No. 721,128. PATENTED FEB. 17, 1903.

F. H. LOVERIDGE & C. D. HASKINS.

MULTIPLE SERIES SYSTEM OF ELECTRICAL DISTRIBUTION.

APPLICATION FILED NOV. 9, 1896.

NO MODEL. 4 SHEETS—SHEET 1.

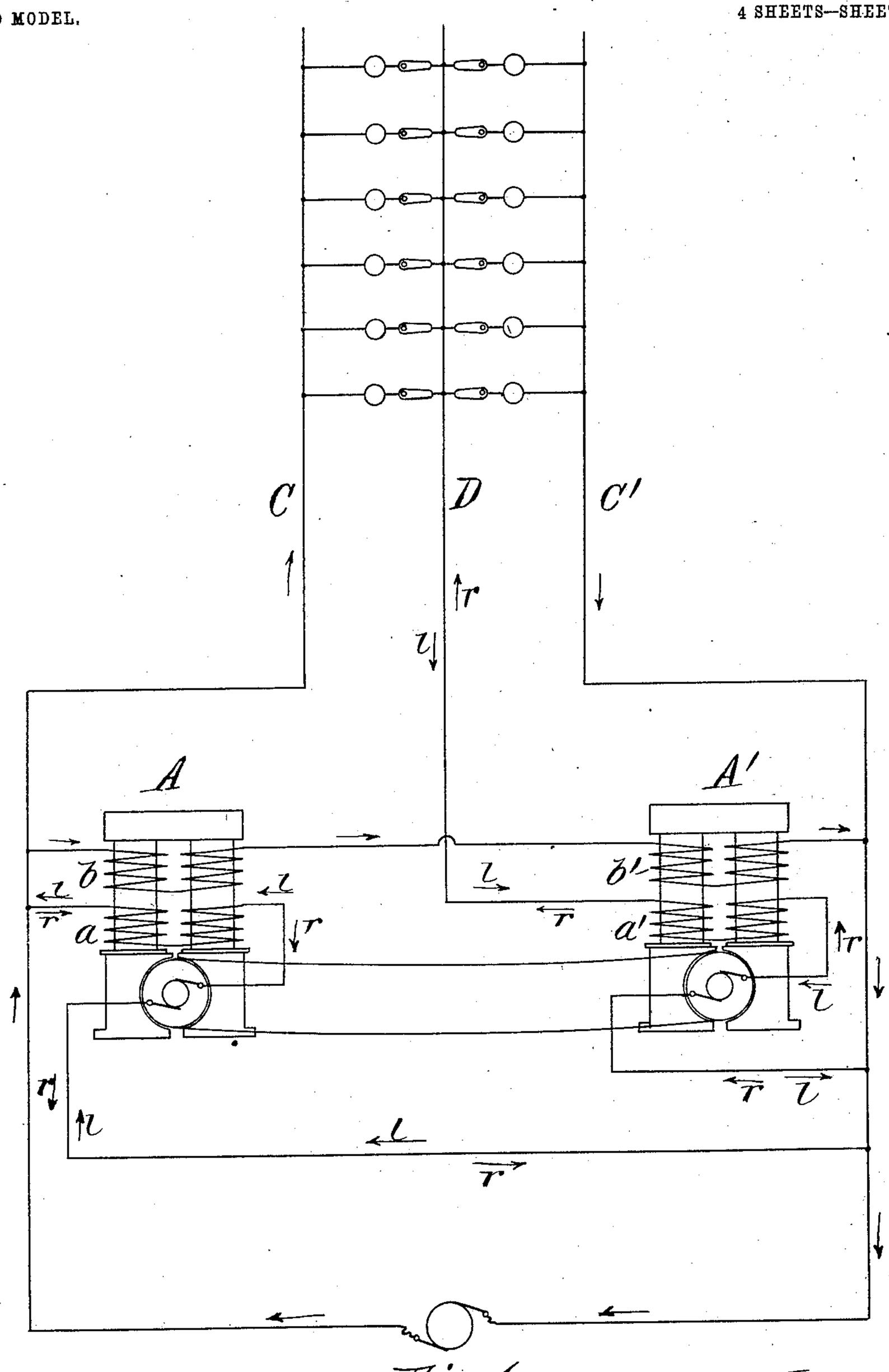

Fig. 1.

