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A. I. GRAVIER.

APPARATUS FOR DISTRIBUTING ELECTRICITY.

No. 300,068. Patented June 10, 1884.

Fig. 1,

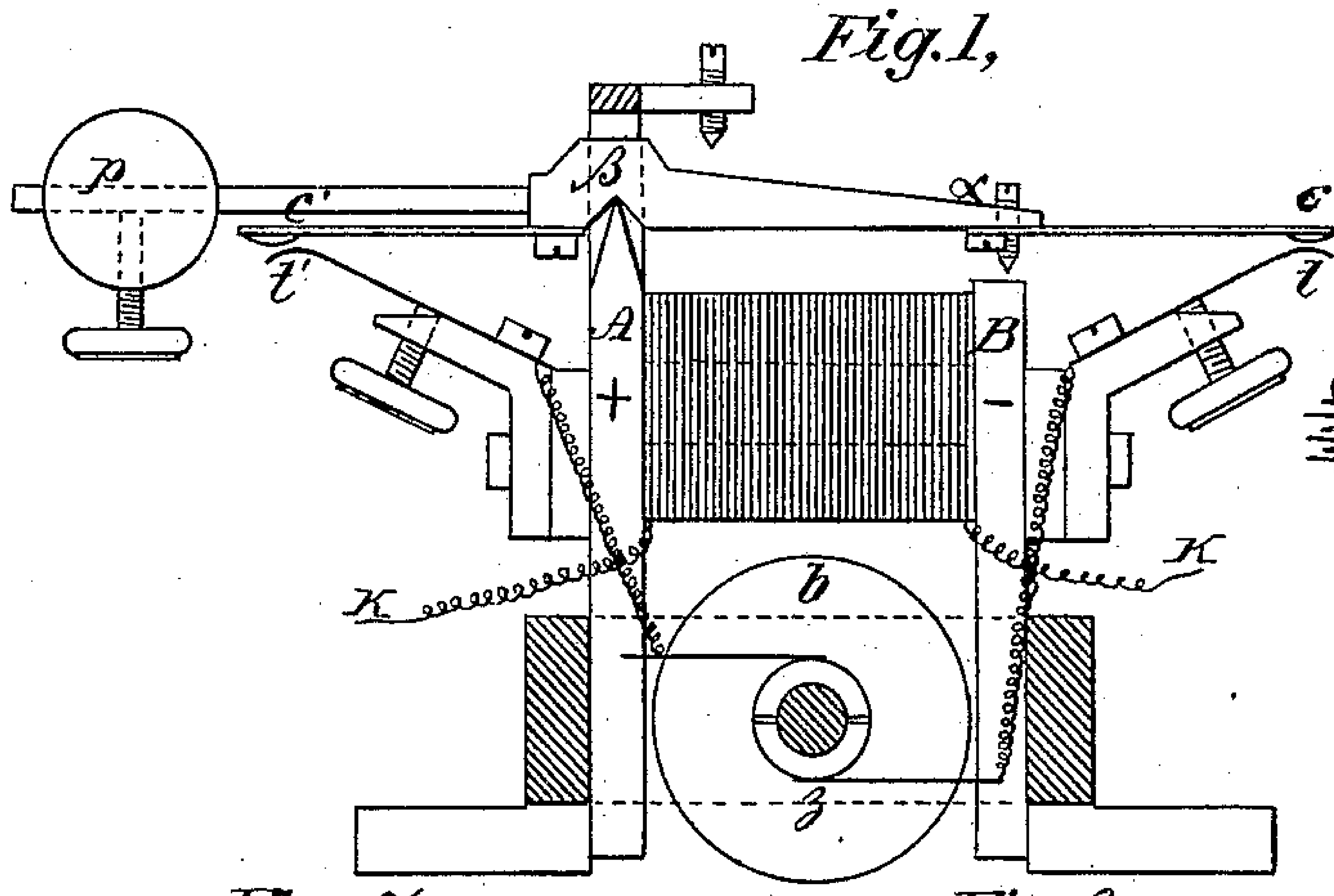


Fig. 2,

