No. 803,254. PATENTED OCT. 31, 1905.

H. R. STUART.

METHOD OF REGULATING ALTERNATING CURRENT ELECTROMOTIVE FORCE.

APPLICATION FILED SEPT. 26, 1903. RENEWED OCT. 25, 1904.

Fig. 1.

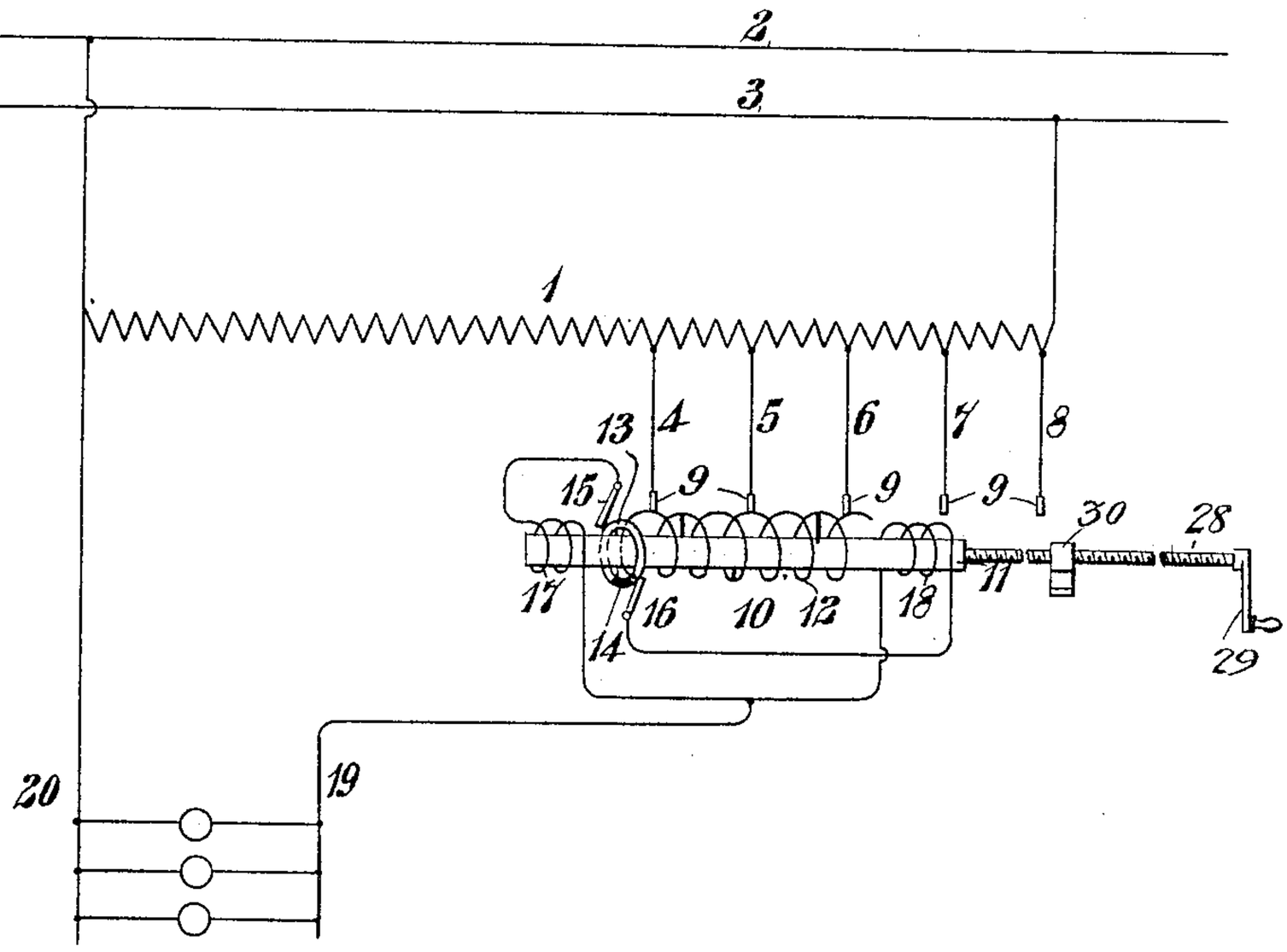
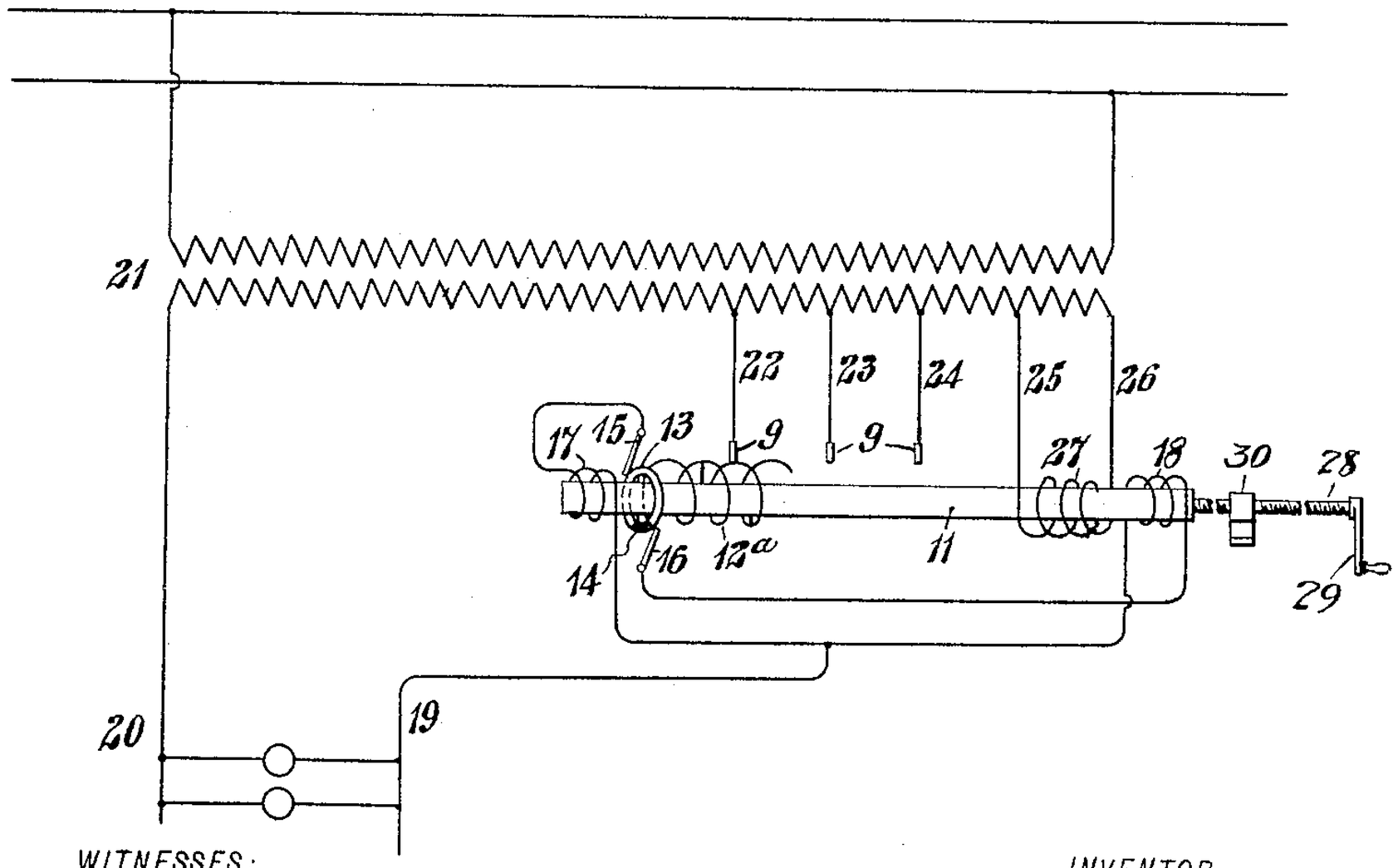


