(No Model.) 3 Sheets—Sheet 1.

T. A. EDISON.

ELECTRICAL GENERATOR.

No. 281,351. Patented July 17, 1883.

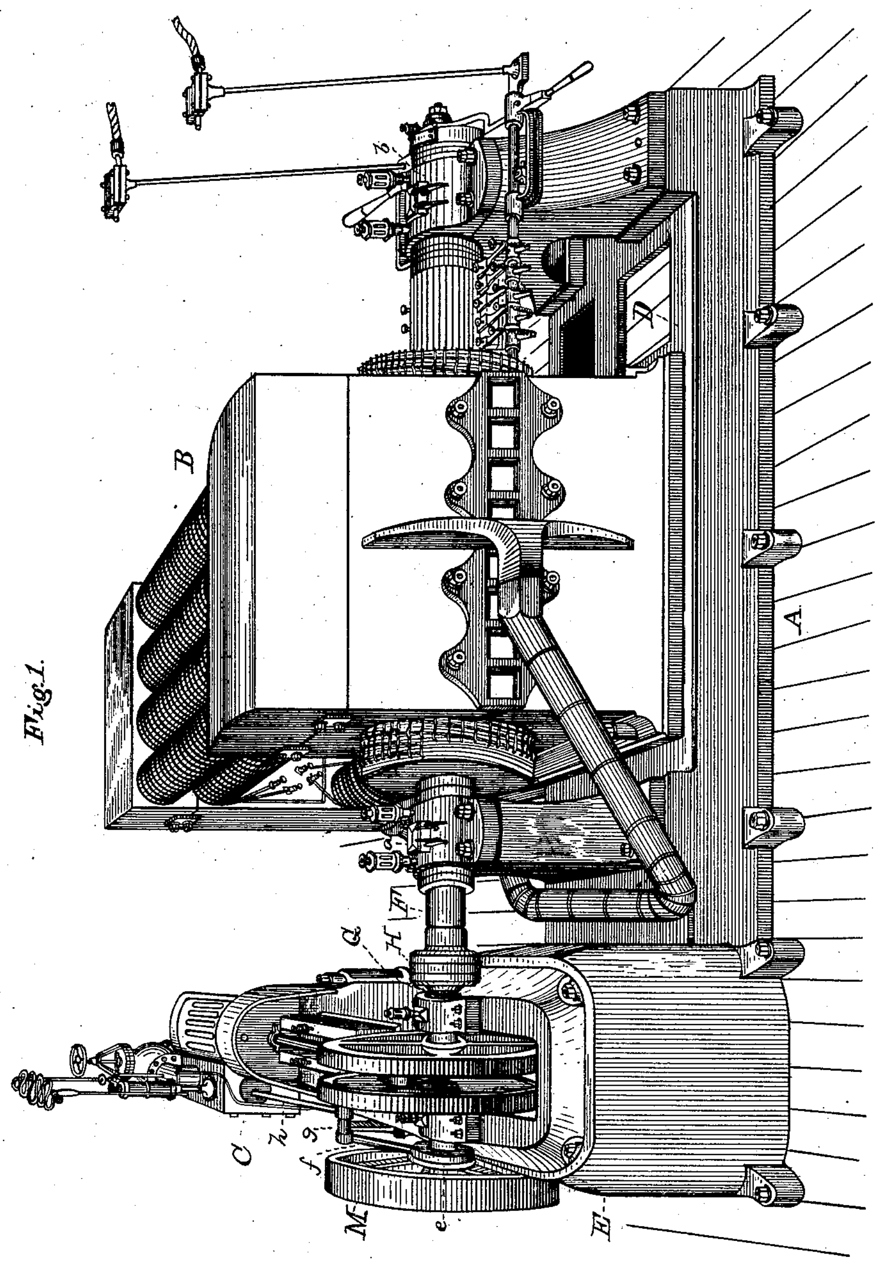

Fig. 1.

ATTEST:

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INVENTOR:

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(No Model.)

T. A. EDISON.

3 Sheets—Sheet 2.

ELECTRICAL GENERATOR.