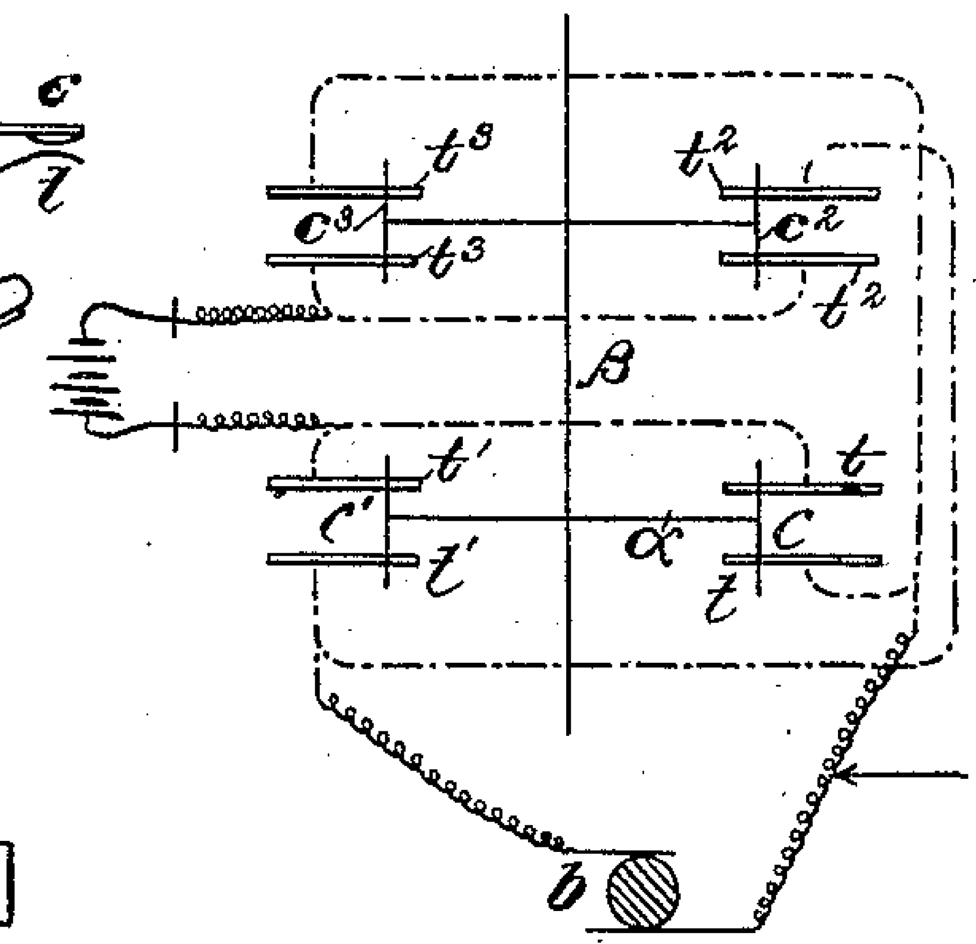


Fig. 7,

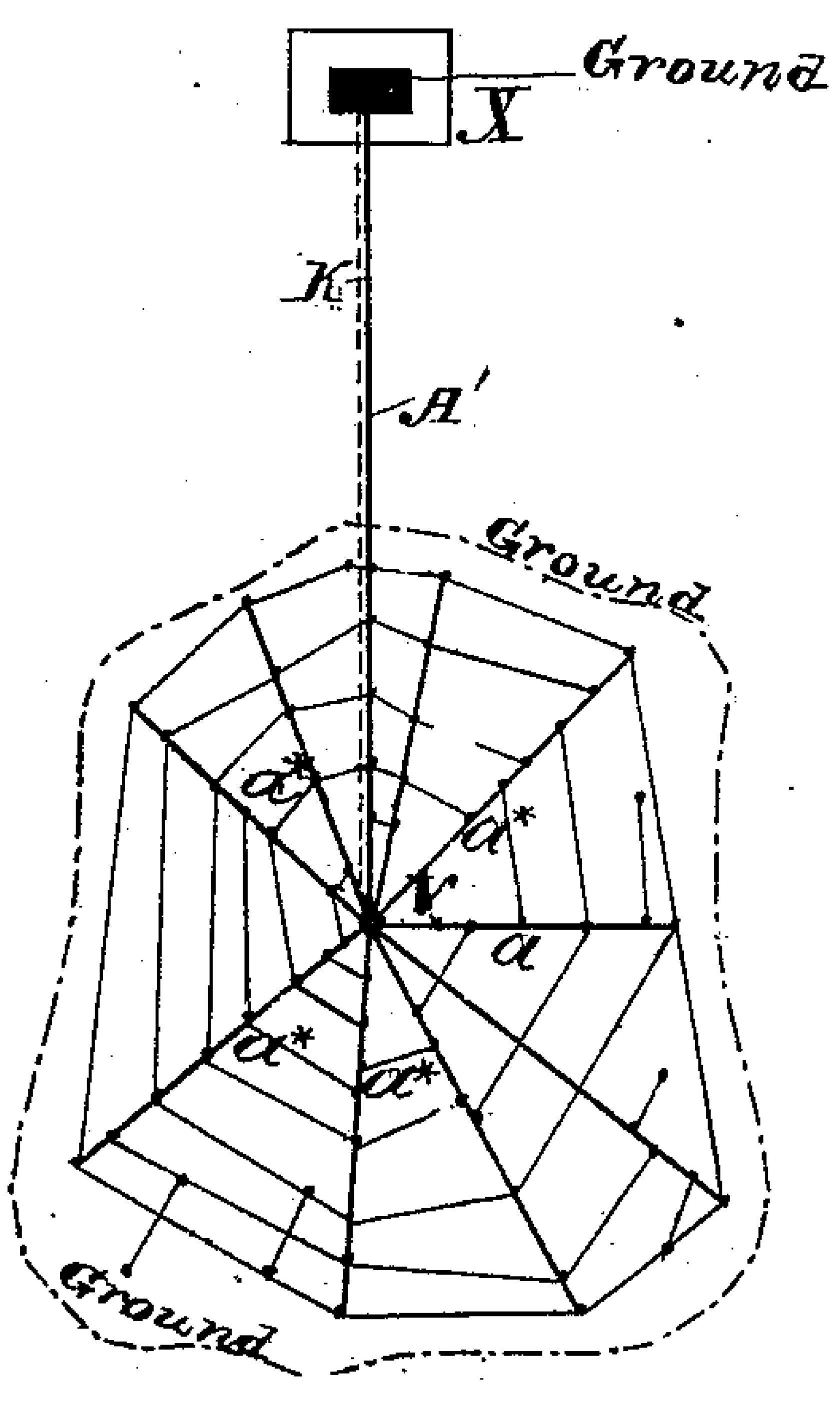


Fig. 8,

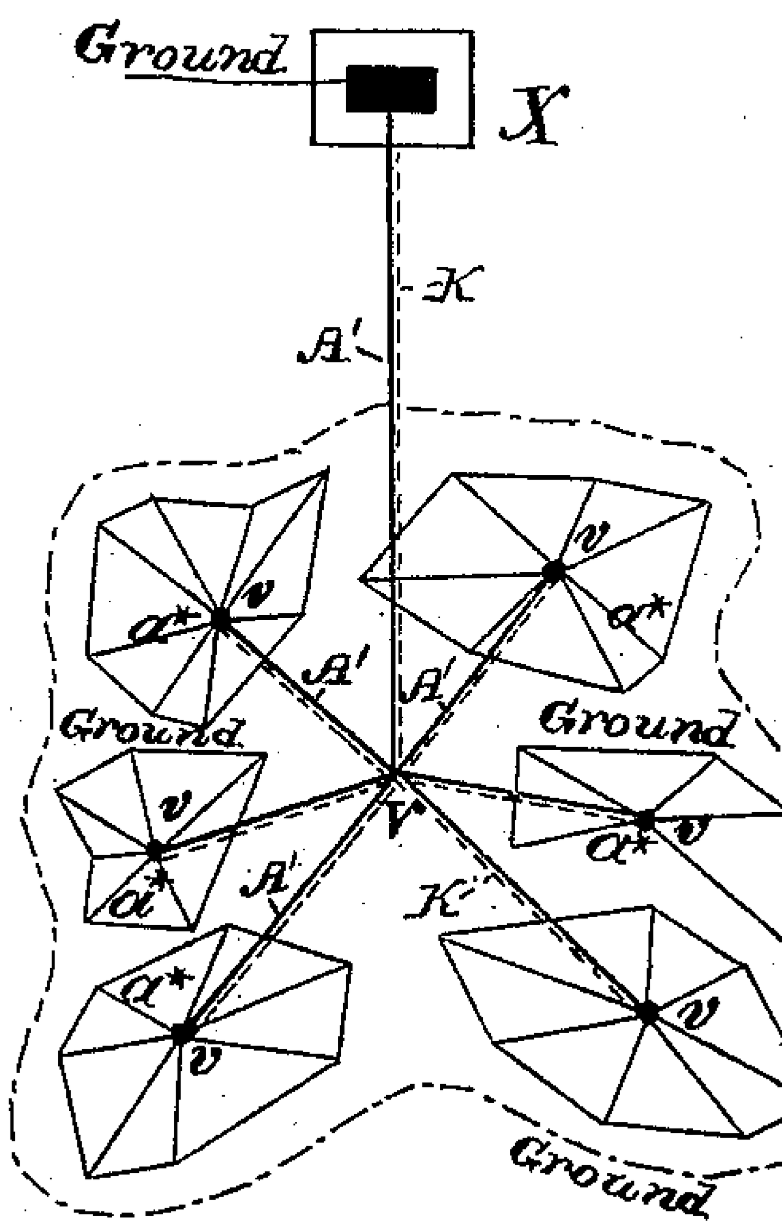


Fig. 9,

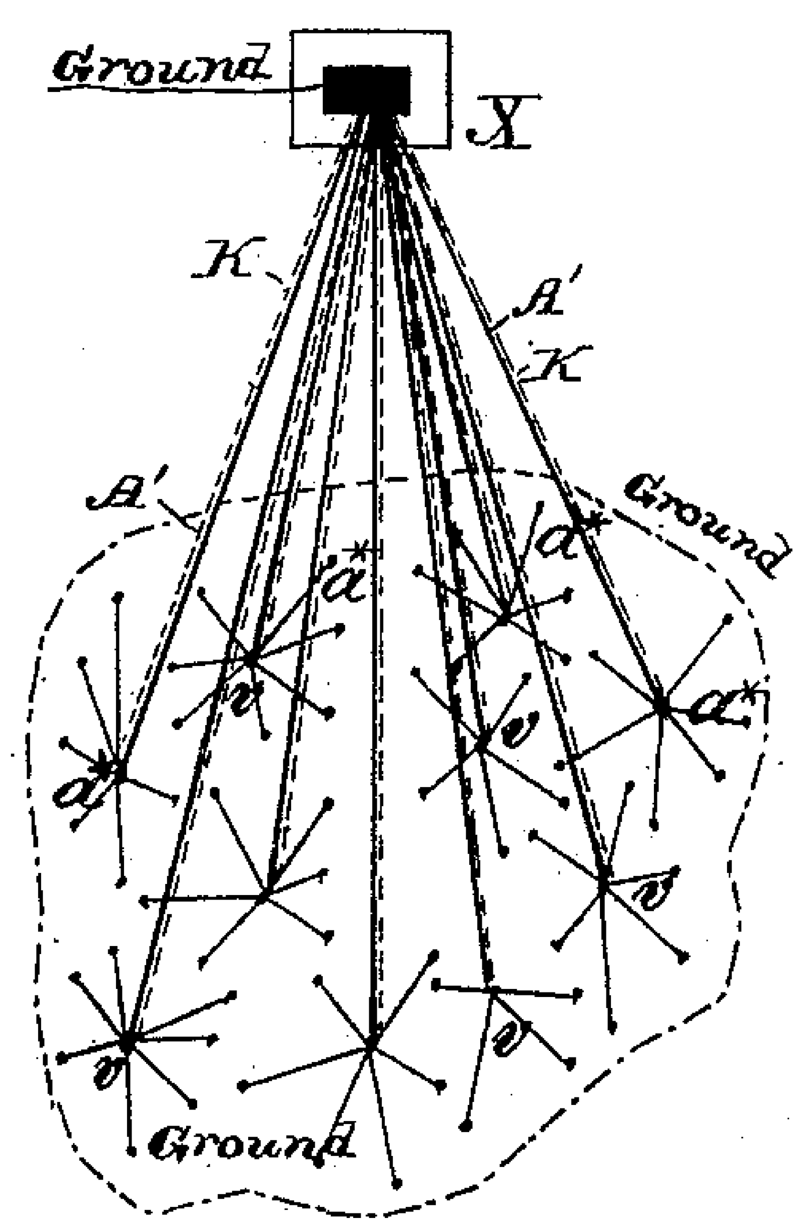