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NO MODEL. 4 SHEETS—SHEET 2.

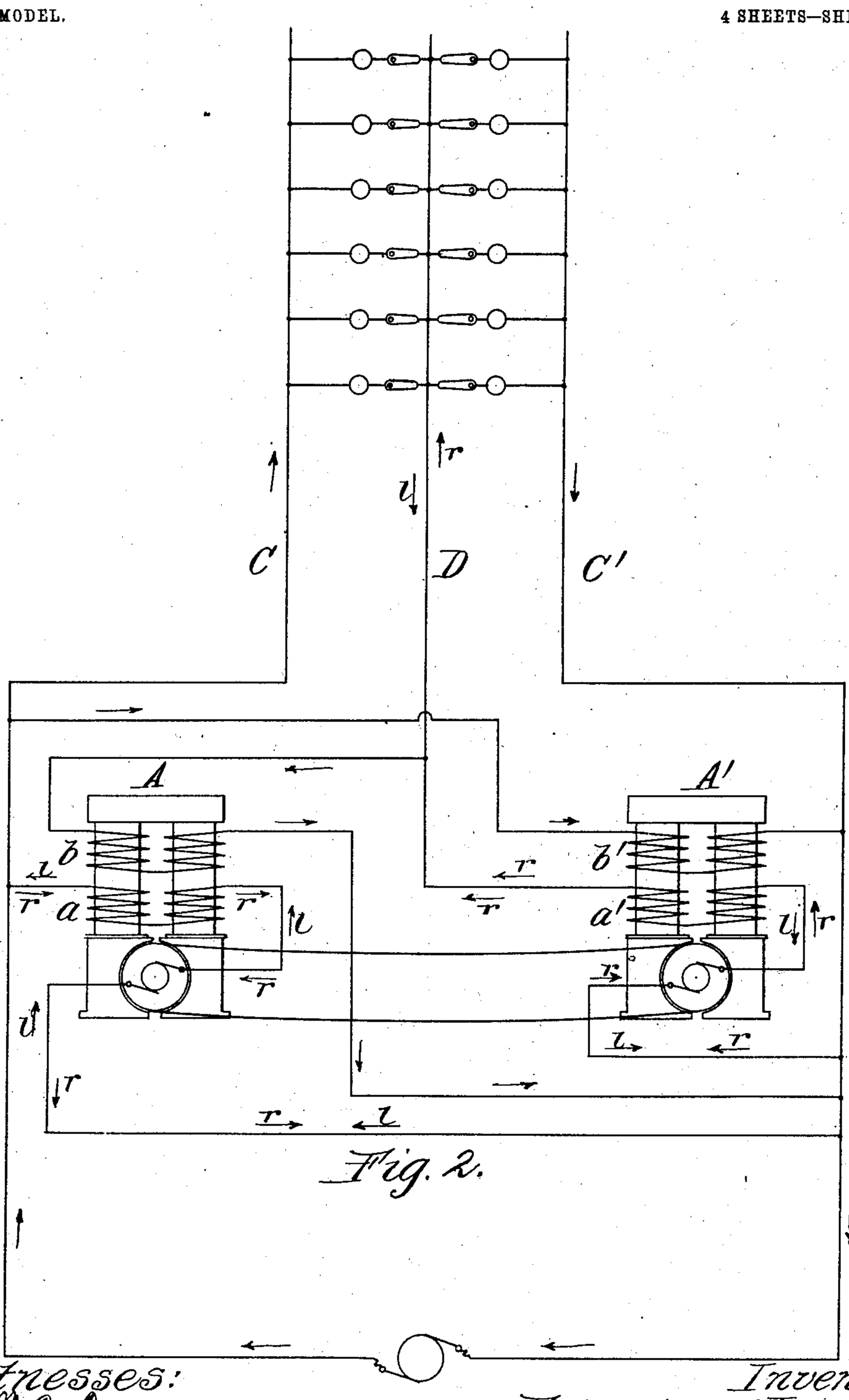

Fig. 2.

