(No Model.) 2 Sheets—Sheet 1.

E. THOMSON.

SYSTEM OF ELECTRIC DISTRIBUTION.

No. 496,020. Patented Apr. 25, 1893.

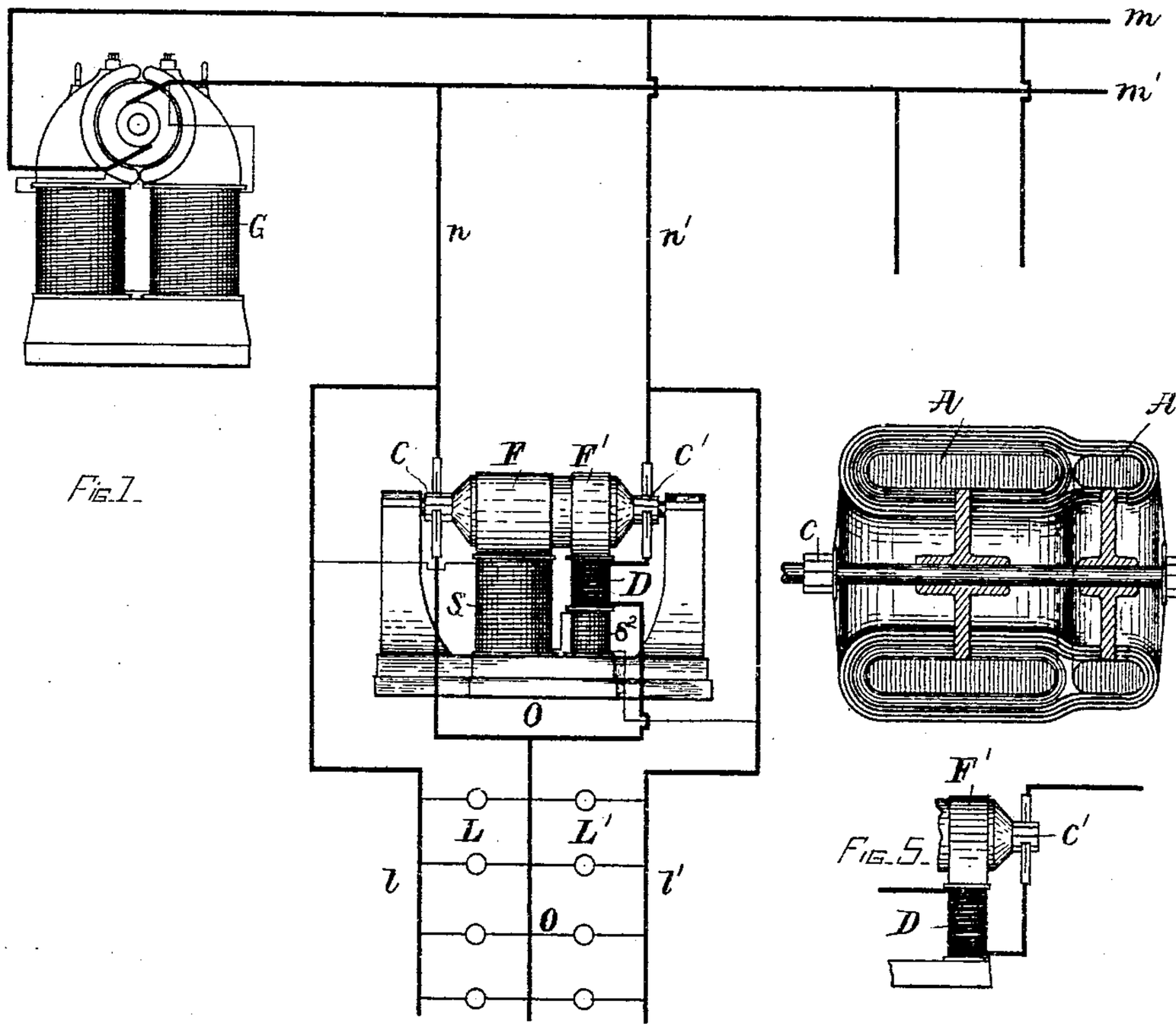

Fig. 1.