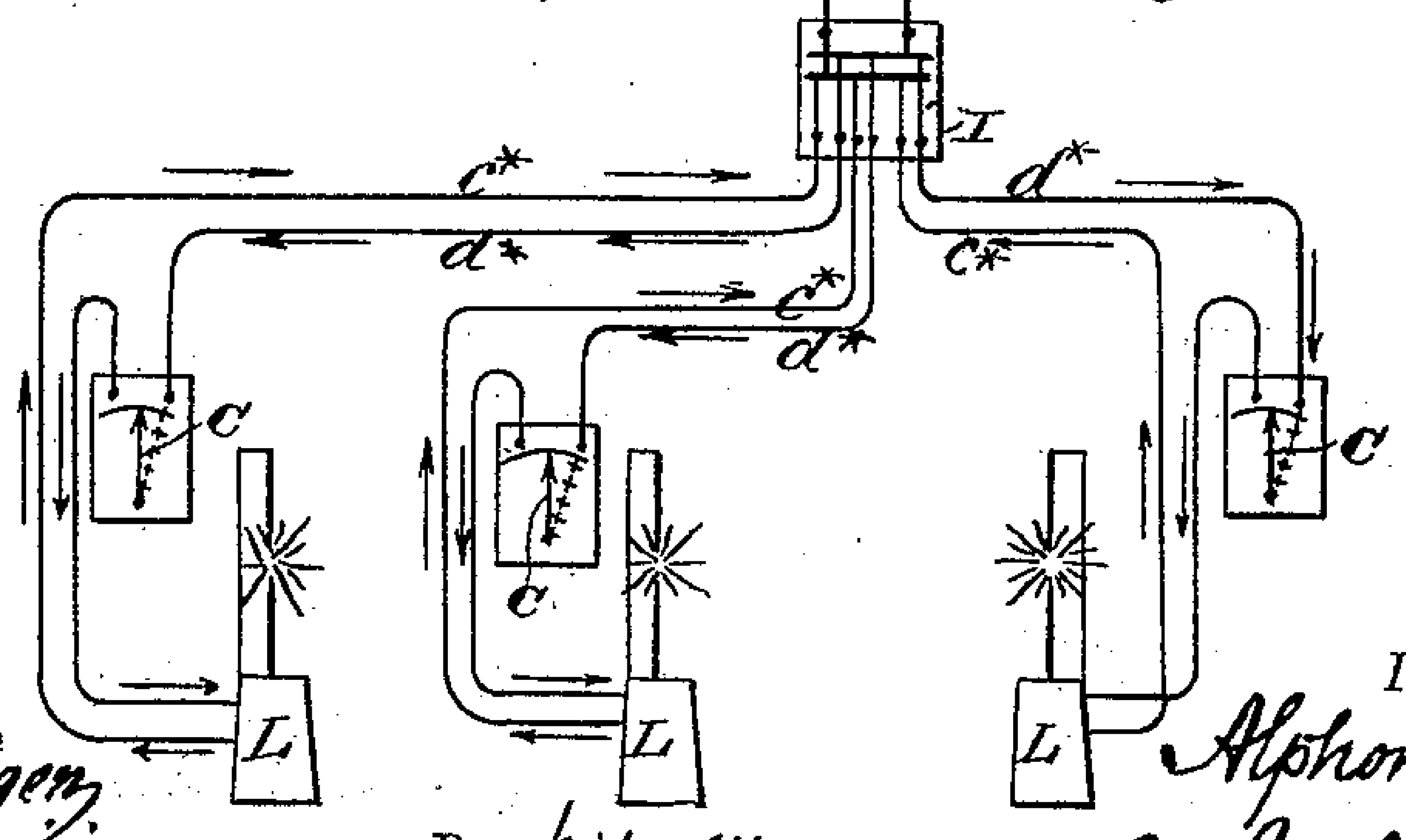


Fig. 10,



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(No Model.) 4 Sheets—Sheet 2.

A. I. GRAVIER.

APPARATUS FOR DISTRIBUTING ELECTRICITY.

No. 300,068. Patented June 10, 1884.

