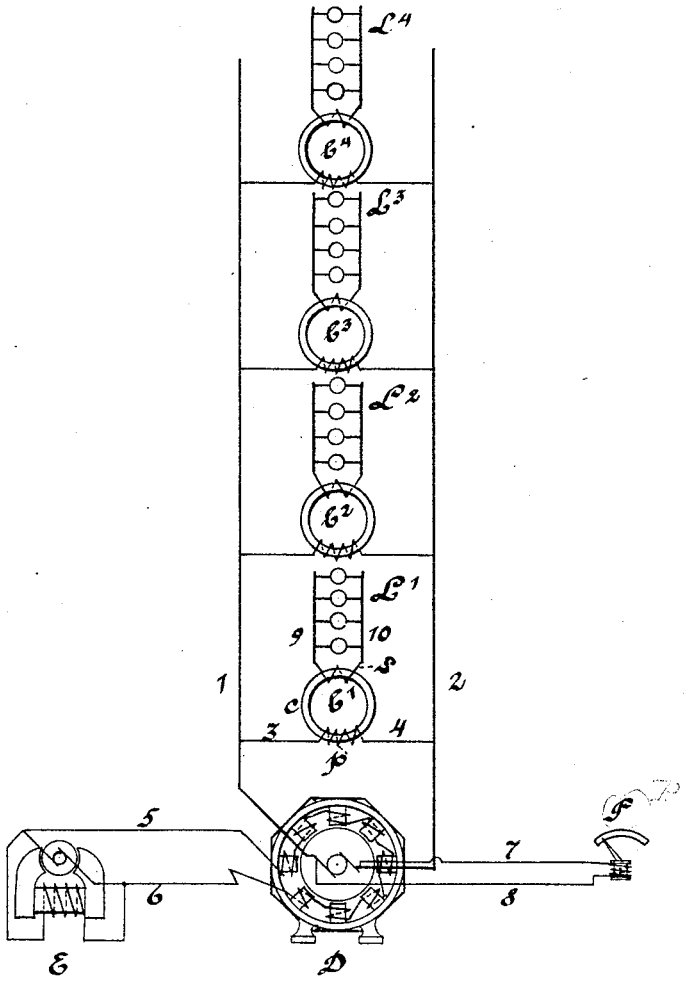
(No Model.)

M. M. M. SLATTERY.

SYSTEM OF ELECTRICAL DISTRIBUTION.

No. 386,936. Patented July 31, 1888.



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MARMADUKE M. M. SLATTERY, OF FORT WAYNE, INDIANA, ASSIGNOR OF ONE-HALF TO THE FORT WAYNE ELECTRIC LIGHT COMPANY, OF SAME PLACE.

SYSTEM OF ELECTRICAL DISTRIBUTION.

SPECIFICATION forming part of Letters Patent No. 386,936, dated July 31, 1888.

Application filed April 5, 1888. Serial No. 269,750. (No model.)

To all whom it may concern:

Be it known that I, MARMADUKE M. M. SLATTERY, a citizen of Great Britain, residing at Fort Wayne, in the county of Allen, in the State of Indiana, have invented certain new and useful Improvements in a System of Electric Distribution; and I do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawing, which forms part of this specification.

My invention is of a system for the distribution of electricity for industrial and economical uses, with special adaptation to incandescent lighting, though it may be applied to other purposes also; but for simplicity I shall in this specification describe its application to incandescent lighting only. I employ for this purpose a dynamo-electric machine generating an alternating current, a number of induction-coils or converters organized to transform the current in the main line at the points of consumption from high potential and relatively small quantity to one of low potential and relatively large quantity, with incandescent lamps or other translating devices in the secondary circuits of the converters.

In the annexed drawing I have shown by conventional symbols the arrangement and relations of the parts of my system.

D is a dynamo-electric machine of any suitable construction generating an alternating current.

E is a continuous current dynamo-machine of any suitable construction, the current from which is employed to magnetize the field-magnets of the dynamo D.

$C' C^2 C^3 C^4$ are induction-coils or converters, and $L' L^2 L^3 L^4$ groups of incandescent lamps in their secondary circuits.

P is a pressure-indicator.

The cardinal points embraced in my invention are, first, the generation of a main alternating current of high potential, which can be transmitted by wires of comparatively small size; second, the conversion of that current into currents of lower potential and larger quantity at the points where the electric energy is to be utilized; third, the largest economy in the process of conversion; fourth, an automatic distribution of the current among the lamps and an automatic regulation of the lamps among themselves, so that the operation of each shall be unaffected by the lighting or extinguishing of the others, and, fifth, automatic adjustment of the load upon the dynamo, so that the work to be done by it and the energy expended by the engine which drives the dynamo shall at all times be approximately proportional to the number of lamps burning.

