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T. A. EDISON.

ELECTRIC MOTOR.

No. 436,127. Patented Sept. 9, 1890.

Fig. 1.

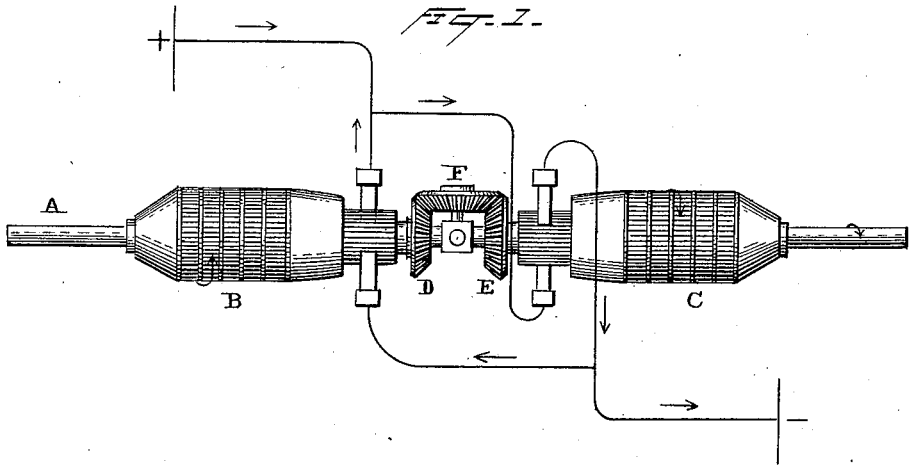
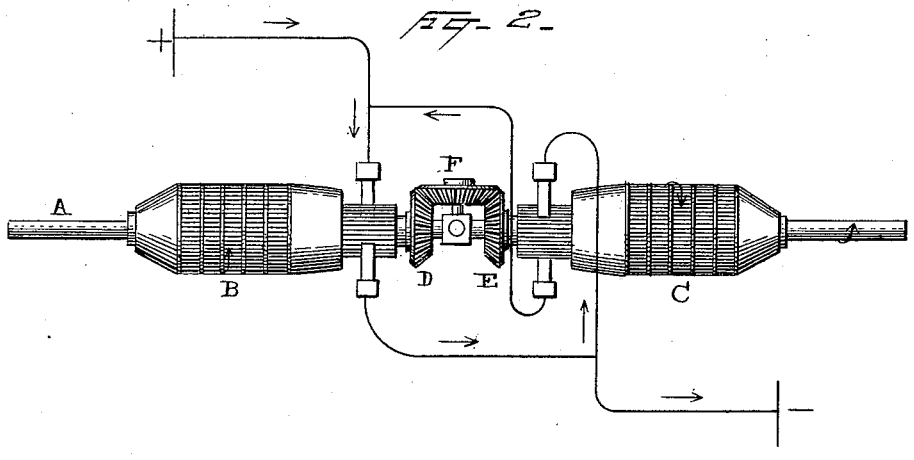


Fig. 2.



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T. A. EDISON.

ELECTRIC MOTOR.

No. 436,127. Patented Sept. 9, 1890.

Fig. 3.

