No. 786,419. PATENTED APR. 4, 1905.

H. H. CUTLER.

SYSTEM FOR OPERATING ELECTRIC VEHICLES.

APPLICATION FILED MAR. 14, 1904.

4 SHEETS—SHEET 1.

Fig. 1.

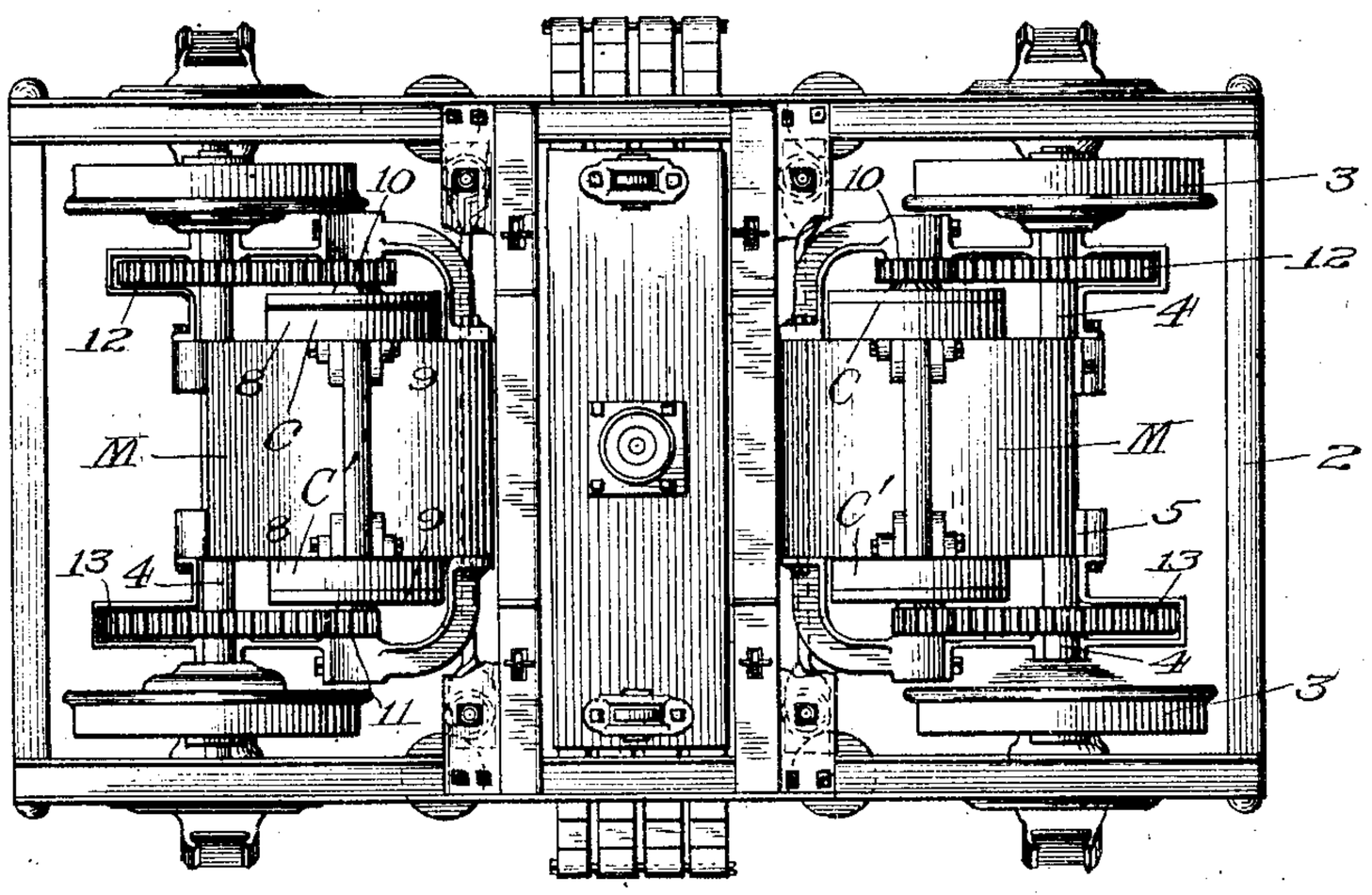
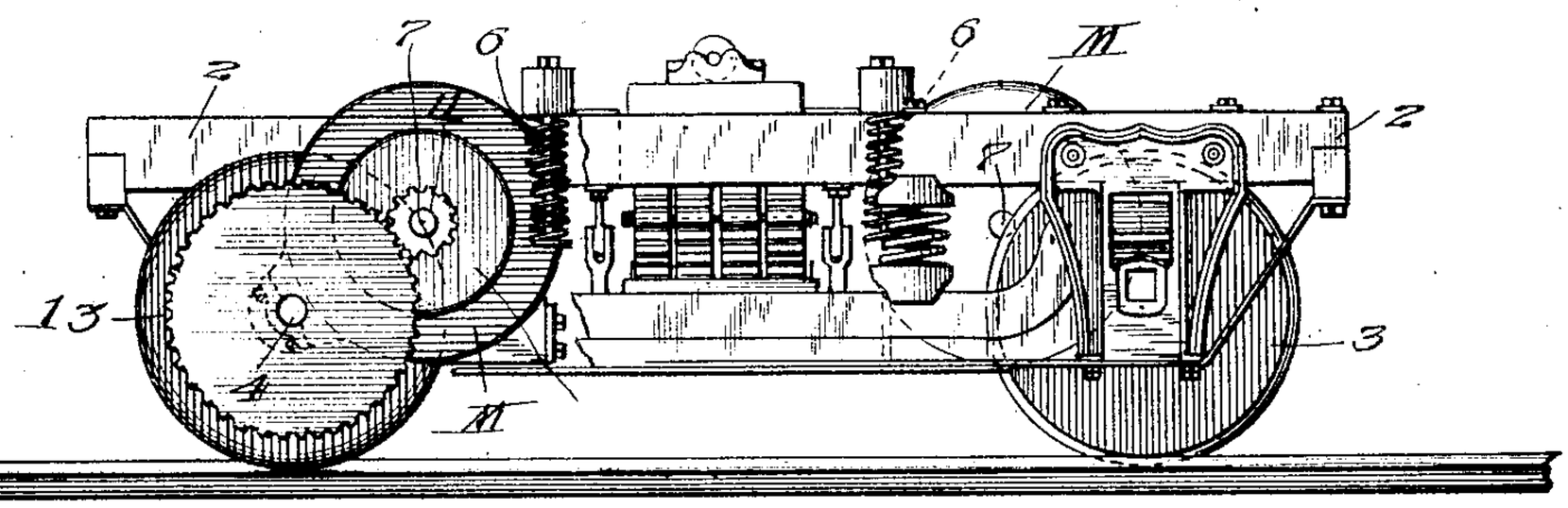