The current generated by the dynamo D may be of as high potential as desired; but, taking considerations of safety and economy together, I prefer to use a dynamo having a normal potential of a thousand volts at its poles and to maintain that pressure constant during the operation of the apparatus. Two main conductors, 1 and 2, convey the current to and from the dynamo, and between these the converters C', C^2, C^3, and C^4 are placed in multiple arc, as shown in the drawing. The circuits through the primary coils of the converters remain constantly closed.

I have shown the converters in the drawing symbolically with ring-cores and double as many turns of wire in the primary as in the secondary. But the shape of the core is immaterial. It may be in the form of a cylinder, horseshoe, rectangle, or otherwise. But there are certain principles of construction which must be adhered to in the proportioning of parts in the converter which are material, and which I will now state. It is necessary, in the first place, that the amount of iron in the core shall be such relatively to the strength of the current to be employed that it shall remain far below the point of magnetic saturation during the working of the apparatus. This point of construction is important for two reasons: First, the greatest economy of conversion is obtained when the rise and fall of magnetism in the core is proportional, as nearly as possible, to the rise and fall of the current in the primary coil, and this condition is attainable only by keeping the core far below the saturation-point, and, second, the same condition secures the largest possible development of

It is impossible to state an exact relation between the weight of the core and the strength of the current; but I have obtained the best results by using about two pounds of iron for every ampère of current in the secondary circuit. Thus, in constructing a converter designed to supply twenty incandescent lamps with one ampère of current each, I use a core weighing about forty pounds.

In converter C′, I have shown, as an example of all, the cross-wires 3 and 4, leading from the main conductors 1 and 2 to its primary coil *p*, its core *c*, its secondary coil *s*, the secondary conductors 9 and 10, and the lamps L′, arranged in multiple arc between the secondary conductors. The lamps are extinguished by cutting them out of the circuit without introducing any resistance in the place of them. In the construction of the coils *p* and *s* the following principles are to be observed: The first thing to be determined is the number of turns of wire which shall be used in the primary coil. This should be so many that with the mass of iron to be used, and the current and potential for which the converter is designed supplied by the dynamo with which it is to be operated, the primary pressure and counter-pressure in the primary coil shall be equal. In this condition an ammeter will show no current whatever in the circuit of the primary when the secondary circuit is open. This requires a special adaptation of the converter to the dynamo with which it is to be used; and a convenient way of securing that adaptation is the following: Having determined the size and shape of the core, first wind upon it for the primary coil as many turns of wire as may be thought sufficient. Then place the converter in the circuit just as it is to be used in practice, with the same dynamo with which it is to be operated and with no secondary coil on it, (or if any be present it must be electrically open,) and place an ammeter in the circuit of the primary coil. If any current is shown by the instrument, the coil is either too long or too short. By adding to or subtracting from its length a point will be found at which the ammeter will not detect the presence of any current in the primary, notwithstanding the dynamo is operating at its full normal speed and with full normal excitation of its field. This indicates the proper length of the primary coil.

I have found in my experiments that the length thus ascertained is such that the coefficient of induction obtained in the primary of the converter corresponds with substantial exactness to that obtained from the armature of the dynamo supplying it, provided the armature-coils and the primary coil of the converter are subjected to equally effective magnetic induction. The true principles of construction may therefore be comprehensively be in the most efficient inductive relation possible to the magnetic field, and, second, the converter should be so constructed that its primary coil shall be in an equally-efficient inductive relation to its magnetic field. When these conditions are perfectly attained, it will be found that with equal lengths of wire subject to magnetic induction on the armature of the dynamo and in the primary coil of the converter the electrical pressure and counter-pressure in the primary of the converter will be equal when the secondary is open; but no rule can be given for the perfect attainment of these conditions. In every armature and converter-coil there is some wire which is more or less idle, and the conditions which affect the efficiency of magnetic induction are complicated, so that the best practical direction which I can give for the application of my invention is to adopt, first, such form of construction, both in the dynamo and converter, as will give the greatest possible efficiency of magnetic induction and then secure equality of electrical pressure and counter-pressure in the primary coil of the converter by suitable adjustment of its length, in the manner which I have described; but those features of construction by which the most effective magnetic induction is obtained are not material to my present invention. Although the apparatus may be in that respect far below the highest standard of perfection, the adaptation of the dynamo and the converters to each other in the manner and upon the principle which I have described will produce the results which I have stated, only with less economy of construction and operation. Having by this means determined the length of the primary coil, the secondary is adapted to it in such a manner as to secure the desired reduction of potential, according to the well-known law affecting the operation of induction-coils. For the purpose of incandescent lighting I have found it convenient in practice to reduce the potential at a rate of twenty to one. In such case I construct a converter so that the length of wire exposed to effective magnetic induction in the secondary shall be one-twentieth the length of that in the primary. The size of the wire in the two coils will be adapted to the quantity of the current to be used, according to well-known rules of electrical engineering.