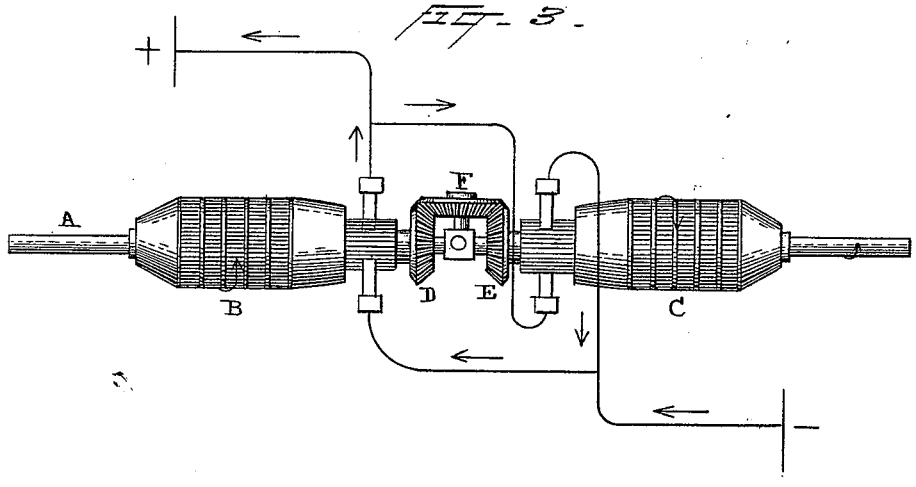
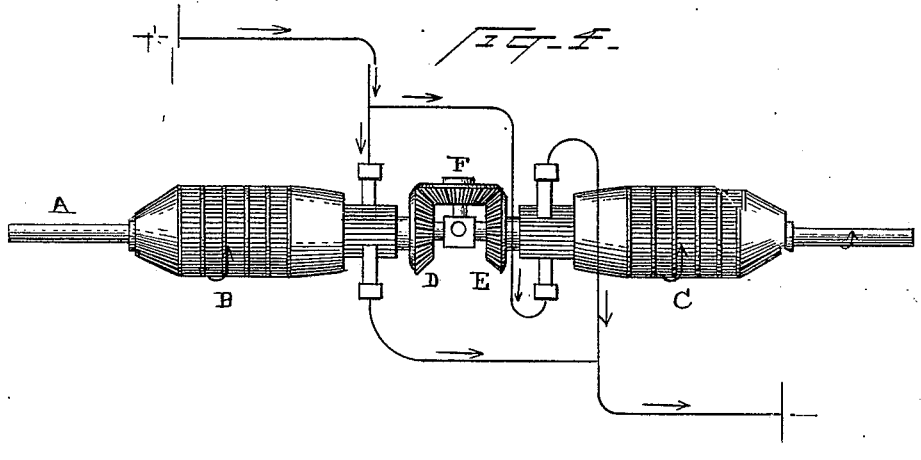


Fig. 4.



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(No Model.) 5 Sheets—Sheet 3.

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ELECTRIC MOTOR.

No. 436,127. Patented Sept. 9, 1890.

Fig. 5.