Fig. 3.

Fig. 5.

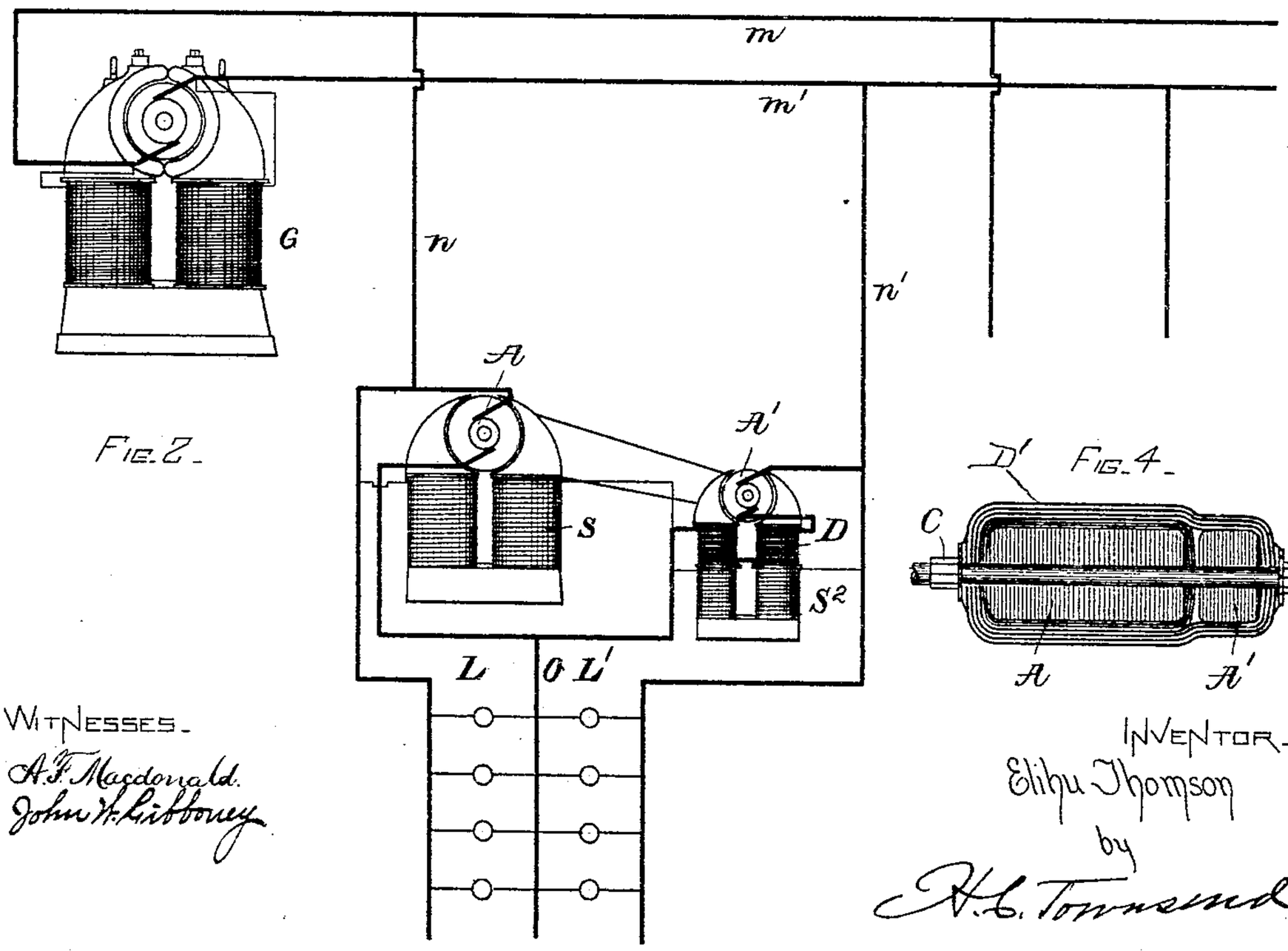

Fig. 2.