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NO MODEL. 4 SHEETS—SHEET 3.

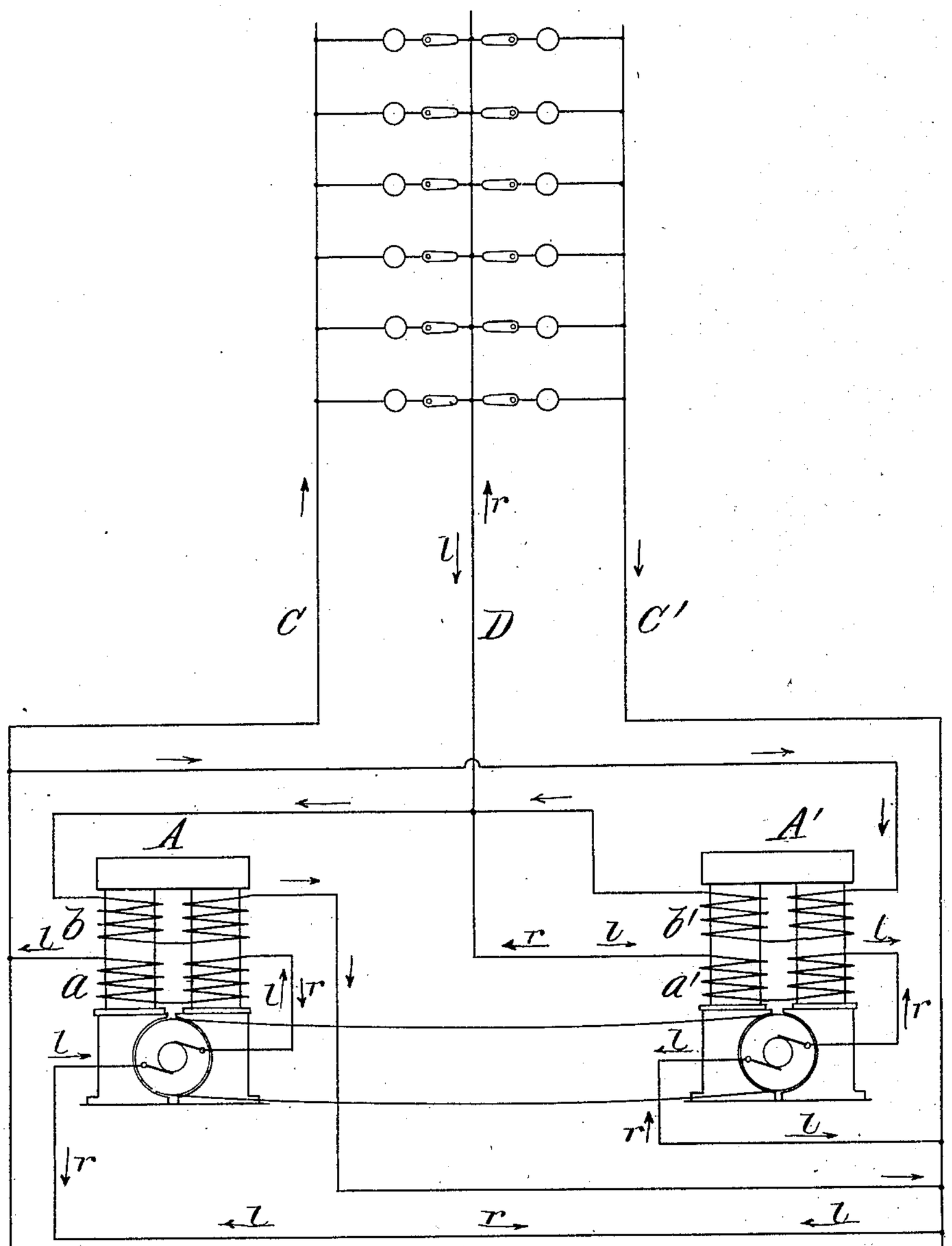

Fig. 3.