Fig. 2.



WITNESSES:

F. H. Miller

Birney Hines

INVENTOR

Harve R. Stuart

BY

Hadley & Carr

ATTORNEY

UNITED STATES PATENT OFFICE.

HARVE R. STUART, OF WILKINSBURG, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

METHOD OF REGULATING ALTERNATING-CURRENT ELECTROMOTIVE FORCE.

No. 803,254. Specification of Letters Patent. Patented Oct. 31, 1905.

Application filed September 26, 1903. Renewed October 25, 1904. Serial No. 229,966.

To all whom it may concern:

Be it known that I, HARVE R. STUART, a citizen of the United States, and a resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Methods of Regulating Alternating-Current Electromotive Force, of which the following is a specification.

My invention relates to the regulation of the electromotive force of alternating-current circuits; and it has for its object to provide a simple and effective method of regulation which shall insure a uniform and gradual increase or decrease, as the case may be, without danger of injury to the regulating devices utilized in practicing the method.

The control and regulation of the voltage of alternating-current circuits have heretofore been generally effected by a step-by-step variation of the active lengths of the windings of transformers, or by the relative angular displacement of two coils between which there is inductive action, or by a combination of these two methods. The former method is objectionable because of the danger of injurious arcing between the contact members of the apparatus employed when large currents or high voltages are regulated and controlled. The latter method is expensive and complex and involves the expenditure of considerable power in the operation of the apparatus employed. I propose to combine the advantages of these two methods and to avoid their disadvantages, as will be hereinafter described and claimed.

Considerable latitude is permissible with reference to the apparatus employed for practicing my invention; but in order that some effective means may be set forth I have illustrated certain apparatus in the accompanying drawings, in which—

Figure 1 is a diagram of circuits and devices indicative of my method of voltage regulation, and Fig. 2 is a similar diagram of a modification of apparatus suitable for practicing the same.

Referring now to Fig. 1, a given portion of an autotransformer-winding 1, which is supplied from distributing-mains 2 and 3, is divided into a plurality of lengths by means of taps or leads 4, 5, 6, 7, and 8, located at proper and preferably equidistant intervals and severally terminating in contact terminals or brushes 9. While only a comparatively small portion of the winding 1 is shown as provided with the spaced leads, it will be understood that all or any other desired portion may be provided with such leads. The regulating and controlling apparatus 10, which is utilized in connection with the transformer-winding and its spaced leads, comprises a laminated core 11, which may be of any form suitable for providing a good magnetic circuit, a helical coil 12, having an exposed surface with which the contact-terminals 9 may engage, a contact-ring 13, having a non-conducting portion 14 at one side, brushes 15 and 16, which make contact with the ring 13, and two choke-coils 17 and 18, the outer terminals of which are respectively connected to the brushes 15 and 16 and the inner terminals of which are connected together and to one side 19 of the work-circuit, the other conductor 20 of said circuit being connected to the terminal of the autotransformer-winding 1 which is opposite to that having the lead 8. The axial length of the helical coil 12 is approximately twice the distance between successive contact-terminals 9, or such that not more than three nor less than two of said terminals may engage therewith at the same instant.

In order to utilize the apparatus above described to practice my invention, it is necessary to move the helical coil 12 both longitudinally and rotatively at such a rate as will insure continuous or uninterrupted engagement of at least two of the contact-terminals 9 therewith, and since one end of the coil is permanently attached to the ring 13 the latter will rotate and move longitudinally with the coil. The core 11 and the coils 17 and 18 may remain stationary, provided the core is of sufficient length and the coils 17 and 18 sufficiently spaced apart to permit of the necessary longitudinal range of movement of the coil 12; but it will probably be generally found more convenient to move the core 11, the coils 17 and 18, and the brushes 15 and 16 longitudinally with and at the same rate as the coil 12, while the latter only is given a rotative movement. These movements may be effected manually or automatically by means of any suitable motive device, as may be found suitable and desirable. I have

shown in the drawings a simple manually-operated means for effecting the desired movements, which comprises a screw-rod 28, having a crank-handle 29 and engaging a stationary nut 30. If the screw-rod and the coil 12 are rigidly attached to the core 11, the coil will be moved both longitudinally and rotatively, so as to effect the desired coöperative engagement between said coil and the brushes 9. A suitable connection may of course be made between the core 11 and the coils 17 and 18 which will insure a longitudinal non-rotative movement of the latter, and the rotative movement of the core which is here indicated may be avoided by employing more complicated operating devices.

The choke-coils 17 and 18 serve to prevent the contact-ring 13 from forming a short-circuited turn around the iron core and at the same time to provide a path for the current to the load in order that there may be no interruptions in the circuit when the brushes 15 and 16 pass over the non-conducting portion 14 of the ring.