Fig. 2.



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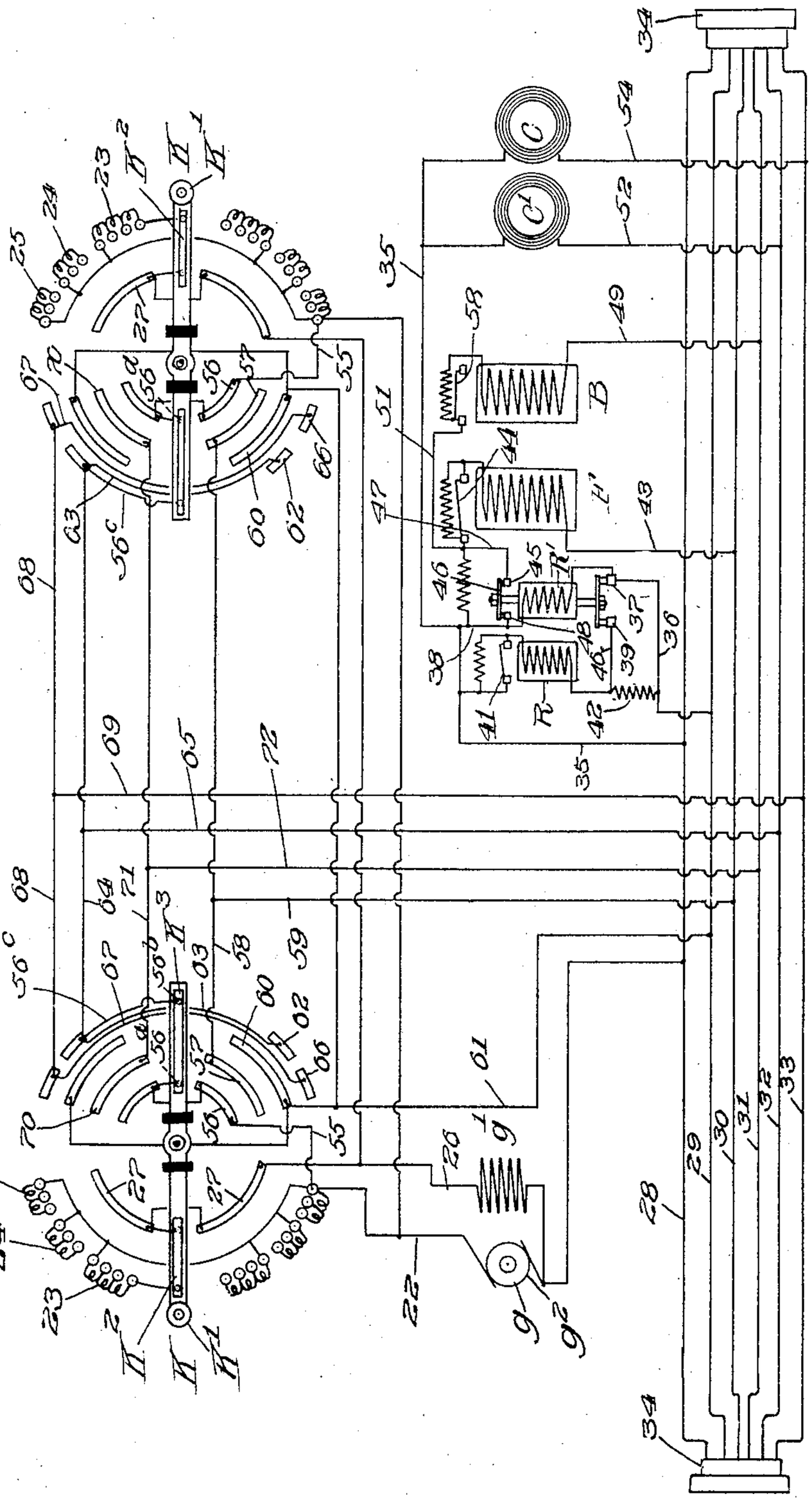
4 SHEETS—SHEET 2.