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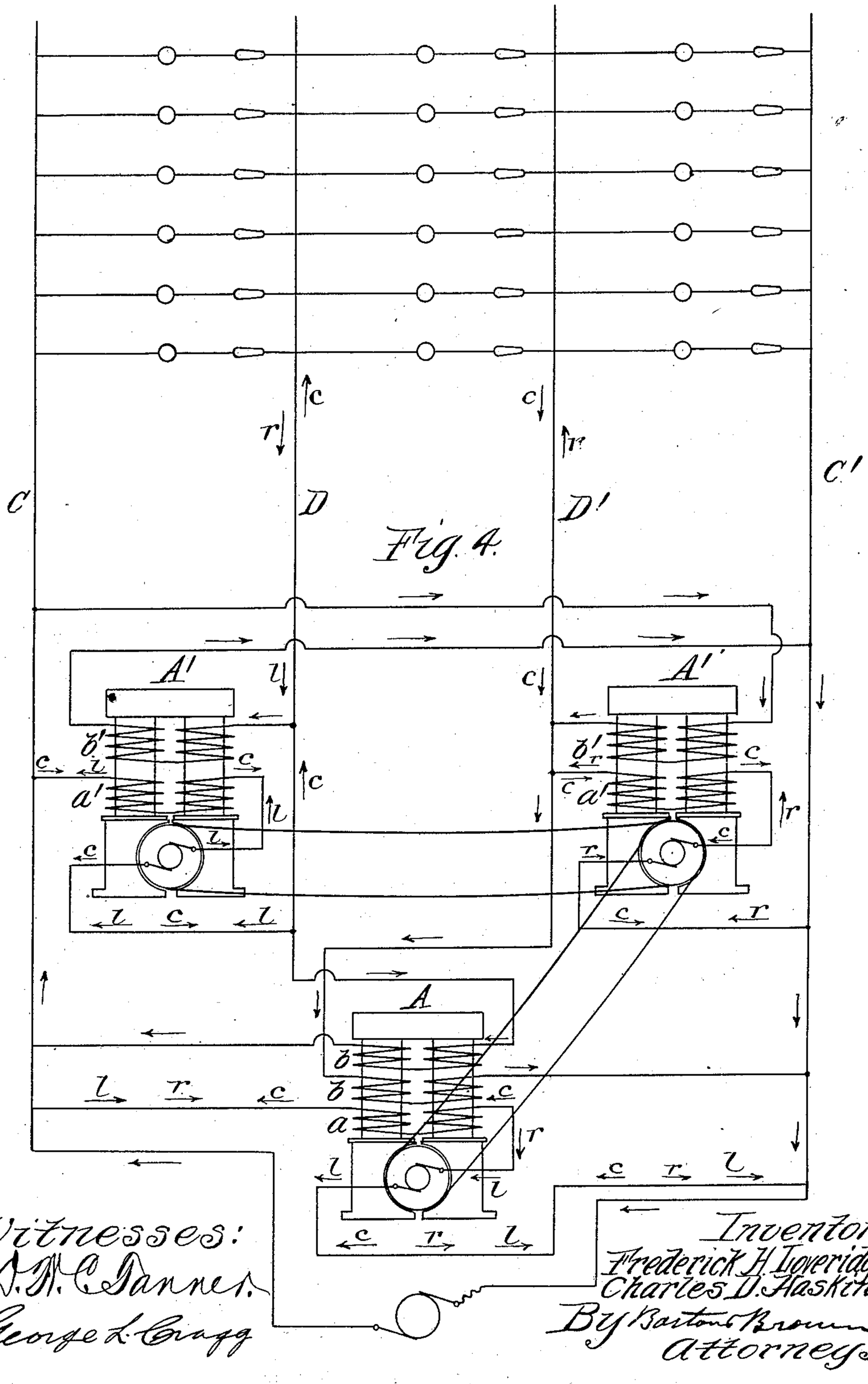
NO MODEL. 4 SHEETS—SHEET 4.



