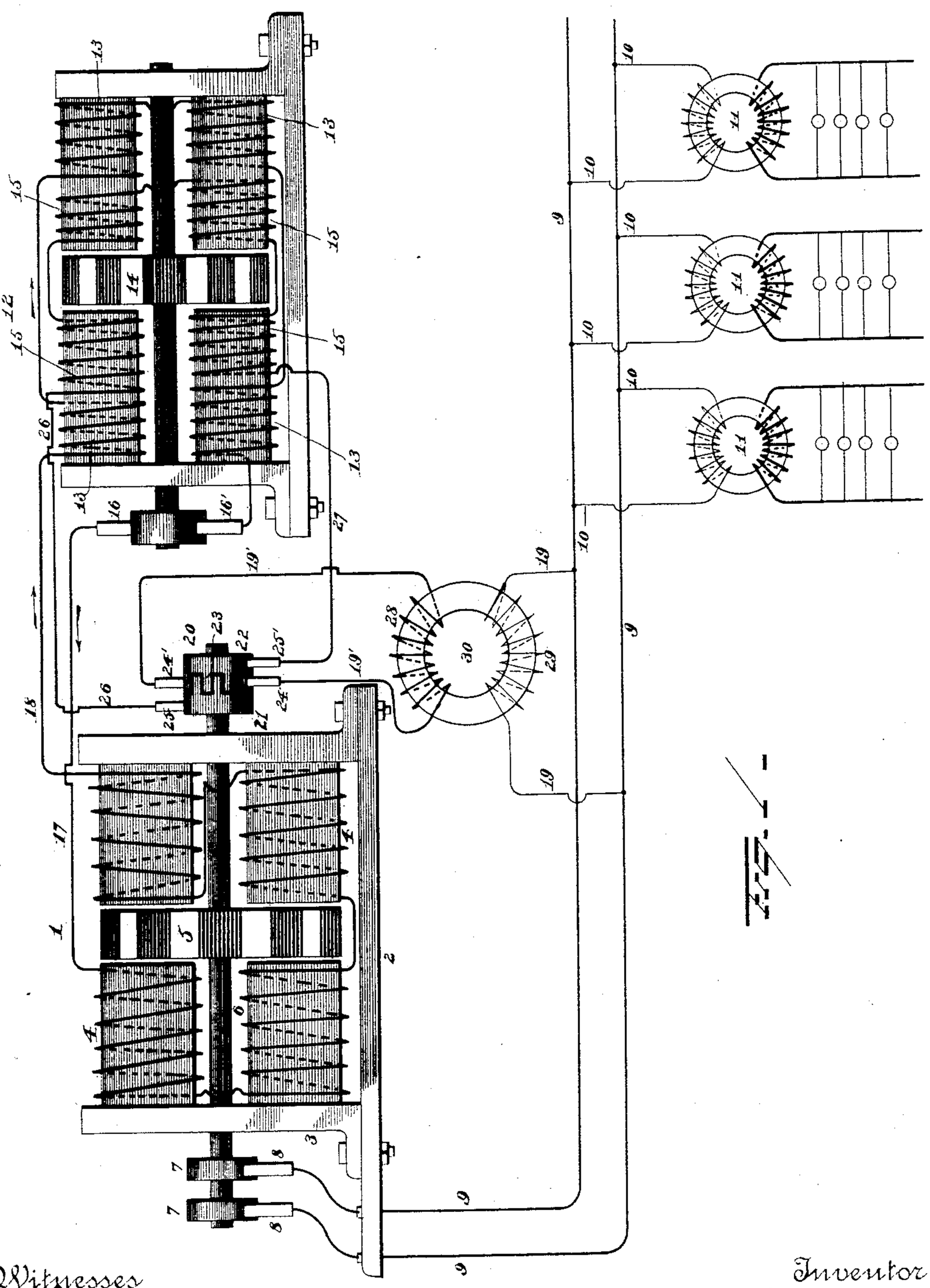
(No Model.) 2 Sheets—Sheet 1.

G. PFANNKUCHE.

REGULATION OF ALTERNATING ELECTRIC CURRENT GENERATORS.

No. 404,859. Patented June 11, 1889.