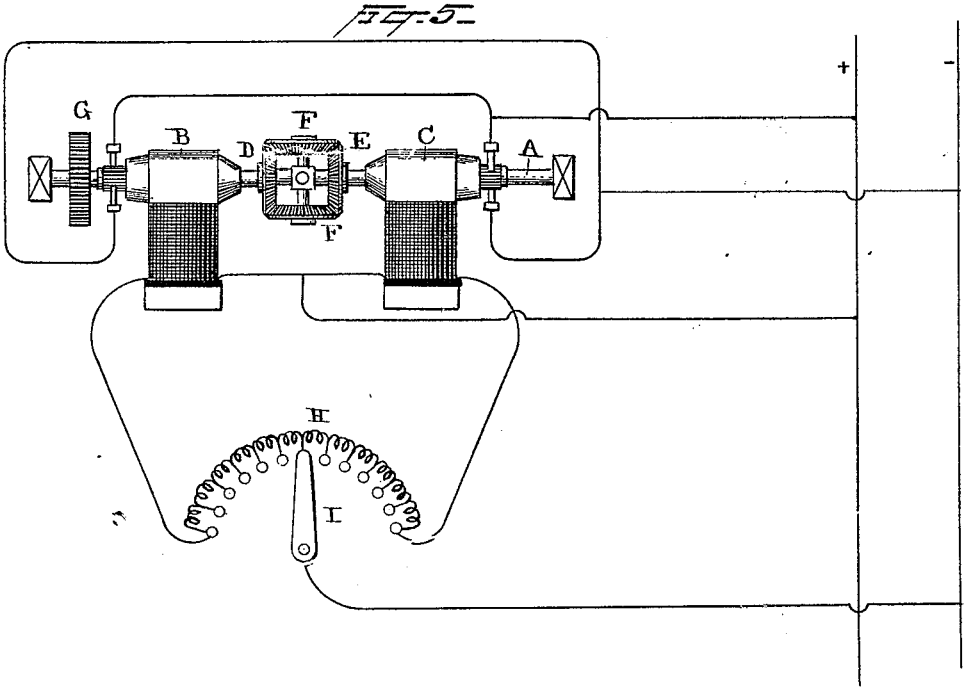
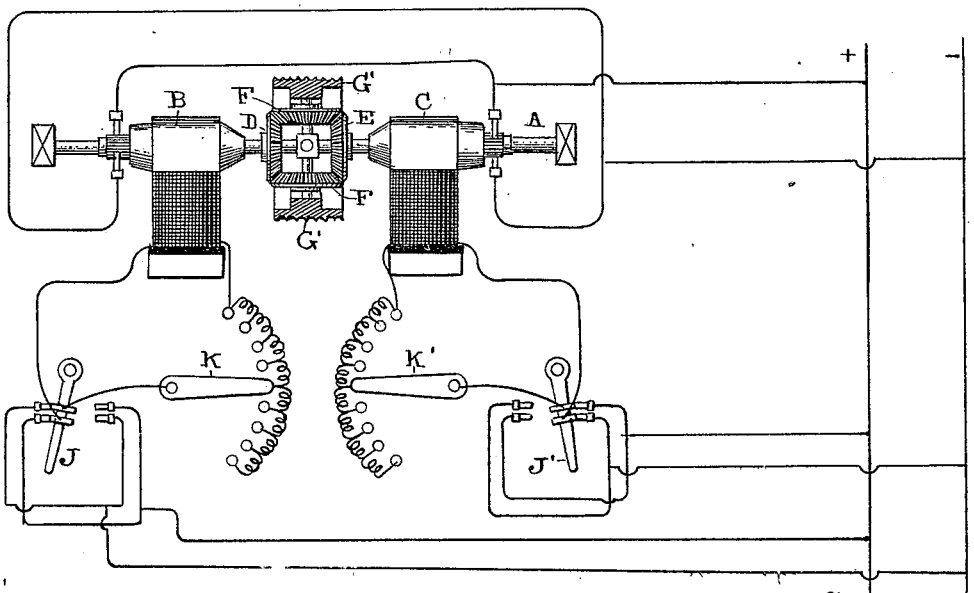


Fig. 6.



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(No Model.) 5 Sheets—Sheet 4.

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ELECTRIC MOTOR.

No. 436,127. Patented Sept. 9, 1890.

Fig. 7.

