also be seen that the restriction of the inductive regulation to points of comparatively small difference of potential renders it feasible to employ a relatively small regulator which may be easily and effectively operated.

It will be understood without further explanation that the secondary electromotive force may be decreased by moving the switch-arm D′ in the opposite direction to that already described.

If a greater range of electromotive-force regulation is desired than is afforded by the construction indicated in the drawings, it may obviously be secured by providing the requisite number of transformer-leads and employing a switch having the same number of stationary contact-pieces and providing suitable means intermediate the induction-regulator and the switch whereby the switch-arm is intermittingly actuated when the movable member of the regulator reaches the proper position for cutting a section of the transformer-winding into or out of circuit.

I desire it to be understood that variation of the active length of either the primary or the secondary transformer-winding is within the scope of my invention and that the construction and arrangement of parts both mechanical and electrical may be varied to suit the ideas of the constructor or operator without departing from the spirit and scope of my invention.

I claim as my invention—

1. The method of raising or lowering the electromotive force supplied by a transformer having a winding the active length of which is variable, which consists in first inductively adjusting the electromotive force corresponding to one length of winding to that corresponding to a different length, and then changing the circuit connections to correspond to the adjusted electromotive force.

2. The method of varying the electromotive force supplied by a transformer having a winding the active length of which is variable, which consists in first inductively varying the electromotive force within limits corresponding to a division of the winding, then cutting such division either into or out of circuit and repeating such operations until the desired change in electromotive force is secured.

3. The combination with a stationary transformer having a divided winding, of a switch or switches for cutting the divisions of the winding into or out of circuit successively, and means for inductively varying the electromotive force between operations of the switch which effect changes in the length of the winding.

4. In a system of electrical distribution, a stationary transformer in combination with a switch or switches for varying the active length of one of the transformer-windings by successive steps and an inductive regulator for varying the electromotive force between certain of said steps, whereby the working electromotive force is gradually varied between maximum and minimum limits.

5. In a system of electrical distribution, a stationary transformer having leads extending from several points in one of its windings, in combination with a switch for connecting said leads successively with one of the line conductors, and an inductive regulator for either raising or lowering the electromotive force to a value corresponding substantially to the next lead in the series prior to connecting such lead with the line conductor.

In testimony whereof I have hereunto subscribed my name this 17th day of January, A. D. 1898.

NORMAN ROWE.

Witnesses:
JAMES B. YOUNG,
H. C. TENER.