Fig. 4.

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FIG. 6.

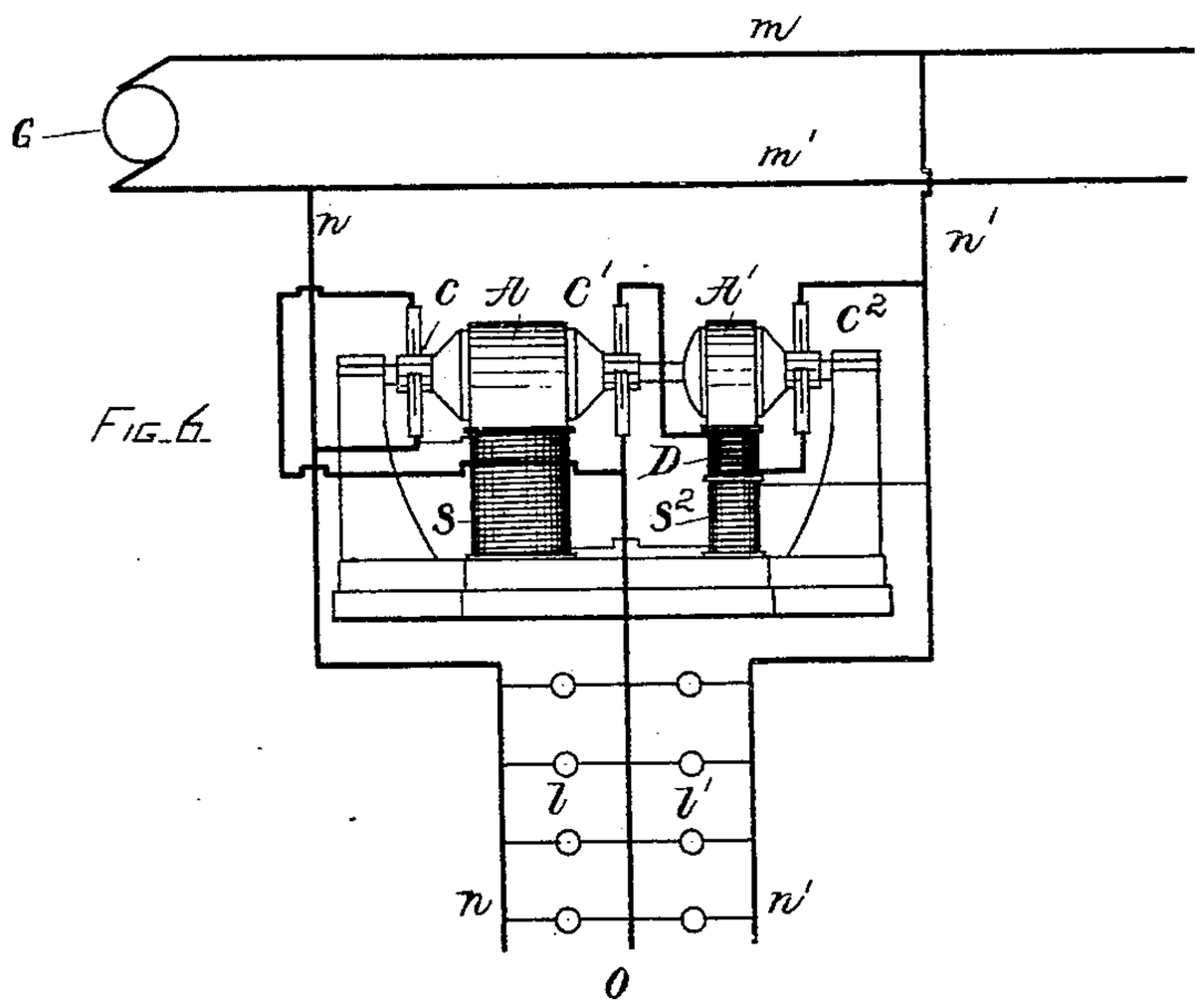


FIG. 7.