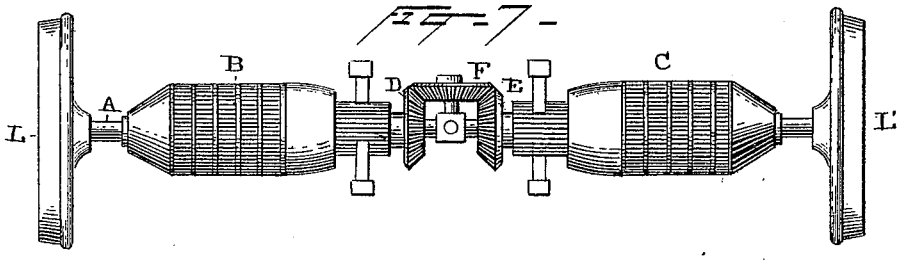
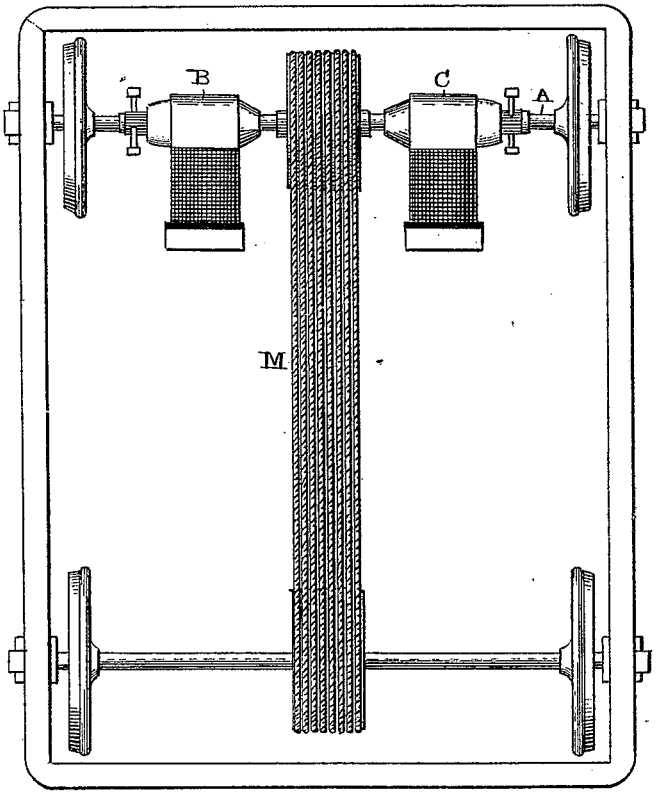


Fig. 8.



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(No Model.) 5 Sheets—Sheet 5.

T. A. EDISON.

ELECTRIC MOTOR.

No. 436,127. Patented Sept. 9, 1890.

Fig. 9.

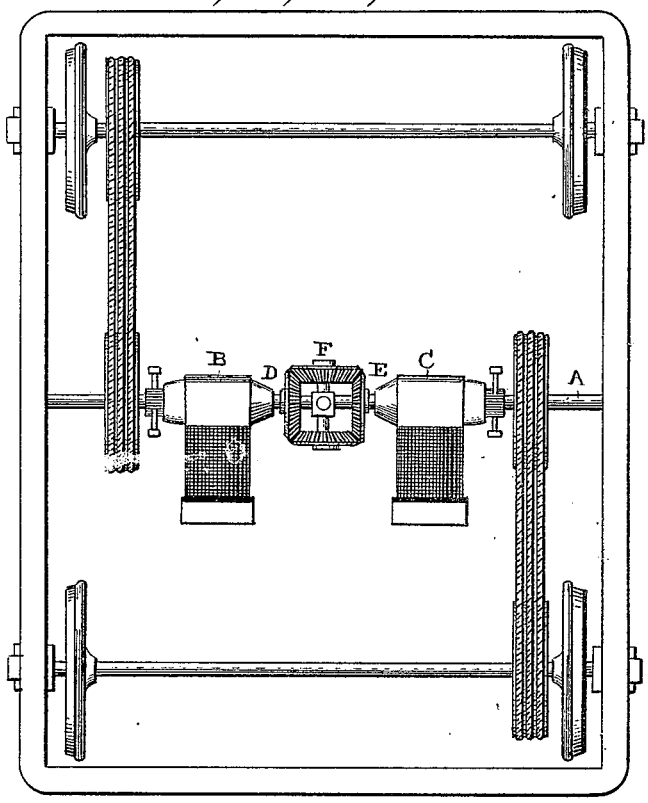
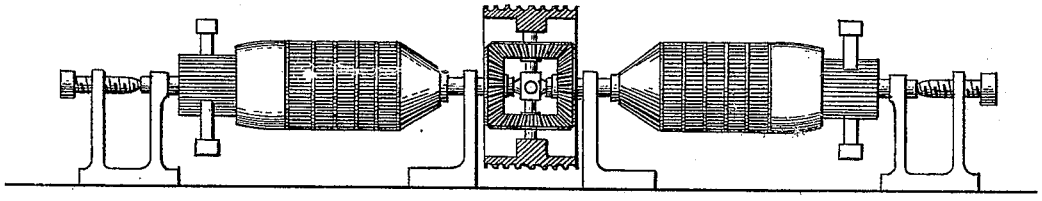


Fig. 10.