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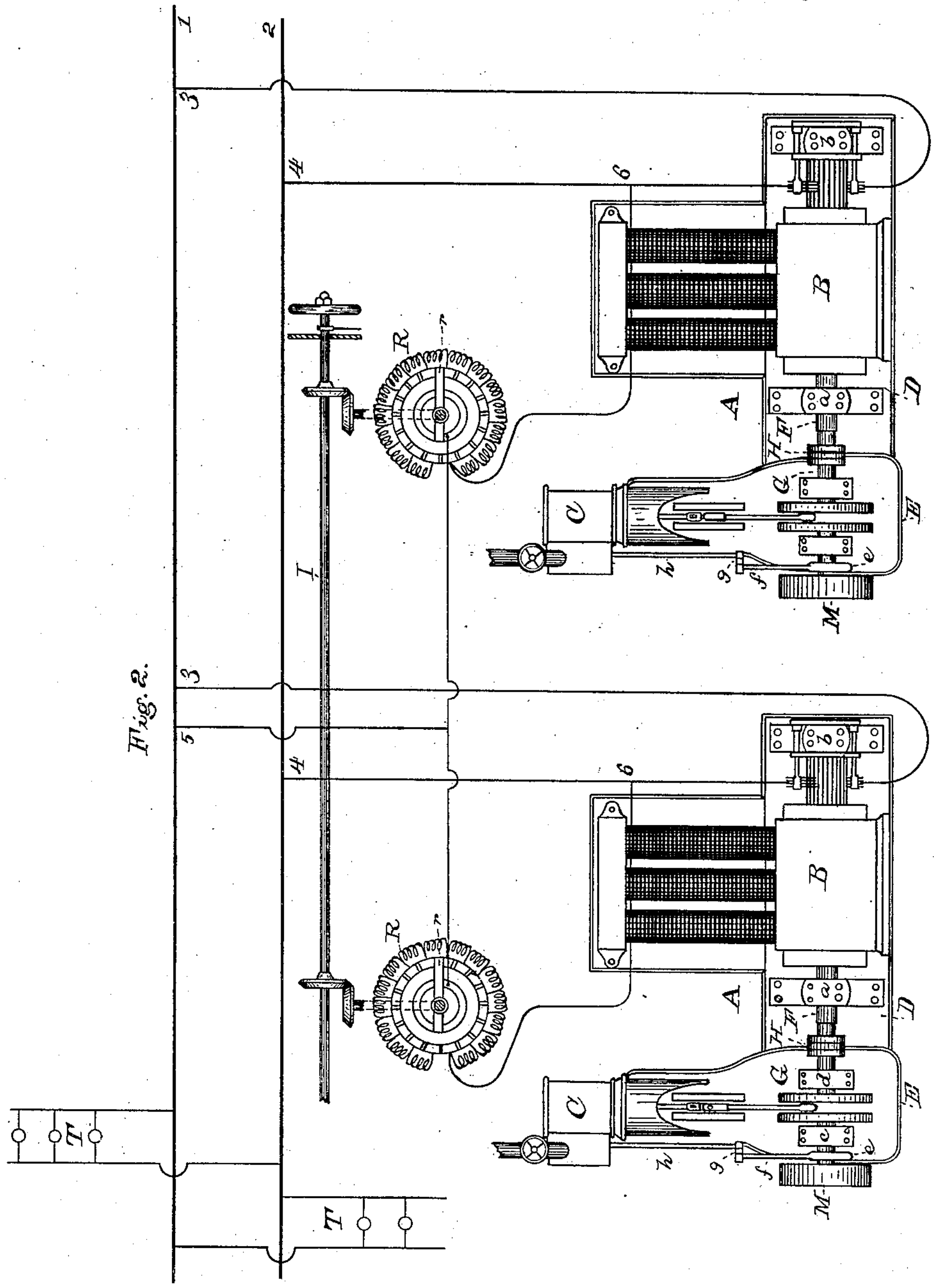
Fig. 2.



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(No Model.) 3 Sheets—Sheet 3.

T. A. EDISON.

ELECTRICAL GENERATOR.