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UNITED STATES PATENT OFFICE.

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MULTIPLE-SERIES SYSTEM OF ELECTRICAL DISTRIBUTION.

SPECIFICATION forming part of Letters Patent No. 721,128, dated February 17, 1903.

Application filed November 9, 1896. Serial No. 611,504. (No model.)

To all whom it may concern:

Be it known that we, FREDERICK H. LOVERIDGE, residing at Coldwater, in the county of Branch and State of Michigan, and CHARLES D. HASKINS, residing at Chicago, in the county of Cook and State of Illinois, citizens of the United States, have invented a certain new and useful Improvement in Multiple-Series Systems of Electrical Distribution, (Case Nos. 19 and 12,) of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

Our invention relates to systems of distribution in which an auxiliary conductor is used, the translating devices being connected in series multiple between the main conductors. Heretofore in sytems of this character, which are automatic in their action, it has been necessary to lead the auxiliary conductor back to the source of energy or to have a bridge-circuit connecting the brushes externally, in which bridge-circuit is placed some means of regulation, or to have some device operated automatically for shifting the regulating apparatus from one side of the system to the other. We show one means of avoiding the complications, waste, and other objections to which these systems are subject in our application, Serial No. 603,339, filed August 20, 1896. In the apparatus therein shown and described the automatic regulation is secured by an auxiliary differential device, to dispense with which is the object of our present invention, which will be more readily understood by reference to the accompanying drawings, in which—

Figures 1, 2, 3, and 4 represent our invention in modifications of the circuits and apparatus.

Like letters refer to like parts in the different figures.

We have discovered that if we connect two dynamo-electric machines with their fields so arranged as to give constant excitation, one of the machines being connected in series between the mains of such a system as we have under consideration, while the other is connected between the auxiliary wire and one of the mains, the two dynamo-machines being belted together or otherwise mechanically connected, that when the load is shifted from one side to the other there will be a regulation to a certain extent for the following reasons:

Referring now to Fig. 1, in which we will assume that coils *b b'*, connected in series between the main conductors C C', are the only field-coils furnishing the field excitation of the machines A A', we will suppose that the current required to supply the translating devices on the right-hand side of the system is the same as that required on the left-hand side. In this case it will be evident that no current will be required to flow over conductor D and through machine A', and, further, that no current will flow if the potential difference at the terminals of the machine is equal and opposed to that existing between the conductors D and C'. The coils *b b'* are so adjusted that machine A will act as a motor and drive machine A' at such a speed that though it is giving out no current the potential difference at its terminals shall just equal that between the conductors D and C'. When the system is operating in this manner, there will be flowing in conductors C C' a certain current, which is the current required to supply the translating devices in the branches of the system. No current will flow through compensating conductor D and machine A'; but enough current will flow between the mains and through machine A to cause it to drive machine A' at the required speed. If now the load be increased on the right-hand portion of the system, the generator A' will be required to furnish a certain amount of current. The potential of the machine will gradually decrease as the output of current is increased, because of the internal resistance of the armature and also the decrease in the magnetic field caused by the demagnetizing effect of the armature-current. This defect will be further aggravated by a decrease in the speed of the armature of the machine A', which results from the decrease in the speed of the armature of machine A. The speed of the armature of machine A decreases by

reason of the decreased counter electromotive force that the armature of machine A is required to furnish, due to the electromotive force lost in the circuit in which the armature is included. All this results in a fall of potential upon the right-hand side, which fall of potential is not so great, however, as it would be were it not for the effect of the two dynamo-electric machines. Since the difference of potential between the conductors C and C′ is maintained constant, the fall of potential upon the right-hand side of the system is accompanied by a corresponding rise of potential upon the left-hand side. Having found by experiments that these results ensue with the arrangement so far described, we conceived the plan of introducing upon the field-magnets of the machine A a pair of similarly-wound helices connected in series with the armature between the two mains C C′. Upon realizing this plan the result was found to be that the current flowing through the coil *a* worked in opposition to the coil *b* to diminish the magnetic field whenever a predominance exists upon the right-hand side. This decrease in the strength of field results in an increase in the speed of the armature of machine A, which in turn increases the speed of armature of machine A′, and thereby increases the electromotive force generated by the machine, whence the potential was more nearly equally divided between the two sides irrespective of the predominance of the load upon the right-hand side.