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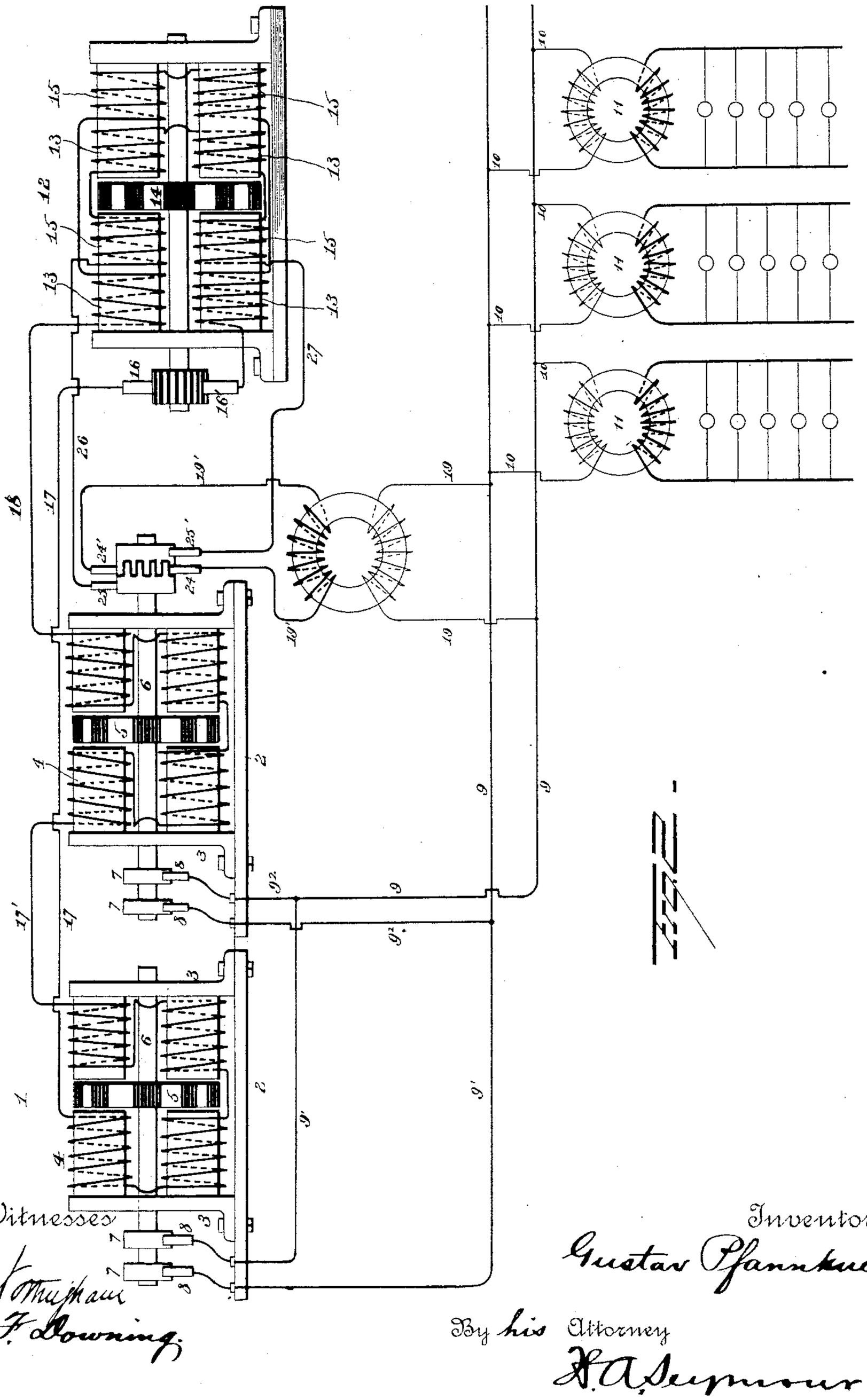

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UNITED STATES PATENT OFFICE.

GUSTAV PFANNKUCHE, OF CLEVELAND, OHIO, ASSIGNOR TO THE BRUSH ELECTRIC COMPANY, OF SAME PLACE.

REGULATION OF ALTERNATING ELECTRIC-CURRENT GENERATORS.

SPECIFICATION forming part of Letters Patent No. 404,859, dated June 11, 1889.