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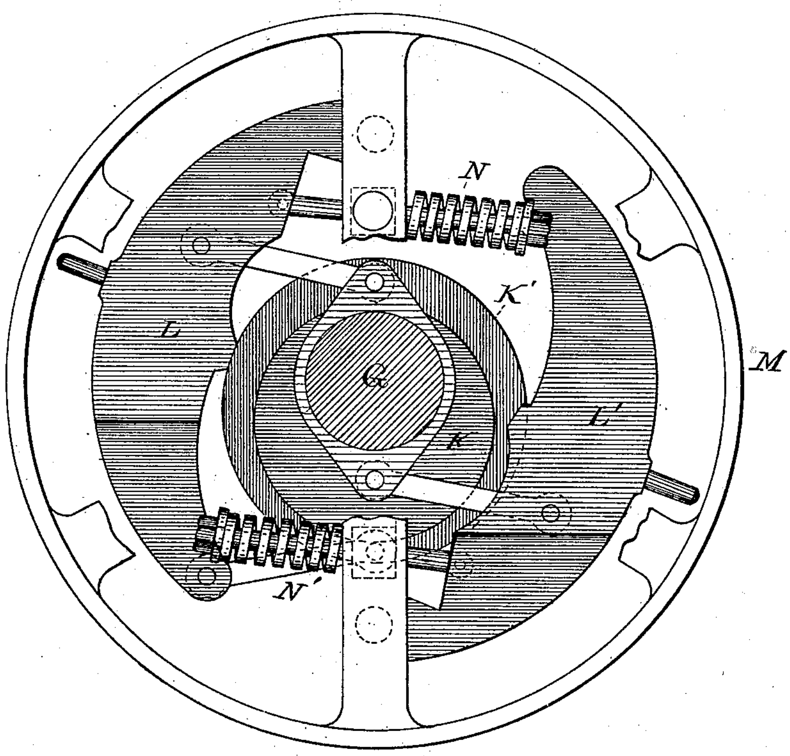
Fig. 3.



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UNITED STATES PATENT OFFICE.

THOMAS A. EDISON, OF MENLO PARK, NEW JERSEY, ASSIGNOR TO THE EDISON ELECTRIC LIGHT COMPANY, OF NEW YORK, N. Y.

ELECTRICAL GENERATOR.

SPECIFICATION forming part of Letters Patent No. 281,351, dated July 17, 1883.

Application filed March 16, 1883. (No model.)

To all whom it may concern:

Be it known that I, THOMAS A. EDISON, of Menlo Park, in the county of Middlesex and State of New Jersey, have invented a new and useful Improvement in Electrical Generators, (Case No. 552,) of which the following is a specification.

The object I have in view is an arrangement and construction of electrical generators and operating steam-engines suitable for use in a central-station plant for supplying electricity to conductors of a system of general distribution, wherein a continuous and constant pressure is maintained on the mains or in other locations where two or more generators are employed, feeding separately into the same circuit. For such a plant I provide separate and independent high-speed and high-pressure steam-engines for operating the dynamo or magneto electric machines, the advantages possessed by this construction over the use of a large low-speed and low-pressure engine for running all of the machines being of vital importance in a general system of electrical distribution. There is greater economy in running generators by separate high-speed engines, since the number of engines in operation can be changed as required by the work to be done or the number of translating devices in circuit. To get a certain speed with a large low-speed engine a definite boiler-pressure has to be maintained, no matter how small the load upon the engine may be; hence there is a great loss of power when the load is small, which loss increases largely as the load is decreased below the point of greatest economy. With the large low-speed engine, when the load is small, the friction becomes an important factor in the work of the engine, and the economy is greatly lessened. These difficulties are not met with when separate high-speed engines are used, since the engines can be thrown out of operation as the load decreases, and the engines left running be worked with good economy. The boilers (of which there would be a number, preferably the same number as the engines) can be thrown out of operation, and hence the boilers can also be worked in the most economical way. With the large low-speed engine an extra engine of equal power would have to be provided for operating the machines in case the first engine should break down or had to be stopped for repairs, cleaning, or for other purposes. This makes it necessary to have double the engine capacity required for running the machines, making the investment for engines larger than when separate engines are used, since with the separate engines I have found that one extra or spare engine in every six is sufficient, making the reserve capacity only one-sixth the entire capacity, and this proportion might be still further reduced. In addition, with the large engine, the breaking down of such engine would cause the total extinguishing of the lamps for a time until the reserve engine could be started; but with a number of separate engines, when one engine breaks down, the load is taken by the other engines, and the lamps are not extinguished, but only a momentary drop in the candle-power occurs, which is instantly corrected by the regulation of the generators in the manner hereinafter stated. The wear upon the separate engines is also less, since they will be thrown out of operation a much greater proportion of the time than the large engine. A most important commercial advantage is the large saving in the investment for real estate for a central-station plant, it being possible to place the separate engines with the small reserve power in much less space than is required by the two large engines, with the necessary shafting, belting, clutches, &c.