Fig. 6,

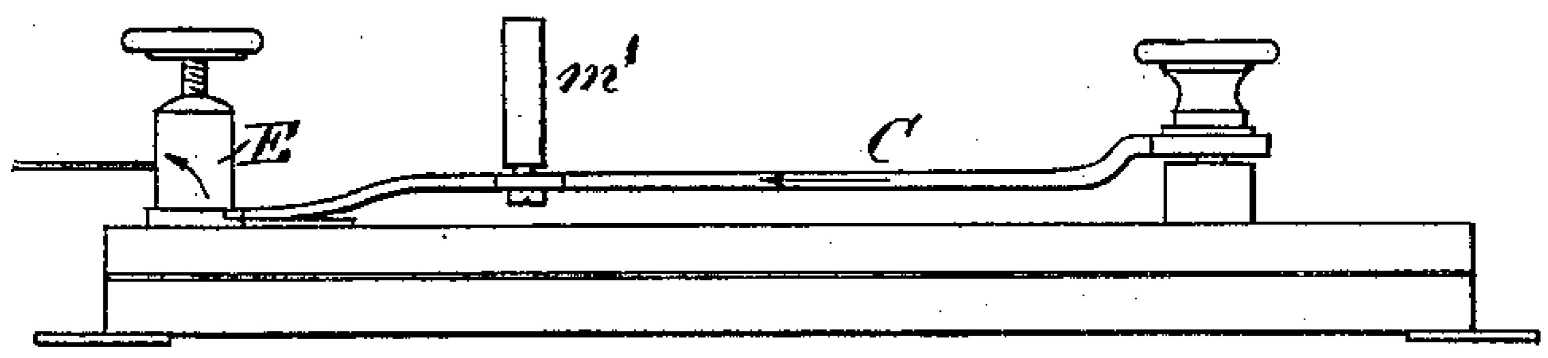
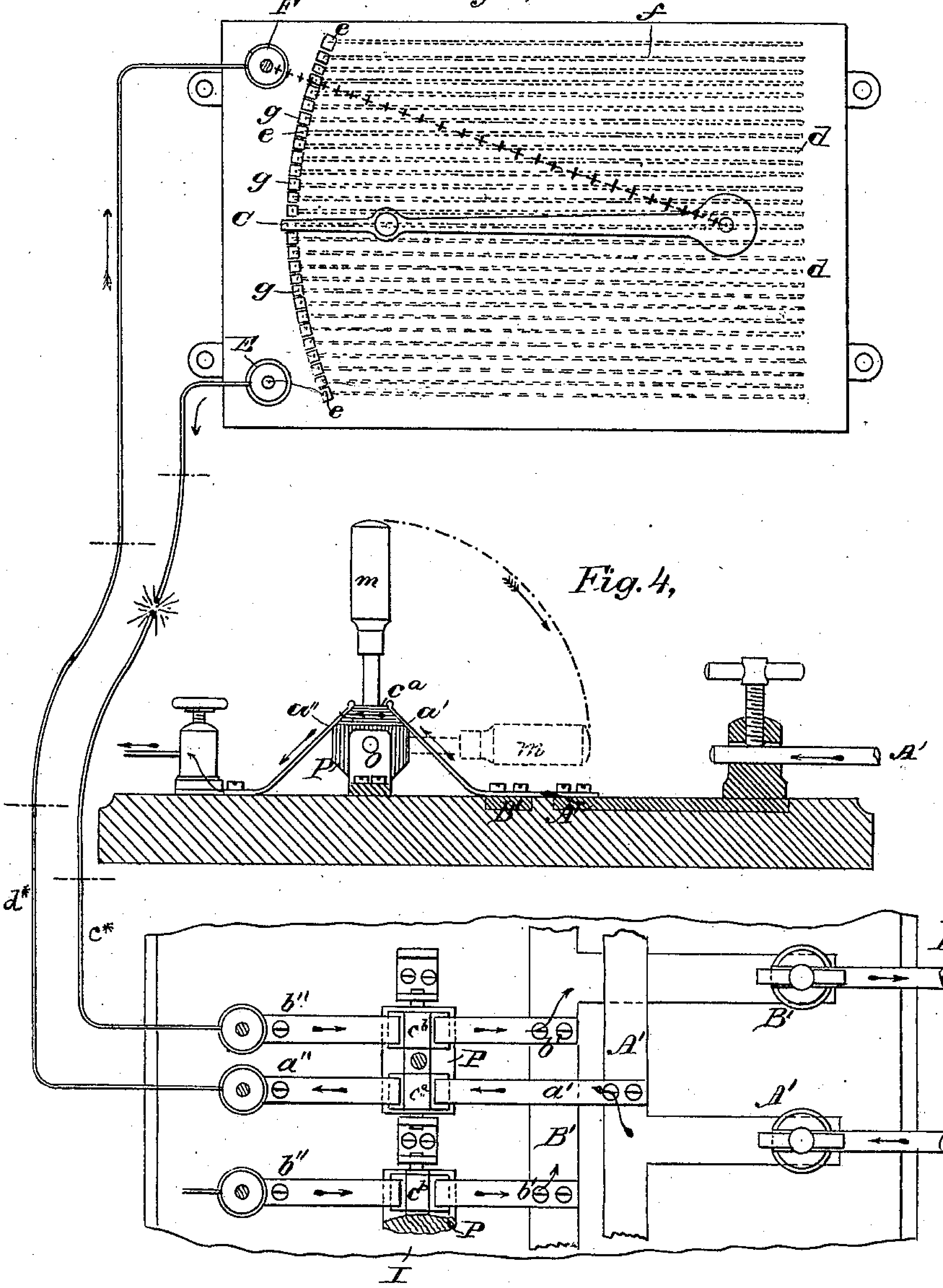


Fig. 5,

Fig. 4,

Fig. 3,



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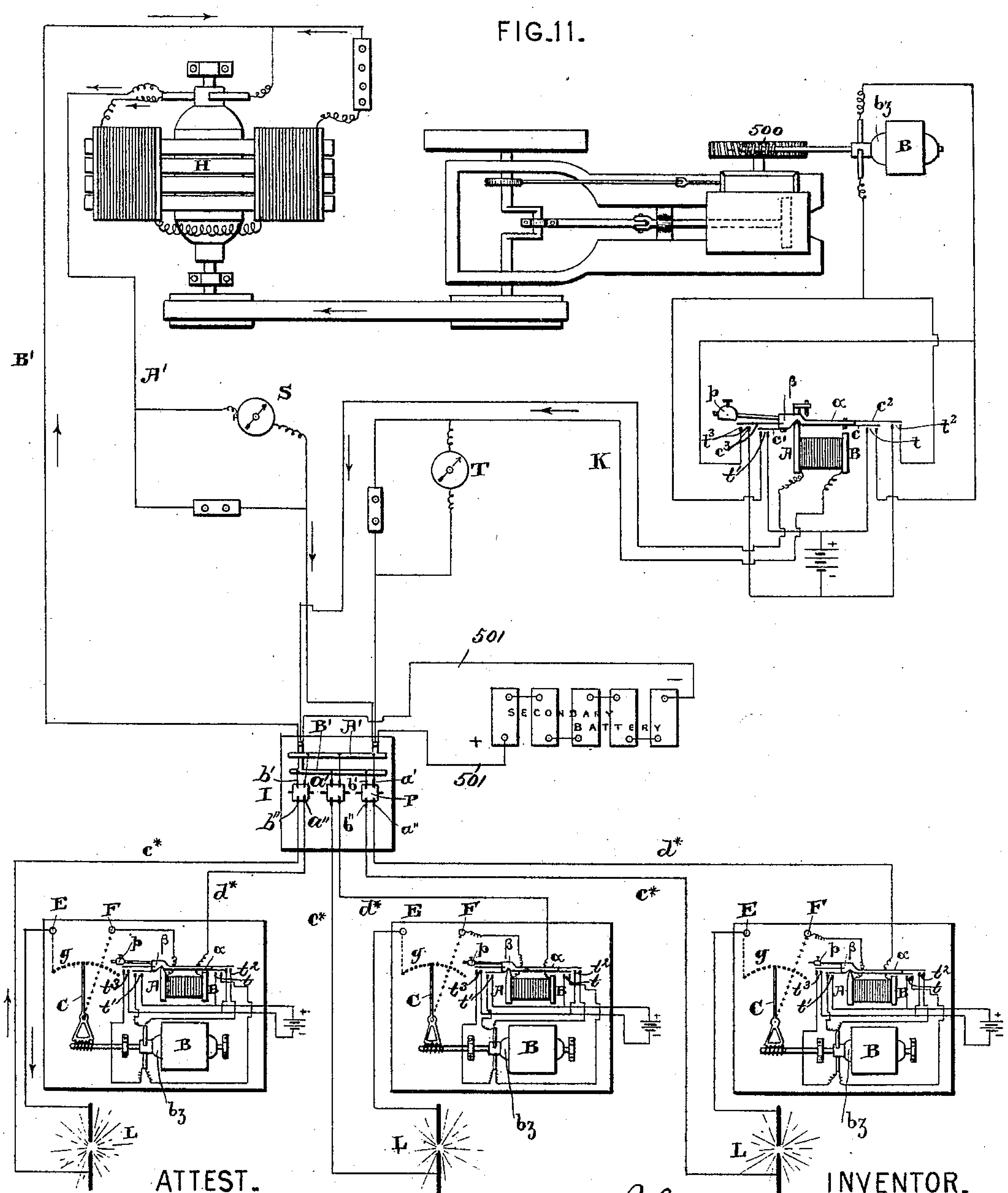
(No Model.) 4 Sheets—Sheet 3.