We found that coil *a* of machine A could be adjusted to a point at which the increasing speed would compensate for loss in potential upon the right-hand side due to the predominance of the load thereof. Further, however, we found the result from the conditions just described that if a predominance of load should prevail upon the left-hand side the change in potential thereon would not be compensated for. We therefore provided the coils *a′* upon the machine A′, connecting them in series with the armature of A′ between the main conductors C′ and the auxiliary D. Upon the introduction of coil *a′* upon the machine A′ it was found to be necessary to readjust the coils *a* of machine A, whereby proper regulation between the action of the machine A and the machine A′ was effected, so that the predominance of load on the left-hand side would be properly compensated for. Under these conditions it was found that the effect of the introduction of the coil *a′* was to compensate for any predominance of load placed upon the left-hand side. Thus by a proper proportioning of the coils we were enabled to maintain the potential equal between the two sides of the series-multiple system under all variations of load upon either side and upon both sides.

We have in machine A a dynamo-electric machine which is reversible at constant speed—that is, it may be used either as a generator and will generate an electromotive force equal to that of the source of electricity or it will act as a motor upon the same difference of potential between its terminals, operating at practically the same constant speed. The same is also true of the machine A′. It is apparent, therefore, that our invention as thus far described may be extended in its application by providing one relatively large machine A to operate two machines A′ in a series-multiple system with three divisions, as shown in Fig. 4.

In Fig. 4 we illustrate such extended application, in which we have shown three branches or three groups of lamps connected in multiple, one group extending between mains C and D, another group between D and D′, and a third group between D′ and C′, the machine A being connected between the main conductors C and C′, while one each of the machines A′ is connected between the main conductor C and compensating wire D and between compensating conductors D′ and main conductors C′.

In the accompanying drawings we have traced the course of the current under different conditions by a system of arrows placed on the various figures. The arrows marked *r* indicate the course of the current when the load predominates on the right-hand side of the circuit—that is, between the main C′ and the compensating conductor D. Similarly, the arrows marked *l* designate the course of the current when the load predominates on the left-hand side—that is, between the main C and the compensating conductor D. Where the current maintains a constant direction, the arrows are not given any reference-letters. In Fig. 4 the arrows marked C indicate the course of the current when the load predominates between conductors D D′.

By our invention we are enabled to secure automatic regulation without the waste due to the introduction of balancing resistances or other means of that sort and without the necessity of carrying the compensating conductors back to the source of energy. We also avoid complications of working mechanism, and no manual attention is required; neither do we require a separate engine for driving the regulating-dynamos.

We have illustrated in Figs. 2 and 3 different connections for the windings *b b′* of machine A A′. These modifications simply show some of the means for producing the constant magnetizing force which is secured by these coils.

It is obvious that various modifications of our invention can be made without departing from the spirit of our invention, and we do not wish to limit ourselves to the precise apparatus and circuits which we have shown and described.

By our improved system for maintaining the potential in a multiple-series system of electrical distribution we are enabled to em-

ploy an undivided source of electricity and at the same time to dispense with bridge-circuits, including the regulating devices heretofore essential when undivided sources of electricity were employed. We also are enabled to equip a system in which the regulating means are permanently connected in the system, switching mechanism for including compensating or other regulating devices being thereby dispensed with. We believe also that we are the first to associate dynamo-electric machines with field-windings so arranged that under some conditions the windings of machine A will be acting in opposition, while the windings of machine A′ will be acting in concert, and under other conditions the windings of machines A′ will be acting in opposition, while windings of machine A will be acting in concert.