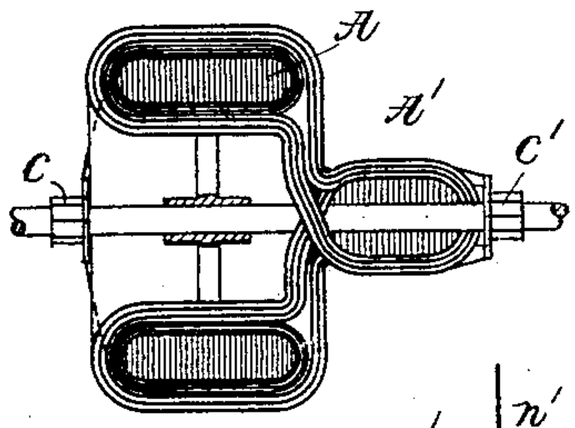
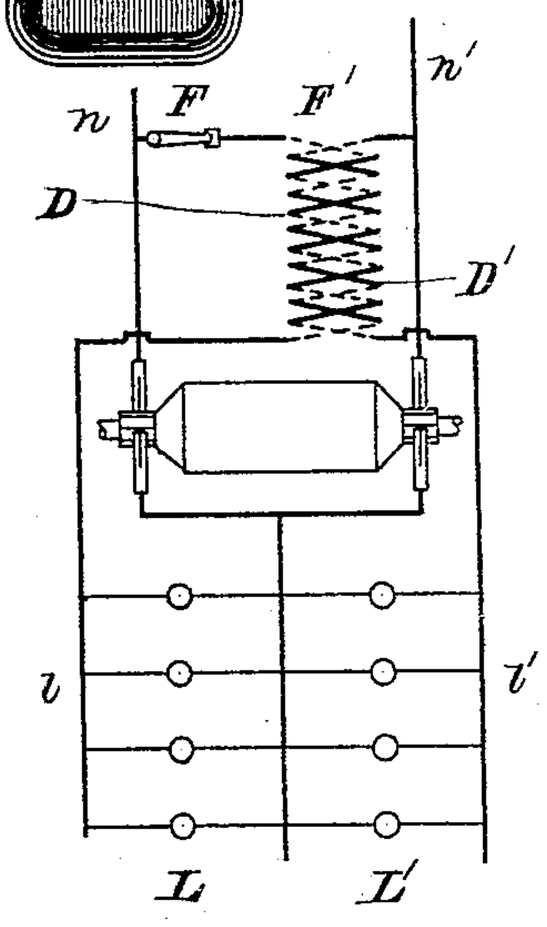


FIG. 8.



WITNESSES.

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UNITED STATES PATENT OFFICE.

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SYSTEM OF ELECTRIC DISTRIBUTION.

SPECIFICATION forming part of Letters Patent No. 496,020, dated April 25, 1893.

Application filed December 29, 1890. Serial No. 376,166. (No model.)

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, and a resident of Swampscott, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Systems of Electric Distribution, of which the following is a specification.

My invention relates to those systems of distribution in which there is a division of the circuits in two parts or portions constituting together what is known as a series multiple arc system, and its object is to provide for an adjustment of the potential in the various parts or portions of the system on changes of load. My invention is designed principally, however, as an improvement on a system heretofore devised by me (Patent No. 360,125, dated March 29, 1887), and involving the use of energy transformers between the sides or portions of the system designed to abstract energy from a side whose load may fall below normal and transform it into energy which shall feed a side or portion of the system wherever the potential is subject to fall or which becomes comparatively more heavily loaded than the first named portion.

With transformers organized to have their sides affected in direct proportion to the change of potential on a side of the system as in that patent, there is a failure of the more heavily loaded side to re-acquire its full potential under the action of the energy transferring apparatus, and my present invention is designed to remove the defect, to which end the invention consists broadly in automatically augmenting the capacity of a side of the apparatus, as generator or motor, as the case may be, so as to bring the transfer up to the full amount and compensate for the tendency of the heavily loaded side of the system to not quite reach its normal potential under the influence of the energy transferring device. In other words I change the relative efficiency of the two sides of the machine, as electro-motive force generators, in accordance with changes in the relation of potential or load on the two portions of the system in which the potential is to be re-adjusted.