A. I. GRAVIER.

APPARATUS FOR DISTRIBUTING ELECTRICITY.

No. 300,068. Patented June 10, 1884.

FIG. 11.



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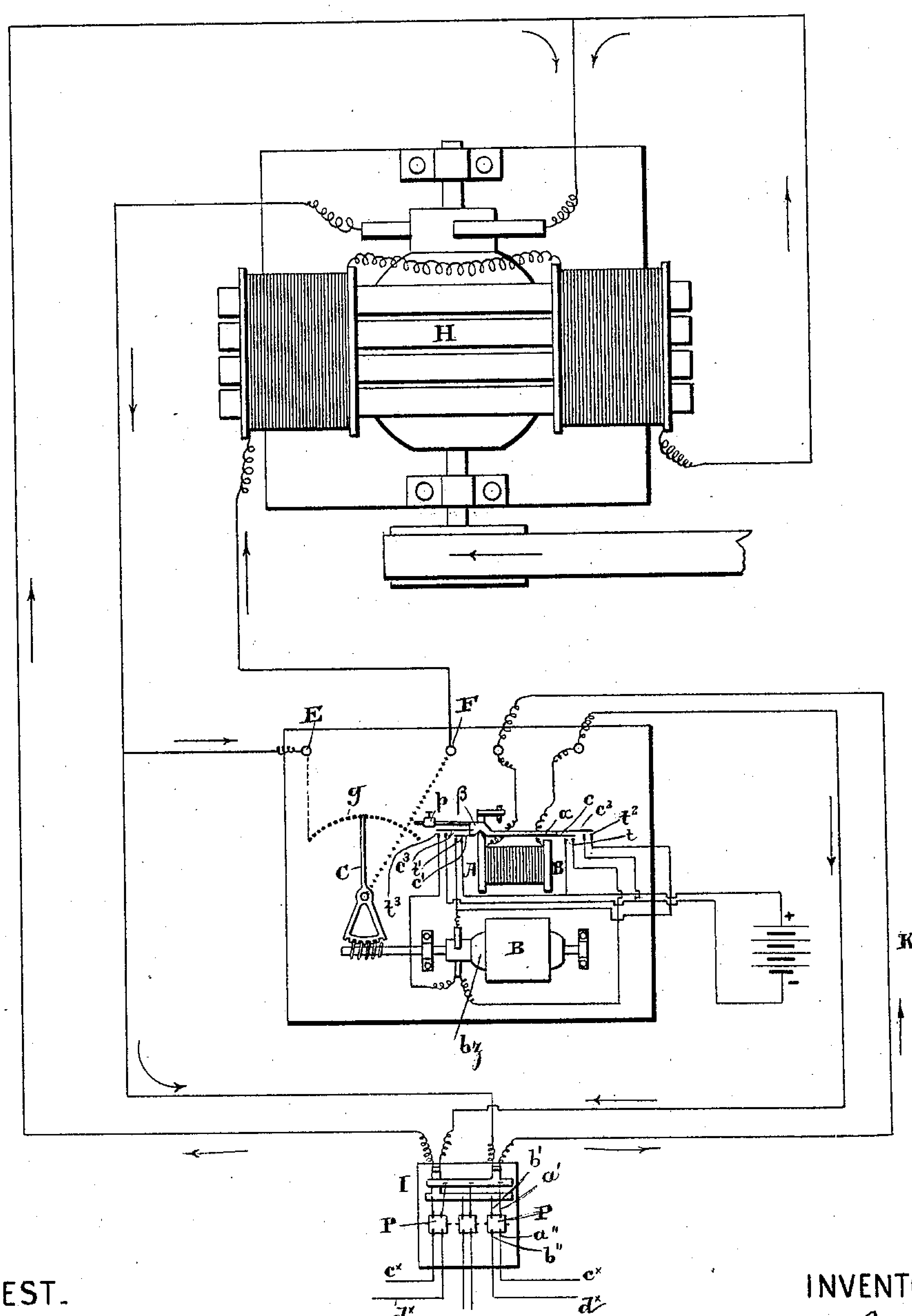
APPARATUS FOR DISTRIBUTING ELECTRICITY.

No. 300,068. Patented June 10, 1884.

FIG. 12.



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UNITED STATES PATENT OFFICE.

ALPHONSE ISIDORE GRAVIER, OF PARIS, FRANCE.

APPARATUS FOR DISTRIBUTING ELECTRICITY.

SPECIFICATION forming part of Letters Patent No. 300,068, dated June 10, 1884.

Application filed February 9, 1882. (No model.) Patented in France June 3, 1880, No. 137,033; in Germany July 29, 1880, No. 15,525, and May 13, 1881, No. 16,682; in Belgium June 13, 1881, No. 54,896; in England June 22, 1881, No. 2,739; in Italy December 19, 1881, No. 13,693; in Austria-Hungary May 20, 1882; in Norway July 18, 1882; in Sweden October 9, 1882, and in Denmark February 27, 1883.

To all whom it may concern:

Be it known that I, ALPHONSE ISIDORE GRAVIER, a citizen of the Republic of France, and a resident of Paris, France, have invented certain new and useful Improvements in Systems for Transmitting and Distributing Electrical Energy, and apparatus for use therein, whereof the following specification is a full and exact description.

This invention relates to an improved system for supplying a number of translating devices—such as lights, motors, and the like—with electrical energy from a common generator or generators, which latter may be of any suitable description—galvanic or thermo-electric batteries, for example—but which would ordinarily and preferably be dynamo-electric machines.

The invention consists, first, in placing the translating devices in a series of derived branches, and in including in each branch, or in such branches as it may be desirable to employ it in, an automatically or electrically adjusted rheostat or resistance apparatus, whereby the current through said branch or branches and the translating device or devices included therein is maintained uniform at a given strength and intensity. Notwithstanding the rise and fall of potential in the main conductors at the ends of the branches, the resistance of the rheostat, being automatically adjusted, compensates for such variation, and counteracts the variation in the strength of current which would otherwise result. The electrically-adjusted rheostat comprises the rheostat proper and the electric governor, or instrument operated electrically to adjust the rheostat proper. The electric governor is preferably such as hereinafter described; but this part of the invention is not limited to it, since other means operated by increase or decrease in the current traversing the same could be used to adjust the rheostat. It is, however, essential that the governor should be excited in the circuit through the translating device and not in an independent branch. The rheostat proper may be of ordinary or of other suitable construction—as, for example, of that hereinafter described.