The dynamo or magneto electric machines and steam-engines are made of the same capacity, and each dynamo or magneto electric machine is mounted upon the same base or bed with a steam-engine. This base is preferably made of cast-iron formed in convenient sections bolted or otherwise suitably secured together to form a solid support for the combined machine. The engine and dynamo have their shafts placed in line with each other and connected directly together to form a shaft common to both the engine and dynamo. The dynamos may be of any desired size. I have found that dynamos capable of supplying economically about fifteen hundred (1500) sixteen (16) candle incandescing electric lamps are well adapted for large central-station plants. By the use of the direct connection between the engine and dynamo great economy results, since no power is lost in intermediate shafting or from the pull or slip of belts. The use of clutches is avoided for connecting the dynamos with and disconnecting them from the shafting. There is no danger of stoppage from breaking of belts or from the breakage or disarrangement of other parts of the intermediate mechanism, as there would be with the low-speed engine and its shafting. The direct connection makes the combined machine simple and reliable and adds greatly to the compactness, which is a feature of great importance, in that less room is required for the plant and the investment in real estate diminished.

With the high-speed engines the movement is uniform and a steady current is produced. The movement is made more uniform by the inertia of the armature, which has considerable weight. For a high-speed engine I have found that one making three hundred and fifty (350) revolutions per minute is suitable for the purpose; but it is evident that the dynamo could be constructed to work at a different speed. I also prefer to use a high boiler-pressure. About one hundred and ten pounds (110 lbs.) is an economical pressure; but it is evident that a lower pressure could be employed. The high-speed steam-engines used by me are provided with automatically-variable cut-off mechanisms. Engines of this kind possess the general advantage over throttling-engines of greater economy in the use of steam, and the especial advantage, when used to operate dynamo or magneto electric machines connected with and feeding into the same circuit, of closer regulation and greater uniformity of speed. Throttling-engines are wholly unsuited for the purpose on account of the loss of power and on account of the want of uniformity in speed. It is necessary that the engines should not vary more than about three per cent. (3%) in speed, and within this the regulation of the engine must be performed. A greater variation would cause the dynamos to differ in electro-motive force to such an extent that those of lowest electro-motive force at any given time would be converted into electromotors and be run as such by the dynamos of greatest electro-motive force. This relation would be reversed by the movement of the governors, and in this way the power would be partly used up in the plant itself, and there would be an overloading of part of the dynamos, accompanied by extra sparking at the commutators and overheating of the armatures.

The most effective governor for cut-off engines for my purpose I have found to be a spring-governor—that is, a governor in which centrifugally-acting weights are opposed by heavy springs. The springs overcome the inertia of the weights, and the governor responds almost instantly to the slightest variation in speed, making all the engines work practically in unison, so that the differences in electro-motive force of the dynamos are not sufficient to cause the unequal loading of the machines; but I do not wish to limit myself to engines with spring-governors, since the variable cut-off mechanisms may be worked by other forms of governor. I have also found that the spring-governor and ball-governor engines may be worked together, one spring-governor engine being capable of compensating for irregularities in two or three ball-governor engines, preventing the occurrence of the peculiar operation before described.

With the base common both to the steam-engine and the dynamo or magneto electric machine, the direct connection between the engine and armature shafts, and the automatically-variable cut-off, the combined machine becomes a self-contained electrical generator, controlled by and accommodating itself to the external load automatically and with economy, and suitable for use in a central-station plant. The automatically-variable cut-off engine and the dynamo have a combined action and react one upon the other. An increase in the number of lamps in circuit throws more work upon the dynamo, and this in turn causes the cut-off of the engine to act at a later point in the stroke, admitting more steam into the cylinder and increasing the power of the engine. A decrease in the number of lamps in circuit has the reverse effect upon the dynamo and engine.