Having thus described our invention, what we claim as new, and desire to secure by Letters Patent, is—

1. In a multiple-series system of electrical distribution, the combination with a main source of current, of main and compensating conductors between which the translating devices are connected, an armature connected between said main conductors and in series with a field-winding which varies the magnetic field in which the armature is disposed, a second armature connected in series with a second field-winding in a branch separate from the last-named circuit, this field-winding also varying the field in which the latter armature is disposed, the latter armature and field-winding being in parallel with the translating devices of one of the branches of the system, the dynamo-electric machines composed of the aforesaid armatures and fields associated therewith having their rotating elements mechanically united, whereby the magnetic fields are varied inversely and the potential thereby maintained in the several branches of the system, substantially as described.

2. In a multiple-series system of electrical distribution, the combination with a main source of current, of main and compensating conductors between which the translating devices are connected, an armature connected between said main conductors and in series with a field-winding which varies the magnetic field in which the armature is disposed, a second armature connected in series with a second field-winding in a branch separate from the last-named circuit, this field-winding also varying the field in which the latter armature is disposed, the latter armature and field-winding being in parallel with the translating devices of one of the branches of the system, a second field-winding associated with each of said armatures, each being in circuit with a source of current adapted to produce in said windings substantially uniform magnetizing power, the dynamo-electric machines composed of the aforesaid armatures and fields associated therewith having their rotating elements mechanically united, whereby the magnetic fields are varied inversely and the potential thereby maintained in the several branches of the system, substantially as described.

3. In a multiple-series system of electrical distribution, the combination with a main source of current, of main and compensating conductors between which the translating devices are connected, an armature and a field-winding connected in series between the main conductors, a second armature and a field-winding connected in series in a branch separate from the last-named circuit, between the conductors of one of the branches of the system, the dynamo-electric machines provided with the aforesaid armatures having their rotating elements mechanically united, whereby the magnetic fields are varied inversely and the potential thereby maintained in the several branches of the system, substantially as described.

4. In a system of incandescent electric lighting having main conductors and one or more compensating conductors, a main source of electrical energy for supplying current to the lamps, said lamps being connected in multiple series, in combination with two dynamo-electric machines, one of said machines having its armature connected across the mains and in series with a coil of the field-magnet thereof, the other of said dynamo-machines having its armature connected in a branch separate from the last-named circuit, between one of the mains and a compensating conductor and in series with a portion of the winding of the field-magnet thereof, said dynamo-machines being self-contained and mechanically separated from the machine which is the main source of energy, but adapted reciprocally to drive one another according to the variation in the load as between the different branches or portions of the multiple-series system, to maintain the electromotive force practically constant, substantially as and for the purpose specified.

5. In a system of incandescent electric lighting having main conductors and one or more compensating conductors, a main source of electrical energy for supplying current to the lamps, said lamps being connected in multiple series, in combination with two dynamo-electric machines, one of said machines having its armature connected across the mains and in series with a coil of the field-magnet thereof, the other of said dynamo-machines having its armature connected in a branch separate from the last-named circuit, between one of the mains and a compensating conductor and in series with a portion of the winding of the field-magnet thereof, said dynamo-machines being self-contained and mechanically separated from the machine which is the main source of energy, but adapted reciprocally to drive one another according to the variation in the load as between the different branches or portions of the multiple-series system, the machine, whichever it may be, which

is at a given time acting as a motor, having its field weakened in proportion as the current increases through its series coil, while operating as a motor, and strengthened in proportion as the current increases through its field-winding, while acting as a generator, to maintain the electromotive force practically constant, substantially as and for the purpose specified.

In witness whereof we hereunto subscribe our names this 5th day of November, A. D. 1896.

FREDERICK H. LOVERIDGE.
CHARLES D. HASKINS.

Witnesses:
JOHN W. SINCLAIR,
D. W. C. TANNER.