Fig. 3.



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4 SHEETS—SHEET 3.

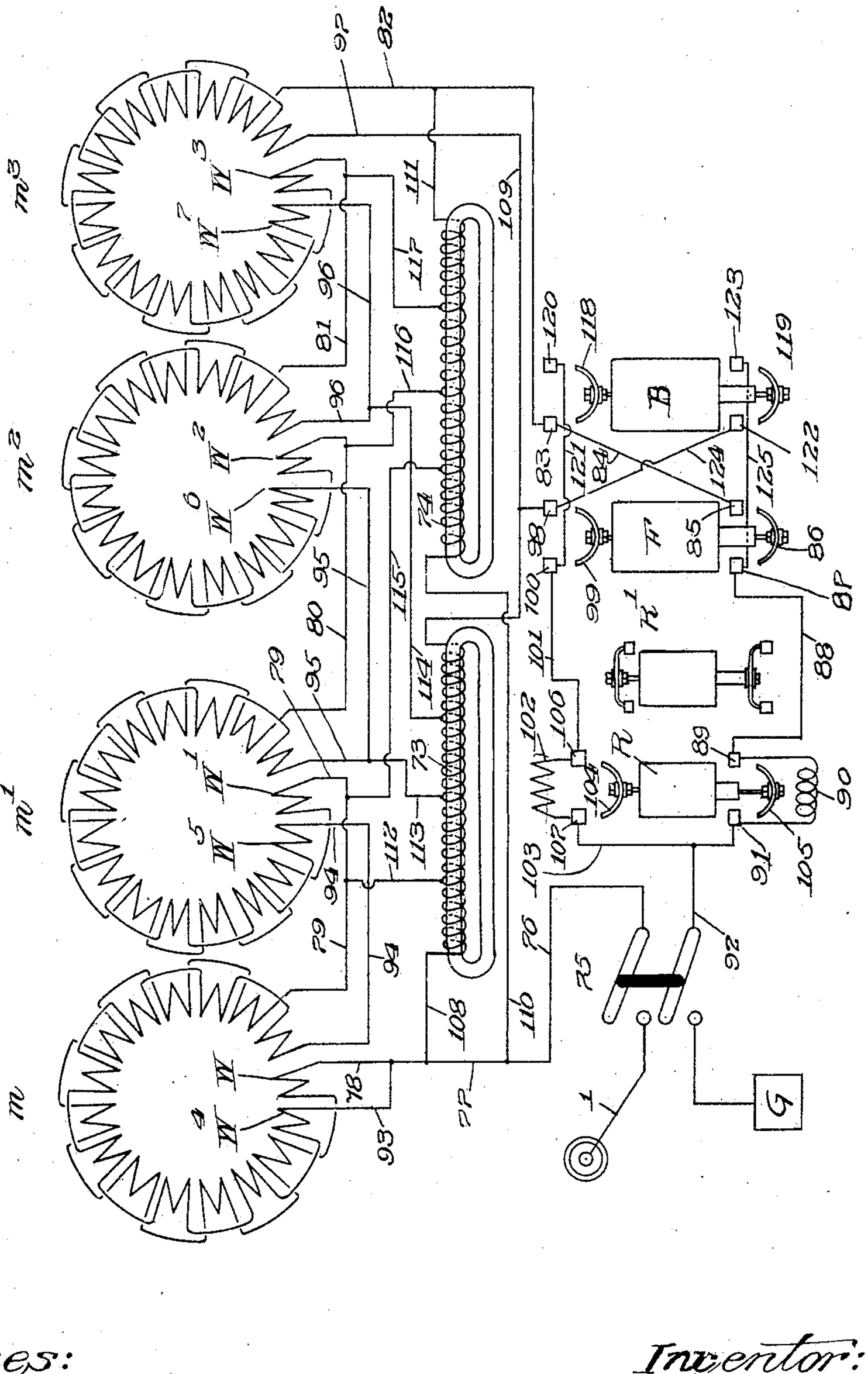