In a central-station plant there is a mutual action and reaction of the dynamos and cut-off engines, which is caused by the fact that the dynamos are connected with and feed into the same circuit. Suppose, for illustration, the maximum capacity of each dynamo to be fifteen hundred lamps, and that there are four dynamos in connection with the circuit and supplying six thousand lamps. Now the load will be equally distributed among the combined dynamos and engines, fifteen hundred to each combined machine, and the cut-offs of all the engines will be acting at the same point. As the lamps are gradually reduced in number the cut-offs of all the engines will vary in unison, cutting off steam earlier in the stroke, until there are but forty-five hundred lamps in circuit, eleven hundred and twenty-five to each dynamo, or something less than that number. Then the connection of one dynamo with the circuit can be broken and its engine stopped. The entire load is then thrown upon the three dynamos, which react upon the cut-offs of their engines and cause them to change in unison the point of cut-off to meet the increase of load. If more lamps are taken off, the same operation takes place until the number of lamps is reduced to three thousand or somewhat under that number, when another machine is disconnected from the circuit. The reverse operation takes place when lamps are being added to the circuit.

When a machine breaks down and has to be stopped, the other machines take the load, dividing it up among them and acting in unison until an additional machine is started, when another division of the work takes place.

The engines have to regulate in unison and quickly, in order to prevent the overloading of part of the dynamos, and this can only be accomplished by the use of the self-contained generators. The generators are preferably dynamo-electric machines having their field-magnets in separate multiple-arc circuits derived from the main circuit; but a separate exciter may be employed. The lamps or other translating devices are arranged in multiple arc, and a change in the number of such translating devices produces variations in the arrangement of resistances and in the electro-motive force of the machine independent of the speed at which the machine is driven. To compensate for this variation in electro-motive force, another species of regulation has to be resorted to in addition to that furnished by the automatically-variable cut-offs of the engines. For this purpose the strength of the field-magnets is varied by varying in unison and to the same extent the current flowing through the field-circuits of the several machines. This may be accomplished by the use of an adjustable resistance in the field-circuit of each machine, all the resistance-adjusting arms being operated simultaneously by a common shaft.

In the drawings, Figure 1 is a perspective view of the self-contained electrical generator; Fig. 2, a top view, partly diagrammatic, showing two of such machines in connection with the same circuit; and Fig. 3, an elevation of the spring-governor cut-off mechanism.

A is a cast-iron base, preferably made in sections bolted together, and forming a support for the dynamo or magneto electric machine B and the high-speed cut-off engine C.

The dynamo or magneto electric machine is preferably constructed as described in my Patents Nos. 263,133, 263,140, 264,647, and 265,785. The field-magnet is arranged horizontally and supported upon a depressed portion, D, of the base, to which it is bolted, while the engine-frame is bolted to an elevated portion, E, of the base.

The armature-shaft F of the machine B is journaled in bearings at *a b* upon the depressed portion D of the base, while the engine-shaft G is journaled in bearings *c d* on the elevated portion E of the base. The shafts F G are brought into line with each other, and are coupled directly together at H by any suitable coupling, preferably one accommodating itself to any slight deviation in the alignment of the shafts.

The commutator-brushes of the several dynamos used in a central-station plant are connected with the same main circuit, 1 2, the armatures being in multiple-arc or derived circuits 3 4 from such main circuit. The field-circuit 5 6 of each machine is a multiple-arc circuit from 1 2. It contains a resistance, R, adjusted by an arm, *r*. The arms *r* of the several resistances are connected with and moved simultaneously by a common shaft, I.

The lamps or other translating devices T are arranged in multiple arc from 1 2 or from circuits derived therefrom.

As before stated, the steam-engines C have cut-off mechanisms, and these are automatically operated by governors.