Application filed November 9, 1887. Serial No. 254,690. (No model.)

To all whom it may concern:

Be it known that I, GUSTAV PFANNKUCHE, of Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in the Regulation of Alternating Electric-Current Generators; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention has reference to improvements in the regulation of alternating electric-current generators, whereby the latter become adapted for use in general systems of distribution in which the number of translating devices is variable. It is more especially designed for use in connection with such systems of distribution in which the translating devices are in multiple-arc branches derived from a main or trunk line, and in which it is desired to maintain a constant difference of potential at the terminals of the derived branches or working-circuits, which are frequently at great distances from the generator. In such systems, as in all other systems of distribution, the difference of potential at the brushes of the generator is dependent upon the relation of the external resistance to the total resistance in such manner that when the external resistance increases the difference of potential at the brushes also increases, while at the same time less current is generated in the armature, and when the external resistance decreases the difference of potential at the brushes also decreases, and more current is at the same time generated in the armature. From this it becomes clear that in a multiple-arc system of distribution, whenever one or more working branches are opened, provision should be made to decrease the strength of the field-magnets, and whenever additional working-circuits are closed the strength of the field-magnets should be increased, in order to maintain a constant difference of potential, substantially as in constant potential dynamos for incandescent electric lighting.

The object of my invention is to accomplish this result automatically and effectively in a separately-excited alternating-current generator, or in a number of such generators, and provide for this purpose an exciter which furnishes currents of one direction to the field-magnet coils of the alternating-current generator or generators; and the arrangement is such that the strength of the current furnished by the exciter is controlled by the difference of potential at the brushes of the alternating-current generator. For this purpose the field-magnets of the exciting-dynamo are provided with auxiliary energizing-coils in addition to the ordinary coils, which auxiliary coils are wound in opposition to the normal coils and are in a branch of the main line near the brushes—*i. e.*, in a shunt around these brushes. Since the currents derived from the main line are alternating, the branch to the auxiliary coils of the exciter must be provided with a commutator for straightening these currents before they reach the auxiliary coils. All this I have set forth and claimed in another application filed by me, and the invention hereinafter described is an improvement upon the invention claimed in said other application.

The currents traversing the main line, if intended to be used for the operation of induction-transformers or secondary transformers or other like translating devices, are necessarily of comparatively very high tension, and these currents are not well suited for charging the auxiliary coils of the field of force of the exciter. For this reason, instead of charging the auxiliary coils directly by the currents from the line, I cause these currents to be transformed into currents of suitable lower tension before they reach the commutator above referred to, so that excessive sparking at said commutator is prevented and the current will reach the auxiliary coils with such tension as is suited for the functions which it is designed to perform.

In the accompanying drawings, which form a part of this specification, I have illustrated, mainly in diagram, in Figure 1, my improved automatically-regulated system of generation and distribution as applied to a simple prime generator, and in Fig. 2 the same system as applied to a number of prime generators.

Referring now more particularly to Fig. 1, there is shown an alternating-current gener-

ator 1, which may be of any ordinary or improved construction. It is represented in the drawings as mounted upon a base or platform 2, upon which standards 3 3 of iron are bolted, and which standards constitute the yokes of the field-magnets 4 4. The armature 5, which is preferably of the Brush type, is mounted upon a shaft 6, which may be journaled in the standards, and is driven in any suitable manner. The alternating currents generated in this machine are collected by brushes 8 8, bearing upon collecting-disks 7 7, secured to, but insulated from, the shaft, and having the terminals of the armature-coils connected therewith. All these parts may be of ordinary construction, well understood by those skilled in the art, and need not be specifically described. With the collecting-brushes 8 8 the main or trunk line 9 9 is connected, and at distant points 10 10, &c., this line is tapped by multiple-arc branches in which suitable translating devices are included.

The translating devices 11 11, &c., shown in the drawings are in effect inductoriums designed to convert currents of a given tension into currents of different tension. The alternating-current generator used in the system here shown is constructed to furnish currents of comparatively very high tension, and the inductoriums or secondary generators are therefore arranged with their fine-wire coils in the multiple-arc branches 10 10, &c., while their coarse-wire coils include translating devices adapted to be operated by currents of comparatively low tension, like incandescent electric lamps, &c. It will be understood, however, that while my system is eminently adapted for the operation of secondary transformers, it is by no means confined to the feeding of such transformers. Any other suitable translating device may be substituted for the secondary transformers 11 11.