My invention consists further in the novel methods of compensating or regulating the actions of the energy transferring device applied in a system of series multiple arc distribution, and in certain novel combinations of circuits and apparatus involving the use of a machine of the general character described in another application for patent filed by me December 19, 1890, Serial No. 375,197, and wherein I have shown a transformer having an auxiliary magnetic field for a conductor in circuit with or forming an extension of one of the circuits or windings of the transformer the two circuits or windings of which, inductively related to one another, are in the same magnetic field.

In the accompanying drawings:—Figure 1, is a general diagram of apparatus for practicing my invention. Fig. 2, illustrates a modified apparatus for practicing the invention. Figs. 3, 4 and 7, are longitudinal sections of forms of armature that may be used in the machine. Fig. 5, illustrates a modification of the regulating or auxiliary electro-magnet. Fig. 6, is a further modification in the arrangement of the apparatus. Fig. 8, is a further modification in the manner of exciting the auxiliary or regulating magnet in accordance with changes in the relative load of the two portions of the system between which a transfer is to be made.

In Fig. 1, G, is the generator supplying the line with a certain potential and mains leading therefrom shown at m, m'. Branches are taken from the mains leading directly to a machine on the line n, n', which machine is a compensator or transformer of electric energy from one side of the system to the other. The outside lines of the two portions or parts of a system in which changes of load and relation of potential take place are indicated at l, l', while O, is the intermediate or middle wire leading from a point of the system between such two sides or portions. L, are lamps or other devices fed in multiple from one side, and L′, devices fed in multiple on the other side. The outside wires connect to the mains or wires of constant or approximately constant potential in the usual way. The machine which effects a transfer of energy, (in case the lights L or L′, are cut out,) from the lightly loaded side to the other or

heavily loaded side where potential will fall under such circumstances, has upon it two armature windings, and these armature windings terminate in commutators C, C′. The commutator brushes, are connected, respectively, as shown to the mains or wires and the arrangement is such that one of the windings shall at one time act as a motor winding, while the other winding in the field can generate current for the heavily loaded side, or vice versa. Such an arrangement is shown in my prior patent, No. 360,125, and the present invention is an improvement thereon, and is preferably carried out by using my continuous current compensator which is compounded for differences of load.

When the arrangement forming the subject of my previous patent is used without the compensation or regulation such as is herein provided, and the potential or load drops on one side or portion of the system, the transfer of energy to the heavily loaded side is insufficient to fully make good the drop due to the primary change of loading in the other side, and the heavily loaded side will still have a lower potential than it should have, while the lightly loaded side will be at a higher potential than it should be.

In the device or arrangement herein shown in Fig. 1, there is an auxiliary field pole or magnet F′, which is made to vary in strength by means of the regulating coil D, and which acts on a supplemental or auxiliary armature core A′, carrying a winding or part of winding in circuit with or forming an extension of one of the windings acted upon by magnet or core F, which is for the main or principal portion of the apparatus and provides a field that is of substantially constant strength maintained in any manner for the two armature windings placed on core or section of core A, and connected respectively to the two portions of the system between which transfer is to be effected.