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UNITED STATES PATENT OFFICE.

THOMAS A. EDISON, OF LLEWELLYN PARK, NEW JERSEY.

ELECTRIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 436,127, dated September 9, 1890.

Application filed May 24, 1890. Serial No. 352,986. (No model.)

To all whom it may concern:

Be it known that I, THOMAS A. EDISON, a citizen of the United States, residing at Llewellyn Park, in the county of Essex, State of New Jersey, have invented a certain new and useful Improvement in Electric Motors and in Methods of Operating the Same, (Case No. 860,) of which the following is a specification.

The object of this invention is to produce an improved method and apparatus for the operation of machinery of all kinds by electric motors, and especially machinery of that character which it is desired to vary in speed and to reverse in direction.

The invention is especially applicable to the propulsion of moving vehicles—such as street-cars and the like—for which use it has especial advantages; but it is also applicable to the running of elevators, and also, as before indicated, to the driving of all classes of machinery. It is designed to secure the desired variations in speed and direction of rotation without the utilization of energy-wasting devices.

In carrying out my invention I employ two electric motors, which are connected with the shaft to be driven by differential gearing, for which purpose the epicyclic gearing may be employed.

In Figures 1, 2, 3, and 4, which illustrate the principle of the invention, A is a shaft upon which are loosely mounted, so as to turn independently thereon, two electric motors B C, the armatures only of which are shown for simplicity of illustration. These armatures are connected with a line-circuit marked + —, and they carry on their adjoining ends two beveled gears D E, which turn with the armatures independent of the shaft A, and which engage with opposite sides of an epicyclic gear F, mounted upon a stud fixed to the shaft A between the armatures. If the two armatures are revolving in opposite directions with equal speed, it is evident that the epicyclic gear F will be simply rotated without exerting any rotary effort upon the shaft A, which will remain at rest. This condition of affairs may be assumed to be reached when the field-magnets of the two motors are of equal strength. Should it be desired to rotate the shaft A in the direction indicated by the arrow in Fig. 1, the field-magnet of the motor B may be strengthened, while that of the motor C will be made weaker. The effect of this is to accelerate the speed of motor C and retard that of motor B. The difference in the speed of the motors will result in a rotation of the shaft A in the direction shown by Fig. 1, the machine B under these circumstances acting as a dynamo, while the machine C acts as a motor. If it is desired to reverse the direction of rotation of the shaft A, as indicated by the arrow in Fig. 2, the relative strength of the field-magnets of the two motors will be changed, the field-magnet of motor B being weakened, while that of motor C is made stronger. Now the machine C becomes a dynamo, while the machine B acts as a motor, the speed of the shaft A being equal to the difference in speed between the two machines. Thus it will be seen that a reversal of the direction of rotation of the shaft A may be accomplished without reversing the direction of rotation of the machines, and that the rate of speed of the shaft A in either direction may be varied within wide limits, or the shaft A may be brought to a standstill without stopping the motors.

Under the conditions shown in Figs. 1 and 2 the current will be taken from the main circuit + — in proportion to the energy developed, while the machine which is acting as a dynamo will deliver its current through the local circuit, as indicated, to the other machine acting as a motor, thus conserving the force which is delivered to the machine acting as a dynamo and redelivering the energy, less the percentage due to conversion, for the performance of useful work in the machine acting as a motor. Thus an economical arrangement is produced.

In the application of the invention to the propulsion of vehicles—such as street cars—an additional condition will be introduced if it is desired to stop the car while maintaining the circuit-connections of the machines. Considering that the shaft A is a car-axle which is being driven in the direction indicated in Fig. 2, and it is desired to stop the car, the field-magnets of the two machines may be brought to the same strength, or that of machine B may be made stronger to any degree desired than that of machine C. The conditions while the car is being propelled forward

by its momentum will be as indicated in Fig. 3. The shaft A will then be delivering energy to the machines, with the result of sending current back upon the main line, as indicated by the arrows. The machine B becomes a dynamo, and the machine C a motor; but the current taken by the motor will be less than the current delivered by the dynamo. If the car were running in the other direction, as indicated by Fig. 1, the braking of the car would produce the reverse relation of the machines, machine B becoming a motor and machine C a dynamo.