It would be quite consistent with the theoretical principles of my invention to construct the converter first and then adapt the length of the armature-coils to the converter, so as to secure an equality of pressure and counter-pressure in the primary coil of the converter with its secondary circuit open, and then proportion the other parts of the dynamo to the armature-coils thus determined; but it is obvious that such a method would be too inconvenient in practice to justify its use.

It is not to be understood that the process

of experimental adaptation of the converter to the dynamo here detailed is to be repeated in the construction of every converter. Having once ascertained by the methods here described the proper proportions of the parts in a dynamo and one set of converters to be operated together, that apparatus becomes a pattern for unlimited future manufacture.

The operation of the apparatus of the system is as follows: First, the potential in the main line is kept constant at the point taken as the normal pressure of the system, that being preferably, as I have said, one thousand volts. In the normal operation of the apparatus there will be found to be but little variation from this, and, consequently, rare need of any considerable regulation of the dynamo; but for such regulation as may be required the most convenient means is to vary the strength of the field in the dynamo D by increase or diminution of the strength of the current from the exciter E. This may be accomplished by the use of a shunt-wound field and variable resistance in the circuit of the exciter or by any other method. The pressure-indicator P, placed across the poles of the dynamo by the conductors 7 and 8, shows the potential in the line, and it is the duty of the attendant to regulate the dynamo by it. The amount of current taken from the main conductors by each converter will be proportional to the work done by its secondary under full load, and the distribution calculations are all made with reference to this condition. When the apparatus is put in operation with all its lamps burning, the current is distributed among them equally by equalized resistance, as in the case of a system of lighting by direct currents. It is when part of the lamps are extinguished from time to time, here and there, as the convenience of users may require, that the particular superiority of my system appears in its perfect self-regulation, both of the distribution of the current among the lamps that remain and of the load on the dynamo, and this is brought about in this way: The primary coil of the converter operates to produce by induction a certain phase of magnetism or succession of magnetic impulses in its core, and by these a current is induced in the secondary coil. The current in the secondary coil thus induced reacts upon the core, and induces in it a phase of magnetism, or succession of magnetic impulses exactly contrary to those induced by the primary coil, so that in effect the primary current acts as a magnetizing and the secondary current as a demagnetizing influence upon the core. With the parts of the apparatus properly proportioned, and all the lights in the secondary burning, these antagonizing influences upon the core are approximately equal. Upon the cutting out of a lamp in the secondary the resistance of the secondary circuit is increased and its current diminished. This diminution of current diminishes the demagnetizing power of the secondary, and as one lamp after another is cut out the demagnetizing power of the secondary continues to decrease until, when all the lamps are cut out and the secondary circuit open, its demagnetizing power is *nil*. As this process goes on, the magnetism of the core due to induction from the primary coil reappears with increasing intensity, and with it appears a proportionally-increasing counter electro-motive force in the primary coil, so that when all the lamps in the secondary have been cut out the counter-pressure in the primary is equal to the primary pressure. The apparent effect of this is to diminish the current proportionally not only in the primary coil of the converter and in the cross-wires that lead to it, but in the main line as well at all points between the intersections of the conductors of that converter and the dynamo. At the same time the strength of the current in the other converters of the system and the operation of the lamps in their secondaries remain substantially unaffected. The effect of this apparent reduction of current strength is to reduce in approximate proportion the load on the dynamo and on the engine that drives it. It is not fundamental to my invention to account for this mysterious action of counter electro-motive force; but the explanation of it, which, as I believe, accords most nearly with the observed results, is this: that the core of the converter is, in a true sense, a generator of electricity, and as it passes from one magnetic state to the opposite, under the inductive influence of the primary current, generates a return-current in the primary wire, which flows back to the dynamo. This return-current is of the same potential as the principal current, and may be equal to it in quantity, less only the loss in transformation. It is contrary to the principal current in its phase, and upon its return to the dynamo demagnetizes the armature to the extent of its strength, just as the secondary current of the converter demagnetizes the core to the extent of its strength. By this means it diminishes the load of a dynamo proportionally to its strength. There is therefore an individual relationship and sympathy between each lamp and the dynamo. As long as it burns, it consumes its due share of the current. When it is cut out, a return-current is set up from the primary of its converter to the dynamo, which demagnetizes the armature and lightens the load of the machine.