The windings on the armatures are shown in Fig. 4, where one winding, connected with the commutator C, overlaps the portion of the armature core A, while the other winding D′, is wrapped over that and the additional or auxiliary portion A′, of the core and is connected to the commutator C′. These windings under normal conditions would be about equally effective for electro motive force development when revolving in the field. The field itself, as shown in Fig. 1, is energized by a shunt coil S, taken across the mains n, n', to provide constant excitation. The field F′, is made variable in strength by the action of coil D, either alone or in conjunction with another coil so as to secure a differential action. In the present instance a coil S^2, in circuit with S, provides an excitation constant in amount, and the coil D, when traversed by current tends to cut down the magnetism which is normally of a character to act upon the portion of winding moving in it so as to develop an electro-motive force of the same sign in the circuit as that developed by F, in that one of the armature windings with which the former is in circuit. The coil D, is traversed by current which varies with the potential on the side L′, of the system to which commutator C′, is connected. Such a variable current may be caused to flow in any desired way, automatically or otherwise, and directly or indirectly from such variations of potential. It is preferable, however, for simplicity, to connect the coil D, into a circuit with one of the transformer circuits, as that connected with the side L′, of the system. In this way, the magnetism produced by the coil S in the field F, is practically constant, while the magnetism of the other poles or field F′, is variable with the work or load. If preferred the changes of magnetism of the field F′, may be produced by the direct winding D, as in Fig. 5, and the shunt winding S^2, omitted. In this case the coil D, would normally or when the load is even or properly proportioned carry no or little current and the magnetism of F′, would normally be of no effect in one way or the other, either to assist or oppose the efficiency of the side of the transformer connected to C′. If the side L′, were less heavily loaded current flowing in the coil D, would flow in a direction to develop magnetism in F′, of a sign to produce an electro-motive force assisting the applied electro-motive force in the winding of C′, under F, this being the action through the whole range of variations, while in the case of the differential magnet the action would be first a diminution of counter tendency passing to zero and then rising in a way to produce an electro-motive force assisting. Under very light loads or under even loads on the two sides of the line O, the effect is in Fig. 1, that the coarse winding D, on the accessory field F′, is ineffective as it is traversed by little or no current, but on a difference of load existing as though L, were the heavily loaded side and L′, were not, then a certain current passing through D, magnetizes the core on which it is wound in such a way as to increase the potential on the side L, at the expense of the potential on the side L′. This it would do in the case in question by acting in opposition to the magnetism on the side of the core on which it is wound or opposing the magnetism produced by the coil S^2, on the field F′, thereby rendering the winding connected to the commutator C′, less effective in developing an electro motive force which would oppose the passage of current through the two parts of the winding while not affecting the field of the commutator C. In other words with a certain difference of potential on the side L′, the coil D, would cut down the magnetism of F′, or might carry current sufficient to render it *nil* or to even reverse the magnetism in which case the electro-motive force developed would be now in a direction to assist the applied electro-motive force tending to cause flow of current in the winding of C′, which is in the field F. The relative efficiency

of the two sides of the apparatus or a change in the relation equivalent to a change in the effective length of the two inductively related windings, would therefore be produced and such change would follow the change in the difference of potential on the lightly loaded side or the change in the relative potentials of the two sides of the system. This would make the relation between the windings such that a higher potential would be developed at C, than would exist at C′, consequently the heavily loaded side L, would receive the higher potential and sufficient to restore the normal potential. If the reverse were the case and L′, were the heavily loaded side then the effect would be reversed and the effect on the windings reversed and in any case a compensation effected. In this case the potential on the side L, being greater the winding connected to C would carry a greater current while on the side of less potential L′, the electro-motive force developed in the portion of winding exposed to the action of F′, would rise and would assist or supplement that developed in that one of the windings in the field of F, which connects to C′, and which in such case would raise the potential on the side L′. In this case the armature winding as it now is made to feed the side L′, would pass current through D, in a direction to increase the magnetism of F′, and such auxiliary field would serve to augment the transfer of energy so as to keep the side L′, up to the normal potential.

Either the forms of armatures Figs. 3 or 4, or other forms may be used. In Fig. 3, the portion of the core A, which is a ring core is wound with a set of coils connected to the commutator C only, and the two core sections A, A′, are wound with another set of coils which are connected with the commutator C′, and the relations of the fields are such that the field surrounds a larger portion of the armature core, and the field F′, affects only the portion A′, but of course other forms of armature having the same properties might be employed and sometimes without an iron core.