I prefer to use a spring-governor. In Fig. 3 is shown a form of spring-governor cut-off which I find well suited to the purpose, although I do not wish to limit myself to any particular form of governor. The engine-shaft G is provided with a double eccentric, K K′, connected by links to weights L L′, which are pivoted to the arms of the wheel M, keyed to the shaft. The weights L L′ are opposed by heavy springs N N′. Around the outer eccentric K′ is the eccentric-strap *e*, which is connected by rod *f* with a rocking arm, *g*, which in turn is connected with the valve-rod *h*.

I do not claim herein the peculiar features of the self-contained machine, *per se*, independent of its connection with other machines, or independent of the nature and arrangement of the translating devices supplied by it, since the same will be made the subject of another application for patent; and it is to be understood that all other patentable features of invention described or shown but not claimed herein are reserved for protection by other patents, and have been or will be embraced in other applications for patents.

What I claim is—

1. The combination, with one circuit, of two or more dynamo or magneto electric machines connected with such circuit and feeding into the same, and two or more independent steam-engines operating such dynamo or magneto electric machines, substantially as set forth.

2. The combination, with one circuit, of two or more dynamo or magneto electric machines connected in multiple arc with such circuit, and two or more independent steam-engines operating said dynamo or magneto electric machines, substantially as set forth.

3. The combination, with one circuit, of two or more dynamo or magneto electric machines connected with such circuit and feeding into the same, and two or more independent steam-engines operating such dynamo or magneto electric machines and having automatically-variable cut-off mechanisms, substantially as set forth.

4. The combination, with one circuit, of two or more dynamo or magneto electric machines connected with such circuit and feeding into the same, and two or more independent steam-engines operating such dynamo or magneto electric machines, and having cut-off mechanisms varied automatically by spring-governors, substantially as set forth.

5. The combination, with one circuit, of two or more dynamo or magneto electric machines

connected in multiple arc with such circuit, two or more independent steam-engines operating said dynamo or magneto electric machines, and translating devices connected in multiple arc with such circuit, substantially as set forth.

6. The combination of a dynamo or magneto electric machine, a steam-engine with automatically-variable cut-off, the direct connection, and common base, with translating devices connected in multiple arc with said machine, substantially as set forth.

7. The combination of two or more self-contained electrical generators connected with and feeding into the same circuit, each of such self-contained electrical generators being composed, essentially, of the following parts, viz: a dynamo or magneto electric machine, a high-speed steam-engine having an automatically-variable cut-off, a direct connection between the shaft of said engine and that of said dynamo or magneto electric machine, and a supporting base or bed common both to said steam-engine and said dynamo or magneto electric machine, substantially as set forth.

8. The combination of two or more self-contained electrical generators connected with and feeding into the same circuit, each of such self-contained electrical generators being composed, essentially, of the following parts, viz: a dynamo or magneto electric machine, a high-speed steam-engine provided with a variable cut-off and a spring-governor varying such cut-off automatically, a direct connection between the shaft of said engine and that of said dynamo or magneto electric machine, and a supporting base or bed common both to said steam-engine and said dynamo or magneto electric machine, substantially as set forth.

9. The combination, with one circuit, of two or more dynamo or magneto electric machines connected with such circuit and feeding into the same, two or more independent steam-engines operating such dynamo or magneto electric machines, and means for varying the electro-motive force of the machines independent of the speed of the engines, substantially as set forth.

10. The combination, with one circuit, of two or more dynamo or magneto electric machines connected with such circuit and feeding into the same, two or more independent steam-engines operating such dynamo or magneto electric machines and having automatically-variable cut-offs, and means for varying the electro-motive force of all the machines simultaneously independent of the speed, substantially as set forth.

11. The combination of a dynamo or magneto electric machine, a steam-engine with automatically-variable cut-off, the direct connection, and common base, with means for varying the electro-motive force of the machine independent of the speed, substantially as set forth.

12. The combination, with one circuit, of two or more dynamo or magneto electric machines connected in multiple arc therewith, two or more independent steam-engines operating such dynamo or magneto electric machines, means for varying the electro-motive force of all the machines simultaneously independent of the speed, and translating devices connected in multiple arc with said circuit, substantially as set forth.

This specification signed and witnessed this 5th day of March, 1883.

THOS. A. EDISON.

Witnesses:

WM. H. MEADOWCROFT,

H. W. SEELY.