The field-coils of generator 1 are charged by an exciter 12, which is preferably a series-dynamo of the Brush type. The field-magnets of this exciter are provided with two sets of coils—one set 13 13, &c., being the normal field-coils, connected in series with the armature 14, as usual, and the other set 15 15, &c., being wound in opposition to the normal coils, are charged by a transformer, the fine-wire coil of which is in a shunt around the collecting-brushes 8 8 of the alternating-current generator, as will presently appear.

From commutator-brush 16 of the exciter the circuit of the latter may be traced by arrows from wire 17 to and through the coils of field-magnets 4 4 of generator 1 and by wire 18 to and through the normal coils 13 13, &c., of the exciter, and back to the commutator and armature 14 by brush 16′. Thus it is seen that the field-coils of the alternating-current generator are in the external circuit of the exciting-dynamo, and will receive a normal charge from the same so long as the field of force of the exciter remains unchanged.

Upon the armature-shaft of generator 1 is mounted, but insulated therefrom, a commutator 20, composed of two hollow cylindrical blocks 21 and 22, each provided at one end with a number of segmental teeth 23, alternating with segmental spaces, and these two blocks are so mounted upon the armature-shaft that the teeth of each block engage the corresponding spaces in the other, with insulating material (indicated by heavy lines) intervening between the two blocks.

Two commutator-brushes 24 24′, bearing upon the segmental portion of the commutator, are connected by wires 19′ 19′ with the terminals of the coarse-wire coils 28 of a transformer 30, the fine-wire coils 29 of which are connected by wires 19 19 with the main line, as shown, so as to form a shunt around the collecting-brushes of the alternating-current generator. Two other brushes 25 25′, bearing upon the undivided cylindrical portions of blocks 21 and 22, respectively, are connected by wires 26 and 27 with the terminals of the auxiliary coils 15 15, &c., of the field-magnets of the exciter. The total number of segments of commutator 20 is equal to the number of alternations of current in generator 1, and they are so located upon shaft 6 relative to the coils of armature 5 that one of the brushes 24 24′ will bear upon a segment of one of the blocks 21 22, while the other of these brushes will bear upon a segment of the other of these blocks during the prevalence of one electrical impulse.

It will now be easily understood that the alternating currents from the line reaching the fine-wire coils 29 of the transformer 30 by wires 19 will generate alternating currents of lower tension in the coarse-wire coils, and that these electrical impulses will be straightened out by the commutator and will leave the same by one of the brushes 25 25′ and return by the other after having traversed the auxiliary field-coils 15 15 of the exciter in the inverse direction to the current in the normal coils 13 13, generated by the exciter itself. The auxiliary field-coils 15 15 are thus in effect charged by a shunt around the brush-terminals of generator 1, and as the difference of potential at those terminals varies the auxiliary coils will be variably charged, and they will therefore variably modify the strength of the field-magnets of the exciter.

The automatic regulation to a constant difference of potential at the terminals of working-circuits in a system of distribution provided with my apparatus can now be explained.

The prime generator and the exciting-dynamo are started simultaneously. The current from the latter energizes the field-magnets of the former, and the strength of said field depends upon the strength of current from the exciter. This exciter, in so far as it is an ordinary self-exciting dynamo, will furnish a current depending upon its construction and speed; but in so far as its auxiliary field-coils are fed indirectly by a shunt across