In Fig. 5, the direct coil affects the smaller field and does so in the same way as in the former figures only that its effect is not differential, that is the core at times is absolutely dead or free from magnetism and at other times the core will be affected by current passing through the coil D, in one direction or the other according as energy is being fed from side L′, to L, or from L, to L′. In the first case when the difference of potential on the side L′, increases with decrease of load L′, and relative increase of load L, the current will pass through the coil D, in one direction to feed the transformer winding on the side thereof connected to L′, and such feeding and consequent reinforcing action of the additional coil F′, will obviously continue so long as a variation from normal difference of potential exists. In this case the magnetism of F, will produce an electro-motive force tendency aiding the winding of the transformer which is for the time being the motor winding and is required to transfer energy to the heavily loaded side, just as in the case of Fig. 1, where the current in D, is sufficient in amount to reverse F, and give it a polarity due to the winding of D. In the other case when the difference of potential falls on the heavily loaded side L′, and current is therefore fed from the side of the transformer connected to L′, the auxiliary coil D, will be traversed by current in the opposite direction and the electro-motive force will be raised by the action of the supplemental field magnet F′, which will now be of polarity to assist that developed in the transformer winding feeding under the action of F.

In Fig. 2, the arrangement is a little modified since the energy transferring portion of the machine is separated into two machines and the two armatures connected together, that is I may have in the machine, if I choose, two armatures A and A′, of the same or of different size one affected by the shunt field and geared or belted one to the other, the armature A′, being affected by the shunt field and also by the direct field. By proportioning the parts the same effects may be obtained as in the machine Fig. 1, but it is not a desirable structure as it involves two machines, and involves also an adjustment of the commutator which objections are largely avoided by the construction Fig. 1.

Another modification similar in its effects is seen in Fig. 6. Here the effect is the same, but there are three commutators. The armature A, has two windings and the second auxiliary armature A′, has its single winding connected to the commutator C^2. The larger armature A, with its two windings is affected only by the shunt coil S, or other coil acting upon its field and the smaller armature A′, is affected by the direct and shunt windings D, S′, as before, or the direct coil only (D,) may sometimes be employed. The two windings one connected to the commutator C′, and the other to C^2, on the small armature, virtually act as one winding by being connected in series as shown and therefore take the place of the arrangement Fig. 7.

The arrangement Fig. 7, is a combination of what is shown in Figs. 3 and 4, that is the armature section or armature core section A, is shown as a ring and has a winding which connects to the commutator C, while the armature core section A′, is a Siemens core which has a winding passing over the main armature section and over this core and terminating in the commutator C′. Manifestly the effects are the same as in the former figures, the only difference being that the field has to be modified in its proportions and arrangements to suit.

Fig. 8, illustrates a modification in the manner of providing for a variable auxiliary excitation acting upon a side or circuit of the transformer to change in the relative electro-motive force efficiency in accordance with

changes in the load. In this case the said variable field is produced by one or the other of two coils D, D′, which oppose and neutralize one another when the load is even and which are connected with the main wires leading to the two sides of the system. When the side L, has the greater load, the coil D, in the main circuit of such side has the greater current and develops magnetism which assists the side of the tranformer which is abstracting energy from L′, for transfer to L, just the same as the coil D, Fig. 5. When the other side L′, has the greater load the coil D′, which is wound in the opposite direction has the greatest current and acts just as the coil D, Fig. 5, to reinforce side C′, of the transformer operating as a generator.

It will be obvious that my invention is not limited to the number of divisions of the system which are to have their relations of potential kept uniform. It is likewise obvious that the invention is not confined to applying the auxiliary or compensating action to a single side of the energy transferring devices only, and although in my claims I mention one side as having the device applied, I do not of course exclude its simultaneous application to the other side. If applied, however, to the other side or sides, the regulating action would of course be in the opposite way so as to decrease the effectiveness on one side when simultaneously increasing it in the other or vice versa.

What I claim as my invention is—

1. The herein described method of supplementing the transfer of energy from one to another portion of a system of electrical distribution so as to avoid a drop of potential on the heavily loaded portion, consisting in varying an auxiliary magnetic field in accordance with changes in the relation of the load on the said portions of the system between which the transfer is to take place and subjecting a moving conductor in circuit with an armature conductor of the transfer apparatus to the action of such field.