For the driving of some kinds of machinery it may be desirable to produce a greater variation in the speed than can be secured when the motors are capable alone of being driven in opposite directions. In that case the motors may be arranged for independent reversal of their direction of rotation, so that under some circumstances the motors may both be run in the same direction, as indicated in Fig. 4, and while running in the same direction the shaft A will have its greatest speed when the two machines have an equal maximum speed. Thus the speed of the shaft A may be increased from a position of rest to the maximum, which can be secured by running the machines in opposite directions, and then the speed can be further increased by reversing the direction of rotation of the slower machine, so that instead of detracting from the speed it will actually add to it, and the speed will be further increased as this slower machine is brought up to the same rate of rotation as the other, when the maximum speed of the shaft A will be attained. The application of these principles to some of the conditions of use are indicated in Figs. 5 to 10 of the drawings, of which—

Fig. 5 is a top view (with a diagram of one form of the electrical connections) illustrating the driving of a shaft which may be connected by any suitable means with the machinery to be driven. Fig. 6 is a similar view illustrating a different method for the electrical connections, and showing the epicyclic gears mounted on a driving-wheel from which the power-connections are made. Fig. 7 is a top view showing the motor armatures and gearing mounted directly upon a car-axle. Fig. 8 is a top view illustrating the same features as Fig. 7, but showing a driving connection with the other axle of the car. Fig. 9 is a view similar to Fig. 8, showing the motors driving an intermediate shaft which is connected with the car-axles. Fig. 10 is a view illustrating a modified way of mounting the shafts.

Referring to Figs. 5 to 9, inclusive, A is the driving-shaft, B and C are the two motors, and D, E, and F represent the epicyclic gearing. In Fig. 5 a gear-wheel G is shown for transmitting the power developed; but any device may be used for the purpose.

The main current supplying the circuit is indicated by the signs + and —. By the method of connection shown in Fig. 5 the motor-armatures are connected in multiple arc with this circuit + —, and so are the field-magnets. A resistance H is located in the field-circuits of the two machines B C. This resistance is adjusted by means of a switch I in such manner that the portion of the resistance on the right of the switch I is in the field-circuit of the machine C, while the portion of the resistance on the left of the switch I is in the field-circuit of the machine B. The shifting of the switch to the left diminishes the resistance in the field of the machine B, and increases that in the field of the machine C. A movement to the right produces the reverse effect. If the switch I stands at a central position, making the resistances in the two field-circuits equal, the two machines will have an equal speed in opposite directions, and the shaft A will remain at rest. By throwing the switch I to the left the field-magnet of the machine B is strengthened, while that of the machine C will be weakened, resulting in the conditions illustrated by Fig. 1 before referred to, and producing a rotation of the shaft A at a speed which is proportional to the difference in the speed of the two machines, and which may be varied within wide limits. By swinging the switch I to the right the field of the machine C will be made strong and that of the machine B weak, and the conditions illustrated by Fig. 2 will be obtained.

In Fig. 6 the field-magnet circuits of the two machines are provided with current-reversers J J′, and also with separate adjustable resistances K K′. By means of the separate adjustable resistances the field-magnets of the two machines may be independently varied in strength. The reversing-switches J J′ also permit the current through the field-magnet of either machine to be reversed, resulting in a reversal of the direction of rotation of the machine and producing the conditions illustrated by Fig. 4. In Fig. 6 there is also illustrated the employment of a wheel G′, in which the epicyclic gears F are placed. This wheel G′ is illustrated as a grooved pulley for the transmission of power by rope belting; but it may be a smooth-faced pulley or it can be a gear-wheel.