I do not in this application claim, broadly, the combination of an alternating-current dynamo and converters organized to transform the current in the main line from high tension to currents of lower tension and greater quantity in the secondary circuits connected with the main conductors in multiple arc and located at the points of consumption, with translating devices in the secondary circuits, but reserve that subject for another application.

In this application I do not claim the method of transforming, subdividing, and distributing

electricity herein involved, having made separate application for such method by a division of this application.

I claim—

1. In a system of electrical distribution and in combination, an alternating-current dynamo, and converters electrically connected with the main-line conductors in multiple arc and organized to transform the current in the main conductors into currents of less potential and greater quantity in the secondaries, each converter made with a primary coil containing such length of wire exposed to magneto-electric induction that when operated by the dynamo with which it is to be used with its secondary circuit open the electrical pressure and counter-pressure in its primary circuit shall be equal, with incandescent lamps or other translating devices in the secondary circuits, substantially as and for the purposes set forth.

2. In a system of electrical distribution and in combination, an alternating-current dynamo, and converters organized to transform the current in the main conductors into currents of less potential and greater quantity in the secondaries electrically connected with the main conductors in multiple arc, the dynamo and the converters of the system so adjusted to each other by mutual adaptation of their magnetic fields and the lengths of wire upon the armature of the dynamo and the primary coils of the converters, respectively, that when supplied with the full normal current of the dynamo, the secondary circuits of the converters being open, the electrical pressure and counter-pressure in their primary circuits shall be equal, with incandescent lamps or other translating devices in the secondary circuits, substantially as and for the purposes set forth.

3. In a system of electrical distribution and in combination, an alternating-current dynamo, and converters organized to transform the current in the main-line conductors into currents of less potential and greater quantity in their secondaries and electrically connected with the main conductors in multiple arc, each converter containing in its primary coil a length of wire exposed to effective magnetic induction substantially equal to the electrical or circuit length of wire exposed to like effective magnetic induction upon the armature of the dynamo operating the system, with incandescent lamps or other translating devices in the secondary circuits, substantially as and for the purposes set forth.

4. In a system of electrical distribution and in combination, an alternating-current dynamo, and converters organized to transform the current generated by the dynamo into currents of less potential and greater quantity at or near the points of consumption, electrically connected with the main-line conductors in multiple arc and having their primary circuits constantly closed, each converter adapted to the dynamo operating the system by making its primary coil of such length that when supplied with its full proportionate share of the entire normal current of the machine, its secondary circuit being open, the electrical pressure and counter-pressure in its primary circuit shall be equal, with translating devices in the secondary circuits of the converters to be cut out of the circuit when not in use without the introduction of any resistance in the place of them, substantially as and for the purposes set forth.

5. In a system of electrical distribution and in combination, an alternating-current dynamo, and converters organized to transform the current generated by the dynamo into currents of less potential and greater quantity at or near the points of consumption, electrically connected with the main-line conductors in multiple arc and having their primary circuits constantly closed and their secondary circuits constantly open, except when and as closed through translating devices at work, each converter containing a soft-iron core weighing substantially two pounds for each ampere or current normally produced in its secondary circuit, and adapted to the dynamo operating the system by making its primary coil of such length that when supplied with its full proportionate share of the entire normal current of the machine, its secondary circuit being open, the electrical pressure and counter-pressure in its primary circuit shall be equal, with incandescent lamps or other translating devices in the secondary circuits, substantially as and for the purposes set forth.

6. In a system of electrical distribution and in combination, an alternating-current dynamo, and converters organized to transform the current generated by the dynamo into currents of less potential and greater quantity at or near the points of consumption, electrically connected with the main-line conductors in multiple arc and having their primary circuits constantly closed and their secondary circuits constantly open, except when and as closed through translating devices at work, each converter containing a soft-iron core weighing substantially two pounds for each ampère of current normally produced in its secondary circuit, and containing in its primary coil a length of wire exposed to effective magnetic induction substantially equal to the electrical or circuit length of wire exposed to like effective magnetic induction on the armature of the dynamo operating the system, with incandescent lamps or other translating devices in the secondary circuits, substantially as and for the purposes set forth.

In testimony whereof I do hereto subscribe my name, in the presence of two witnesses, this 3d day of March, 1888.

MARMADUKE M. M. SLATTERY.

Witnesses:
LORIN J. WOODRUFF,
C. S. HILTON.