the brush-terminals of the alternating-current generator the strength of its field, and consequently the strength of current generated by it, will also depend upon the relation of the external resistance to the total resistance of the prime generator. Suppose, then, that both machines are started when a given number of translating devices, like the secondary transformers 11 11, are at distant points included in multiple-arc branches from the main line, and that in that condition of the system the alternating-current generator furnishes the required current to the line and produces the required difference of potential. If, now, additional multiple-arc branches 10 10 are introduced, the external resistance of the prime generator will be reduced, and in consequence thereof, as stated above, the difference of potential at the brush-terminals of generator 1 will at once decrease, while at the same time more current will be generated, as required, by the increased number of translating devices. In consequence of the decrease of difference of potential, less current than before will be diverted through the shunt 19 19 into the fine-wire coils of transformer 30, and less current will be generated in the coarse-wire coils of said transformer and sent through the auxiliary coils of the field-magnets of the exciting-dynamo. These coils will therefore less oppose the magnetizing action of the normal coils 13 13, and the field of force of the exciter will consequently become stronger. The exciter will now furnish a stronger current to the field-coils 4 4, &c., of the alternating-current generator, and the difference of potential at the brush-terminals of the latter will therefore be increased. Thus it is seen that such change in the external resistance as will tend to decrease the difference of potential at the brush-terminals will automatically operate to re-establish or maintain the original difference of potential. If, on the contrary, some of the multiple-arc branches 10 10, &c., are opened and the external resistance of the line increased, less current will be generated in armature 5 and the difference of potential at the brush-terminals will be increased. As a consequence of this, more current will be diverted through shunt-wires 19 19 into the fine-wire coil of transformer 30. More current will be generated in the coarse-wire coils of said transformer, and will pass to the auxiliary coils 15 15 of the field-magnet of the exciter, and these coils will now more strongly oppose the action of normal coils 13 13, as before, and the field of the exciter will be weakened. The exciter will therefore furnish a weaker current through the field-coils 4 4 of the prime generator, and the difference of potential at the terminals of the latter will decrease, thus re-establishing the normal difference of potential.

It is clear that my system will operate to maintain a constant difference of potential, whether the changes of external resistance are caused by the closing or opening of working branches or by any other cause, for it responds to and reacts upon variations of differences of potential, irrespective to the causes which produce or tend to produce the same. No artificially-introduced resistances and no manipulations of any kind are necessary to the effective operation of my invention, which is absolutely automatic.

I desire it to be understood that I do not limit myself to the identical details of construction herein shown and described. These details may be varied and modified at will, so long as the fundamental rules laid down in this specification are adhered to; and these rules may be extended to apply without material change to the automatic regulation of the difference of potential in a system of distribution fed by two or more alternating-current generators, as is exemplified in Fig. 2. In said figure of the drawings there are shown two alternating-current generators 1 and 1′, which have either a common armature-shaft or the separate armature-shafts of which are driven at the same speed. The like brushes of these generators are connected together by wires 9′ and 9^2, and with the main or trunk-line 9, so that the two generators have their armatures coupled in quantity with the main line.

The field-coils of the two generators are connected in series by a wire 17′, and by wires 17 18 they are included in the external circuit of the exciter 12, the same as in Fig. 1. In all other respects the arrangement is the same as in Fig. 1, and it will be easily understood that any number of alternating-current generators may be thus arranged with their armatures coupled in quantity and connected with the main line and with their field-magnet coils in series in the external circuit of the exciter without departing from the principle of my invention.

Having now fully described my invention, I claim and desire to secure by Letters Patent—

1. In a system of electrical distribution, the combination of one or more alternating-current dynamos and a separate exciting-dynamo having two sets of field-magnet coils, one set being included in circuit with the field-coils of the alternating-current generator and the other set included in the secondary circuit of an inductorium, the primary of which is in a multiple-arc branch of the main line, substantially as set forth.

2. The combination, with an alternating-current generator (one or more) and an exciting-dynamo for energizing the field-magnets of the alternating-current generator, said exciting-dynamo having differential field-magnet coils, the main coils of which are energized by current generated by the exciter, of an induction apparatus having its primary coil in a shunt across the brush-terminals of the alternating-current generator, the secondary coil having a commutator included in its circuit for straightening the current therein, and conductors for supplying the straightened

current to the regulating field-magnet coils of the exciting-dynamo, substantially as set forth.

3. The combination, with an alternating-current generator (one or more) and an exciting-dynamo having two sets of field-coils, one set being included in circuit with the field-coils of the alternating-current generator, of an inductorium the primary coil of which is of fine wire and included in a multiple-arc branch of the main line, while the secondary coil is of coarse wire and has a commutator included therein for straightening the current flowing therein, and conductors for supplying the straightened current to the regulating field-magnet coils of the exciting-dynamo, substantially as set forth.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

GUSTAV PFANNKUCHE.

Witnesses:
S. M. HAMILL, Jr.,
A. B. CALHOUN.