The invention, secondly, consists in combining with the derived branches which include the translating devices means adapted to be set by hand for adjusting the resistance of the branch so as to vary at will the strength or intensity of current through the said devices. These means, when electrically-adjusted rheostats are used, are such as to change the conditions under which the electric governor is in equilibrium. When rheostats are used without being connected with and operated by electric governors, it is only necessary to adjust directly the resistance. In either case the effect of the hand adjustment or setting will be to decrease the resistance of the branches when a larger current is desired, or to increase it when the current is to be diminished. The difference is that in the one case the decreased or increased resistance is a constant quantity, while in the other it is only a normal quantity, and will vary with any variation of tension on the main conductors.

The invention, thirdly, consists in the combination, with the series of derived branches, which include both the translating devices and adjustable rheostats, (as well those adjustable electrically to maintain uniform a given current as those adjustable by hand to vary the current whether also adjustable electrically or not,) of an electric governor and current-controlling mechanism operated thereby for regulating the electro-motive force of the generator or generators in accordance with the demand—that is to say, with the number of branches and translating devices in circuit—in order to maintain a uniform difference of potential between the ends of the branches.

The invention, fourthly, consists in connecting the two ends of the branches containing the translating devices, or so many of them as may be desired, with a switch for simultaneously making and breaking the connection with both poles of the generator or main conductors, so as, when the connections of any branch are broken, to cut it wholly out of the system. The branch being charged only when in use, there can be no loss from leakage. It is also found that there is less disturbance of the other parts of the system than if a break were made in one wire only, which effect, in my opinion, is due to the extra current not being permitted to pass into the said other parts. The place to be supplied with electricity—it may be a section of a city, an establishment, or only a part of an establishment—is often, as a matter of necessity or convenience, at a distance from the generator or generators.

The fifth part of the invention is designed to overcome the difficulties in the way of an efficient regulation of the current where the translating devices are at a distance from the generator, and are connected in derivation, the object being to render them each independent of the others; and it consists in connecting the branches with the main conductors (which extend to a distance from the generator) at one or more centers, and in including the electric governor for controlling the electro-motive force of the generator or generators in a branch connected with these centers, so that any abnormal change in the potential of these will so alter the current in the said governor branch as to change the electro-motive force of the generator in the direction required to counteract said change of potential. Thus the potential at the centers being maintained uniform, the current in each branch containing the translating devices will be constant so long as the resistance is uniform.

The invention, sixthly, consists in placing a secondary battery at the same centers, so as to prevent sudden changes in potential before the governor can produce its effect upon the generator and counteract the variation.

The invention further comprises a method, hereinafter explained, of ascertaining or regulating the resistance of the derived branches, and also certain special constructions of the switch for connecting and disconnecting the said branches, and of the adjustable rheostats for use in them, as well as the combination or union in one apparatus or system of the foregoing improvements.

In the accompanying drawings, Figure 1 is an elevation, partly in section, of the relay or switch forming part of the electric governor; Fig. 2, a diagram illustrating the contacts; Figs. 3 and 4, views showing the construction of the switches for connecting in or cutting out the branches containing the translating devices; Figs. 5 and 6, front and side elevations, respectively, of the improved rheostat in said branches; Figs. 7, 8, and 9, diagrams showing arrangements of conductors for supplying a district; Fig. 10, a diagram showing the manner of combining with circuits the switch and rheostats shown in the foregoing figures; Fig 11, a diagram showing a complete system, and Fig. 12 a diagram of another method of controlling the electro-motive force of the generators.

The apparatus will first be described in detail, and the manner of connecting them in the system then explained.

The relay or automatic switch, Figs. 1 and 2, consists of an electro-magnet, A B, having a vibratory armature, $\alpha\ \beta$, supported on a knife-edge on one pole, A, of the magnet, and polarized thereby. Set-screws limit the play of the armature. A weight, p, is adjustably secured to an arm of said armature, and tends by its gravity to oppose the attraction of the magnet on the armature. Attached to but insulated from the armature are four contact-pieces, $c\ c'\ c^2\ c^3$, which are supported above and span the space between the pairs of elastic contact-strips $t\ t'\ t^2\ t^3$, attached to the frame of the magnet. In the mid-position of the armature the movable contact-pieces $c\ c'\ c^2\ c^3$ are separated from the stationary strips $t\ t'\ t^2\ t^3$; but when the armature tips in either direction the pieces $c\ c^2$ or $c'\ c^3$, as the tip is to the right or left, electrically connect the strips of the corresponding pairs $t\ t^2$ or $t'\ t^3$. Between the poles of the magnet is supported the rotary armature $b\ z$ of the Siemens or Trouvé or other suitable type. The commutator-brushes of this armature are electrically connected the one with the outside strips of the pairs $t\ t^2$, the other with the outside strips of the pairs $t'\ t^3$, as shown in Fig. 2. The inside strips of the pairs $t\ t'$ are connected with the positive pole of a local battery, and the inside strips of the pairs $t^2\ t^3$ with the negative pole of the same battery. When, therefore, the armature is in mid-position, (which will be whenever the weight p balances the magnetic attraction,) the circuit of the local battery is open and the armature $b\ z$ cut out; but when the one force overpowers the other, (which will be whenever the current circulating in the coils of the electro-magnet rises above or falls below the normal,) the contacts made connect the lower commutator-brush with the positive pole of the local battery, and the upper brush with the negative pole, or vice versa, according to the direction in which the vibratory armature $\alpha\ \beta$ moves, and thus completes the circuit of the local battery through the rotary armature, so that it turns to the right or left, according as the armature $\alpha\ \beta$ is tilted to the right or left. The apparatus is thus a combined relay and motor, the electro-magnet of the relay being the field-magnet of the motor.

In Figs. 11 and 12, for the purpose of clearer illustration, the motor is separated from the relay, and the contacts are differently disposed, the operation being the same as just described with reference to Figs. 1 and 2, but the arrangement being less compact and desirable. The shaft of the rotary armature is mechanically connected with the rheostat-valve or other instrument to be adjusted.

The switch, Figs. 3 and 4, for connecting and disconnecting a branch, consists of a prism, P, of ebonite or other insulating material, journaled in bearings, a handle, m, for turning it, two metal contact-pieces, c^a and c^b, set in said prism, and four contact-springs—$a'\ b'$, forming the terminals of the main conductors A′ B′, and $a''\ b''$, forming the terminals of the branch. When the prism P is in the position shown, the branch is connected in circuit, the corresponding terminals being connected through the pieces c^a and c^b. When the handle *m* is turned down, as shown in dotted lines, the contact-pieces are removed from under the terminal-springs *a″ b″*, and the branch is wholly cut out. Where a number of branches connect with the main conductors A′ B′ at a common point, the switch-board has as many separate prisms P as there are branches.

The rheostat, Figs. 5 and 6, consists of a base or frame provided with two rows of insulated metal pegs, *d e*, respectively, a wire, *f*, wound back and forth around said pegs, a series of contact-plates, *g*, formed by the heads of the pegs *e*, or otherwise connected with them, and a switch-lever, C, movable over said contact-plates *g* by means of an ebonite handle, *m′*. One end of the wire *f* is connected with the binding part E, the other with the last peg, *e*, at the opposite end of the series. The switch-lever C is connected with the other binding-post, F. By turning said lever more or less of the wire *f* will be introduced into the circuit, and the resistance of the latter will be correspondingly increased or diminished.