If the helix 12 is in the position indicated in Fig. 1, in which the contact-terminals 9 of the leads 4, 5, and 6 make contact therewith, current is supplied to the work-circuit through the lead 4, a small portion of the helix, the ring 13, coils 17 and 18, and conductor 19, the voltage supplied to the work-circuit being substantially that between the leads 20 and 4. When the helix is rotated and moved longitudinally to the right, so that the contact-terminal 9 of the lead 4 is no longer in contact with the core, the portion of the core between the leads 5 and 6 becomes the primary of a transformer, the secondary of which is the portion of the helix between the lead 5 and the ring 13. At the moment when the contact between the brush 9 of the lead 4 and the helix 12 is interrupted the ratio of the primary to the secondary turns is approximately one to one, so that the voltage between the lead 5 and the ring 13 is equal to that between leads 4 and 5 or to that between leads 5 and 6. The current is now supplied to the load through lead 5, the portion of the helix between lead 5 and ring 13, ring 13, coils 17 and 18, and conductor 19. Since the voltage in the secondary, represented by the portion of the helix between the lead 5 and the ring 13 opposes the main voltage, the voltage supplied to the load remains practically unchanged; but as the helix is rotated and moved longitudinally the secondary turns gradually become less, and hence the voltage supplied to the load gradually increases until the helix moves out of engagement with the brush 9 of the lead 5, when the secondary portion of the helix will again be maximum and will be gradually decreased to effect a corresponding increase in the voltage supplied to the load, and so on throughout the entire range of movement of the helix.

In Fig. 2 I have shown a two-winding transformer 21, a portion of the secondary winding of which is provided with a plurality of spaced leads 22, 23, 24, 25, and 26, of which leads 22, 23, and 24 are severally provided with contact devices or brushes 9, and the leads 25 and 26 are connected to the terminals of a winding 27, located on the core 11 and constituting the primary winding of an auxiliary transformer, of which the helix 12^a constitutes the variable secondary. The axial length of the helix 12^a is approximately equal to the distance between successive contact-brushes 9, or such that not more than two of said brushes may engage therewith at the same instant. In this form of apparatus one end of the winding 12^a is connected to a contact-ring 13 having a non-conducting section 14, and choke-coils 17 and 18 are provided, the outer terminals of which are respectively connected to brushes 15 and 16, which make contact engagement with the said ring 13, and the inner terminals of which are connected to the conductor 19 of the work-circuit, the apparatus being in all respects the same as regards structure and mode of operation, except that on account of the employment of a two-winding main transformer it is more convenient for the sake of simplicity to provide a separate primary winding for the auxiliary transformer instead of utilizing a portion of the helix as such primary winding, as is done in the apparatus shown in Fig. 1. If desired, however, exactly the same form of apparatus as is shown in Fig. 1 may be employed in connection with a two-winding transformer.

With the form of apparatus shown in Fig. 2 the drop in voltage in the portion of the helical coil between one of the contact-terminals 9 and the ring 13, due to resistance and induction, may be compensated for by so designing the primary winding 27 that the volts per turn of the helical secondary winding 12^a may be slightly increased over the value desired to oppose the main voltage.

As has been already stated, the longitudinal and rotative movement of the helix and, if desired, the longitudinal movement of the core may be effected by any suitable means known in the art or by manual operation. It is not deemed necessary to illustrate such operating mechanism, no claim being made herein to the apparatus.

I make no claim herein to the means shown and described for practicing the method herein claimed, but have made such means a part of the subject-matter of another application filed September 26, 1903, Serial No. 174,773.

I claim as my invention—

1. The method of varying the electromotive force of an alternating-current work-circuit which consists in impressing upon said

circuit voltages which are varied step by step and opposing said impressed voltages by auxiliary voltages which are varied uninterruptedly between zero and values approximately equal to the steps in the impressed voltages.

2. The method of varying the electromotive force of an alternating-current work-circuit which consists in supplying to the said circuit voltages that are the resultants of voltages which are varied step by step and auxiliary opposing voltages which are varied uninterruptedly between zero and values approximately equal to the said voltage steps.

3. The method of varying the electromotive force of an alternating-current work-circuit which consists in supplying to the said circuit voltages that are the resultants of voltages which are varied step by step and auxiliary opposing voltages at the terminals of a transformer secondary winding in series with the work-circuit which are varied uninterruptedly between zero and approximately the values of the step-by-step voltages.

4. The method of varying the electromotive force of an alternating-current work-circuit which consists in supplying to the said circuit electromotive forces that are the resultants of two opposed and progressively-varied electromotive forces, one of which is varied step by step and the other uninterruptedly.

In testimony whereof I have hereunto subscribed my name this 15th day of September, 1903.

HARVE R. STUART.

Witnesses:

JOS. W. ALEXANDER,

BIRNEY HINES.