The electrical connections may be made in various ways, as will be understood by electricians, to accomplish the purposes of my invention without departing from the spirit thereof.

In Fig. 7 the shaft A is shown as the axle of a car, the wheels being shown at L L′. The epicyclic gearing permits of the necessary reduction in speed or multiplication of the power of the motors for the purpose of street-car propulsion, and enables the power to be multiplied and the speed of the car-axle reduced to an unlimited extent in starting the car or in ascending grades, and without diminishing the total speed of the two machines. Since the direction of rotation of

the car-axle can be reversed without reversing the machines, which may always be run in the same direction, the difficulties heretofore encountered with the commutator-brushes upon car-motors can be entirely overcome, such difficulties being largely incident to the reversal of the motors. In case the car is to be operated by having the two motors hung upon one axle it may be desirable to utilize the traction of the other wheels of the car. This may be accomplished by a power-connection between the axle upon which the motors are mounted and the other axle, as illustrated in Fig. 8, in which M is a rope belting extending from a pulley in which the epicyclic gears are mounted to a similar pulley on the other axle. The weight may be distributed in the case of car-propulsion by mounting the motors at the center of the car upon the equalizing-bars, and connecting the shaft driven by the motors with one or both of the car-axles by rope belting or other suitable means, as illustrated by Fig. 9.

In Fig. 10, instead of sleeving the motors upon the shaft to be driven, is shown an arrangement by which the driven shaft is mounted in centers formed in the adjoining ends of the motor-shafts. The epicyclic gears are mounted in a wheel, as shown, from which the power is transmitted. The motor-shafts are held from longitudinal displacement by centering-screws set against their outer ends. It is evident that if the driven machinery is to be operated always in the same direction the direction of rotation of the shaft A will not be reversed, and one machine will always act as a motor and the other as a dynamo. Under such circumstances the machine which always acts as a dynamo may be made smaller than the machine which always acts as a motor. This might be the case in driving a line-shafting or in a street-car which was designed to be turned by a turn-table at the end of the route. My invention contemplates this limited use of the apparatus. Its full benefits, however, are only secured when the driven shaft is required to be reversed in its direction of rotation at intervals, thus causing the utilization of first one machine as a dynamo and then the other to receive the thrust of the other machine, which acts as a motor for the time being.

What I claim as my invention is—

1. The method of operating electric motors, consisting in the employment of differentially-acting motors and utilizing one motor to receive the thrust of the other motor, thus converting the first motor into a dynamo and conserving the energy expended upon it by the second motor, substantially as set forth.

2. The method of operating electric motors, consisting in the employment of differentially-acting motors and utilizing one motor to receive the thrust of the other motor, thus converting the first motor into a dynamo and conserving the energy expended upon it by the second motor and varying the speed of the driven machinery by varying the relative speed of the two machines, substantially as set forth.

3. The method of operating electric motors, consisting in the employment of differentially-acting motors and utilizing one motor to receive the thrust of the other motor, thus converting the first motor into a dynamo and conserving the energy expended upon it by the second motor and reversing the direction of rotation of the driven machinery without reversing either of the motors by changing the dynamic relations of the two motors, substantially as set forth.

4. The combination, with a driven shaft, of two electro-dynamic or dynamo-electric machines, a differential gearing connecting such machines with the shaft to be driven, and means for changing the dynamic relations of such machines, substantially as set forth.

5. The combination, with a driven shaft, of two electro-dynamic or dynamo-electric machines, a differential gearing connecting such machines with the shaft to be driven, and means for varying the strength of the field-magnets of such machines, substantially as set forth.

6. The combination, with a driven shaft, of two electro-dynamic or dynamo-electric machines, differential gearing connecting such machines with the shaft, and means for simultaneously increasing the strength of the field-magnet of one machine and decreasing the strength of the field-magnet of the other machine, substantially as set forth.

This specification signed and witnessed this 17th day of May, 1890.

THOS. A. EDISON.

Witnesses:
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THOMAS MAGUIRE.