2. The herein described method of regulating the action of an energy transferring apparatus placed between different portions of a circuit subject to changes in their relative loads, consisting in subjecting one or both sides of the machines to the action of an auxiliary regulating coil or coils, and varying the current in such coil or coils in accordance with the changes in the relation of the loads in the two portions of the circuit between which a transfer is to take place.

3. The herein described method of regulating the transfer of energy from either side to the other of a system of distribution, consisting in transferring the energy from that side on which the potential rises above the normal to that on which it falls below, and at the same time varying a magnetic field or fields acting upon the circuit of one or both sides of the transfer apparatus so as to supplement or augment the transfer and restore the potentials to normal.

4. In a transfer apparatus connected to circuits as and for the purpose described, the method of regulating the capacity of the machine in transferring energy from a more lightly loaded to a more heavily loaded part of the system, consisting in subjecting a side or portion of the apparatus to the action of an auxiliary or compounding or regulating coil carrying current varying with the load, and adapted to change the relative efficiency of two sides of the transfer apparatus.

5. In a system of electric distribution, the herein described method of regulating the distribution of energy in different parts or portions thereof, consisting in transforming or converting the energy of the side on which the potential rises into energy on a side or portion in which the potential falls, and varying an auxiliary magnetic field for a conductor in circuit with a coil or conductor of the transforming apparatus in accordance with variations in the relative proportions of load on the two portions of the system from normal.

6. The combination with a series multiple arc system, of a continuous-current energy-transformer connected to main and middle or intermediate wires, and provided with a compounding or regulating field magnet coil D, as and for the purpose described.

7. In a system of electric distribution, the combination with two parts or portions of circuit fed from the same mains but subject to variations of the relative potential from normal, of a converter comprising two armature circuits or conductors connected to said parts and revolving in a common magnetic field, and an auxiliary magnetic field variable with a change in the relative load on the two parts and constituting a field for the conductor which forms an extension of the circuit of said armature conductors.

8. In a multiple series system of distribution, the combination with sides or portions of the system in which the relation of potential is subject to variation, of a converter connected to the outer wires and an intermediate wire of said portions, transformer circuits or conductors connected respectively to said portions and in a common magnetic field, an auxiliary variable field variable with the load of a side or portion of the system, and a conductor therein forming an extension of the circuit of one of said transformer circuits.

9. The combination with a multiple series system of distribution, of an energy transferring apparatus connected to the outer and intermediate wires of portions of the system subject to change of load and comprising connected armature circuits or conductors mounted on the same or connected shafts and revolving in a suitable field or fields, and an auxiliary field magnet coil for augmenting or reinforcing the action of a side of the apparatus, as motor or as generator, according to

the changes of potential on the side or portion of the system to which it is connected.

10. In a system of electric distribution, the combination with two portions of the circuit subject to changes in their relative potential, of sets of armature wires or conductors mounted on the same shaft and revolving in the same field, a connection from one terminal of both armatures to an intermediate wire of the system, connections from the remaining terminals to outer wires of the system respectively, an auxiliary variable magnetic field, and an armature conductor revolving therein and included in the circuit from one of said armature terminals, as and for the purpose described.

11. The combination with outer and intermediate wires for different portions of a system of distribution, of an armature carrying different windings connected to said wires as described, an auxiliary armature, and a differential field-magnet therefor wound with two coils one carrying constant current and the other current varying with the potential on a side of the system, said auxiliary armature having conductors in the circuit of a winding on the former armature, as and for the purpose described.

12. The combination with a system of distribution, of an armature A, having two windings, an armature A′, having a winding forming an extension of a winding upon the first, a constant magnetic field for the first armature, an auxiliary field magnet for the armature A′, a coil or coils for said field magnet carrying current varying with the load on a side or portion of the system, connections from both armature windings to an intermediate portion of the system, and connections from the opposite terminals of the armature windings to outer wires of the two portions of system subject to variations in their relative potential.

Signed at Lynn, in the county of Essex and State of Massachusetts, this 22d day of December, A. D. 1890.

ELIHU THOMSON.

Witnesses:
JOHN W. GIBBONEY,
BENJAMIN B. HULL.