Referring now to Fig. 11, H is a dynamo-electrical machine having its poles connected by the main conductors A′ B′ with the switch-board I, (of the construction shown in Figs. 3 and 4, and described with reference thereto,) in which center a number of branches, *c* d**, which include translating devices shown as arc lights L. In each of these branches, in addition to the translating device, is a self-adjusting rheostat, which is adapted also to be adjusted by hand, the same comprising a rheostat proper (of the construction shown in Figs. 5 and 6) and an electric governor (of the construction shown in Figs. 1 and 2) having the shaft of its rotary armature *b z* connected by worm-gearing with the switch-lever C of the rheostat proper. The coil of the relay-magnet A B is connected in the wire *d** of the appropriate branch between the binding-post F and the terminal-spring *a″* on the switch-board I. The relay-armature *α β* operates, as the current through the coils rises above or falls below the normal, to close the local-battery circuit at the contacts $t\ t^2$ or $t'\ t^3$, so that the current of the said battery traverses the coils of the revolving armature *b z* in one direction or the other, and causes said armature *b z* to revolve in the direction required for moving the switch-lever C to correct the variation. The hand adjustment is effected by altering the position of the weight *p* (see Fig. 1) so that it will balance the attraction caused by a greater or less current in the coils of the relay. At the switch-board I, where the branches center, a secondary battery is placed in a loop, 501, derived from the main conductors A′ B′, and permanently connected with the terminals of said conductors.

The dynamo-electrical machine is driven by a steam-engine the supply to the cylinder of which is controlled by an electric governor of the construction shown in Figs. 1 and 2. The relay is excited in a loop or branch, K, and the rotary armature *b z* of the motor is connected with the supply-valve through the worm-gearing 500 in such a way that when the current in the relay increases above the normal the armature turns the valve in the direction for cutting off the steam, and when the circuit decreases it turns the valve in the opposite direction and increases the supply of steam. The supply of steam controls the speed of the dynamo-electrical machine, and consequently its electro-motive force. The loop or branch K, containing the electric governor, is connected with the main conductors at the centers where the connection of the branches is made—that is, at the switch-board I—so that the potential of the said centers will be kept constant, and consequently the current through each translating device will depend solely upon the resistance in its own branch, and not at all upon the number of branches in circuit, whereas if the loop or branch K were connected directly with the poles of the generator H the resistance of the main conductors A′ B′, being common to all the branches, would cause the current in any branch to vary with the number of branches in circuit, the difference in potential between the poles of the generator being kept constant.

In operation, whenever a lamp is to be lighted, the corresponding prism, P, or the switch-board I is turned into the position shown in Figs. 3 and 4. The current then enters the branch circuit, and the difference in potential between the terminals of the main conductors is immediately diminished, so that the current in the loop or branch K diminishes, the weight retracts the armature *α β* and closes the circuit through the rotary armature, which thereupon revolves and turns the valve connected with it, supplying more steam to the engine driving the dynamo until the increased speed of the latter restores the normal difference in potential at the switch-board I. The armature *α β* then breaks the connection of the rotary armature *b z* and remains in equilibrio until some new disturbance brings it into action. If a lamp is to be extinguished, the proper prism P is turned, so as to cut the branch entirely out of the circuit. The difference in potential between the terminals of the main conductors is thereby increased, the current in the governor-relay at the generating-station rises, and the electric governor immediately diminishes the supply of steam to the prime motor, reducing the speed of the dynamo-electric machine until the normal difference in potential at the terminals is restored.

It is obvious that the connection or disconnection of one branch will, if other branches are in circuit, disturb to a certain extent the current in the others; but the relay at the generating-station being very delicate, it will almost immediately cause the motor or rotary armature to move the supply-valve so as to restore the normal conditions. In some cases the corrective action of the electric governor at the generating-station may be sufficient; but in many cases, especially where the center of distribution or switch-board I is at a considerable distance, it is desirable to use additional means for preventing fluctuations in one derived branch from the opening or closing of another. The secondary battery at the center of distribution, so soon as the difference of potential between the terminals, or, as it may be called, the "electro-motive force" at the center of distribution, falls or rises, commences to discharge or to absorb the electrical energy, and thus prevents any great change in said electro-motive force until the increased or diminished speed of the dynamo-electrical machine restores the normal conditions. The electric governors in the translating branches also assist in preventing fluctuations from this as well as from other causes, for as soon as the electro-motive force at the center of distribution falls below or rises above the normal, the said governors diminish or increase the resistances of their respective branches, so as to maintain uniform the current therein, notwithstanding these variations at the center of distribution. If it be desired to increase or decrease the current supplied to any translating device, the weight or the vibratory armature of the relay can be shifted to increase or diminish its retractile power. Thus if it be desired to increase the current the weight will be moved a suitable distance away from the fulcrum, and the electric governor will shift the switch-lever C until the normal resistance of the branch is sufficiently diminished.

If the rheostats be used without any electric governor, as shown in Fig. 10, the switch-lever C is turned by hand. Of course in the latter case the electrical adjustment to correct fluctuations is lost.

In Fig. 11 the alteration in the electro-motive force of the generator is effected by alterations in the speed of the dynamo-electrical machine, and by the alterations in excitation of the field-magnets, which would, as shown, (the field being excited in a derivation of constant resistance,) follow as a consequence upon the alterations in speed; but means other than those for altering the speed could be used. For example, the electric governor could be made to increase or decrease the resistance of the branch including the field-magnets, so as to vary the strength of the field, and thus change the electro-motive force without altering the speed. Such arrangement is shown in Fig. 12, wherein a switch-lever, C, connected by worm-gearing with the shaft of the armature *b z*, successively cuts out or connects in resistance-coils, not shown, but connected with the contact-plates *g*, like the wire *f*, Fig. 5, according as it is turned in one direction or the other.

In order to notify the attendant at the generating-station whether or not any derived branches are in circuit, galvanometers S T, respectively, are placed in the main circuit A′ B′ and governing branch K. When the indications coincide, all the consumption or translating branches will be cut out, because, in order that they may coincide, the whole current which passes through the galvanometer S must pass as well through the galvanometer T. As soon, however, as one or more of the branches c^* d^* are connected in circuit, the current through the galvanometer S is increased, while that through the galvanometer T remains as before. The number of branches c^* d^* in circuit will also be indicated by the position of the galvanometer-needle, because the current through the instrument S increases with the number of branches in circuit.

In Fig. 10 the dynamo is not illustrated, nor the governing branch, nor the secondary battery, and the electric governor for adjusting the rheostat in the branches is also omitted. The switch-levers C are to be turned by hand.

Where a large district is to be supplied, it would not be convenient to have a separate branch for each translating device or each set of translating devices, as shown in Figs. 10 and 11. In such cases the dispositions illustrated in diagrams Figs. 7, 8, and 9 could be adopted. One or more centers of distribution, V or *v*, are made at suitable points, and there is a net-work of conductors, a^*, connected with each center, while a governing branch or loop, K, extends from each center to the generating station X, where it passes through the relay of the electric governor. The branches containing the translating devices are connected with these conductors at suitable points, and include or may include adjustable rheostats, as shown in Figs. 10 and 11. No return-circuits are shown in Figs. 7, 8, and 9. The lines are represented as grounded; but it is obvious that return-conductors could be used in place of grounding. The main conductor A′ and the conductors of the consumption or translating branches are shown in full lines, while the governing branch or loop K is represented in dotted lines. At each center of distribution a secondary battery may be used.

The dotted lines around the conductors in Figs. 7, 8, and 9 indicate the boundaries of the cities or districts to be supplied, the generating-station X being outside of the same.

When possible, it is desirable to regulate the relative resistances of the derived branches, arranged as shown in Figs. 10 and 11, by the following method: Having ascertained the resistances of a translating device—say an arc lamp and circuit, and utilizing the whole current of the generator—multiply the resistance of the translating device by the number of derived branches. To obtain the resistance of each device to be placed in the several branches, and having reduced to a minimum the resistances of the generator and main conductors, which are common to the circuit of all the translating devices, subtract this minimum from the resistance of the circuit ascertained as above, and multiply the remainder by the number of branches for the resistance of each branch. Thus if the generator be a Gramme machine, furnishing a current of thirty webers under an electromotive force of one hundred volts, the resistance of the total circuit would be three and thirty-three one-hundredths ohms, (3.33,) and of the lamp (constituting the translating device) one-half that, or one ohm and sixty-six and one-half hundredths, (1.665.) If there be three lamps in derivation, as shown in Figs. 10 and 11, the resistance of each lamp will be three times the above, or four and ninety-eight hundredths ohms, (4.98,) and may burn a carbon of about nine millimeters in diameter, that having approximately one-third the cross-section of the carbon, (of 16 millimeters,) which it has been found advisable to employ in using the whole current in one lamp. Reducing the resistance of the generator and the main conductors to a minimum—say to twenty-five (.10+.15) one-hundredths of an ohm—subtracting this from 1.665 ohms—the resistance of the circuit outside the lamp—and multiplying the remainder by three, (the number of branches,) we have $3\times1.415=4.245$ ohms, as the proper resistance for each branch. Under these conditions the current will be utilized in the most advantageous manner, the speed and electro-motive force of the generating-machine varying but little, and the energy expended in each light being approximately one-third of the whole, whether the other lights are burning or not.

It is obvious that if a galvanometer were placed in the governing branch or loop K it would give indications whereby an attendant could regulate the electro-motive force of the generators by hand. The use of the automatic governor, however, relieves the attendant of the special care which otherwise would be required.

Cylindrical blocks could be used in place of the prisms P of the switch-board I. The contact-pieces should be a sufficient distance apart to prevent a spark from passing when a branch is opened or closed. They are preferably of copper, and the springs a' b' and a'' b'' of nickeled iron.

The wire f of the rheostats is preferably iron wire, tinned, nickeled, or silvered. The judicious use and multiplication of the centers of distribution V or v, Figs. 7, 9, permit the employment of thick wires on short lengths only in the positions where they would be most useful. It insures a good division of the electricity in the net-work with a mininum cost.

I do not make claim herein to the electric governor or rheostats or switch described, unless when used in the system explained; but the said instruments are of my own invention and are believed to be new devices, and I reserve the right to make separate applications therefor.

I am aware that heretofore a telegraphic switch has been devised for introducing a loop into the main line at an intermediate station without breaking said main line, the object being to connect or disconnect at will the office-instruments at the intermediate station without interfering with the transmission of messages which may at the time be passing over the main line. This switch operated to break the connection of the loop at both ends simultaneously; but it also operated to connect with each other the main-line contact, so that the main line was complete. In the present invention the switch, when turned to disconnect one of the loop branches, leaves a break between the main-circuit contacts at that switch. This is essential, for if said contacts were connected, the loop branches remaining in circuit would be short-circuited. No claim is therefore made to the combination of switches with the loop branches and main circuit, unless the said switches are so constructed and arranged that when a switch is turned to cut out a loop branch the connection between the main conductors is broken at that switch.

Having now fully described my said invention and the manner of carrying the same into effect, what I claim is—

1. The combination, with a series of translating devices in branches of a common circuit, of self-adjusting rheostats operated electrically, included in the same branches with the translating devices, for increasing or decreasing automatically the resistance of said branches as the current through the translating devices rises or falls, substantially as described.

2. The combination, with translating devices in branches of a common circuit, of self-adjusting rheostats adjustable also by hand to vary the normal resistance thereof, said rheostats being placed in the same branches with the translating devices, so that when set they maintain the current through the translating devices at a given strength, and when desired may be adjusted by hand to vary the said current, substantially as described.

3. The combination, with translating devices in branches of a common circuit, a generator for supplying electricity to said circuit, and adjustable rheostats in the said branches, of an automatic electric governor for controlling the electro-motive force of said generator, substantially as described.

4. In a system of distributing electricity, the combination, with the main circuit and the derived or looped branches containing the translating devices, of switches for connecting and disconnecting simultaneously both wires of the loop branches, the connection of the wires of the main circuit being broken at each switch when the corresponding branch is cut out, substantially as described.

5. The combination, with translating devices

in branches connected with the main circuit at common points or centers, and main conductors extending from said centers to the generating-station at a distance, of a governing branch returning from said centers to the generating-station, substantially as described.

6. The combination, with translating devices in branches connected with the main conductors at common points or centers, of secondary batteries included in a loop or branch, also connected with the main conductors at said centers, substantially as described.

7. The combination, with the translating devices in branches, and the generator for supplying electricity to the circuit, of the secondary battery in a loop or branch, and an electric governor for controlling the electro-motive force of the generator, also placed in a loop or branch, substantially as described.

8. The combination, with translating devices, a generator, and the conductor forming a circuit, of the secondary battery in a branch or loop, and self-adjusting rheostats in the same branches, which include the translating devices, substantially as described.

9. The combination, with translating devices, a generator, and conductors forming a circuit, of the secondary battery in a loop or branch, the self-adjusting rheostats for controlling the resistance of the branches, including the translating devices, and the electric governor for controlling automatically the electro-motive force of the generator, substantially as described.

10. The combination, with translating devices in branches of a common circuit, the conductors constituting said circuit, a generator, and a governing branch, of a galvanometer or similar instrument in the main circuit, and an additional one in the governing branch, whereby the attendant at the generating-station may ascertain when the translating devices are all out of action, substantially as described.

11. A system of electric lamps, generator, and conductors comprising a generator and main conductors of low resistance, a number of translating devices, each having a resistance as many times as great as that of a lamp using the entire current as the number of translating devices is greater than one, and being included in a separate branch having a resistance equal to that of the circuit supplying a single lamp increased in the same proportion, the common resistances of the generator and main conductors first being deducted, substantially as described.

12. A system of distributing electricity, comprising, in combination, main conductors extending to a distance, a generator having its poles connected with said conductors, a series of branches derived from said conductors at common points or centers, a switch-board through whose contacts the said branches are connected with the main conductors, translating devices and self-adjusting rheostats in the said branches, a loop permanently connected with the main conductors at the said centers, a secondary battery in the loop, a governing branch derived from the main conductors at the aforesaid centers, means for controlling the electro-motive force of the generator, an electric governor operating said means and placed in said governing branch, a galvanometer in one of the main conductors, and a second galvanometer in the governing branch, said self-adjusting rheostats being provided with devices to be set by hand for varying the normal resistance or resistance which each rheostat has when the normal difference in potential between the aforesaid centers is maintained, and said self-adjusting rheostats being also provided with or comprising a rheostat proper having a resistance-wire, a series of contacts, and a switch-lever, and an electric governor having a relay and an electric motor, the latter connected with the switch-lever and the aforesaid electric governor for controlling the electro-motive force of the generator, in like manner comprising a relay and a motor, and the said switch-board having independent prisms, with a duplicate set of contacts for making or breaking the connection of both conductors of the derived translating branches, and the resistance of the translating devices and of the derived translating branches being adapted to the construction of the generator, all substantially as described.

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

ALPHONSE ISIDORE GRAVIER.

Witnesses:

ALFRED COINY,

ROBT. M. HOOPER,

U. S. Consulate-General.