Fig. 4.

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4 SHEETS—SHEET 4.

Fig. 5.

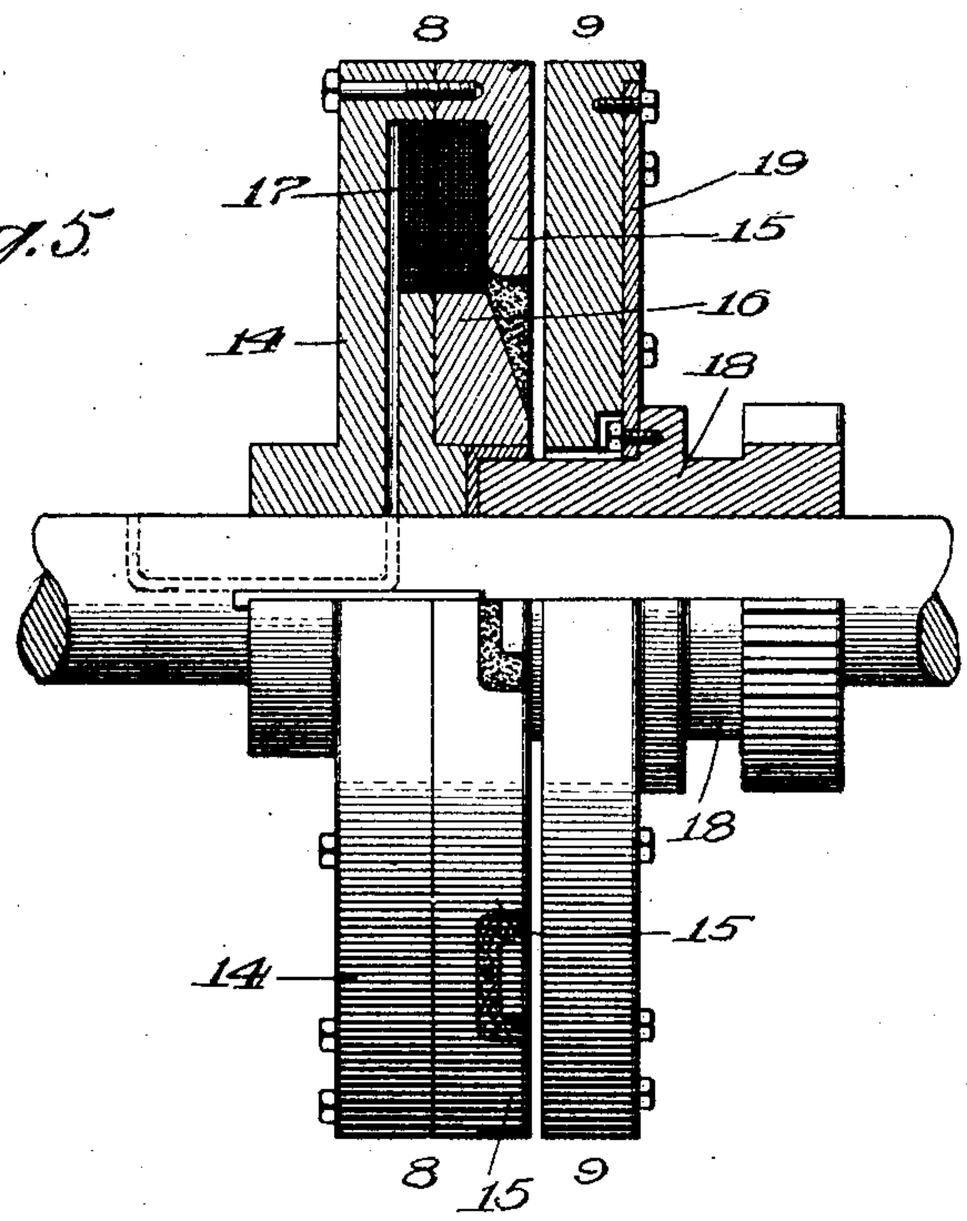
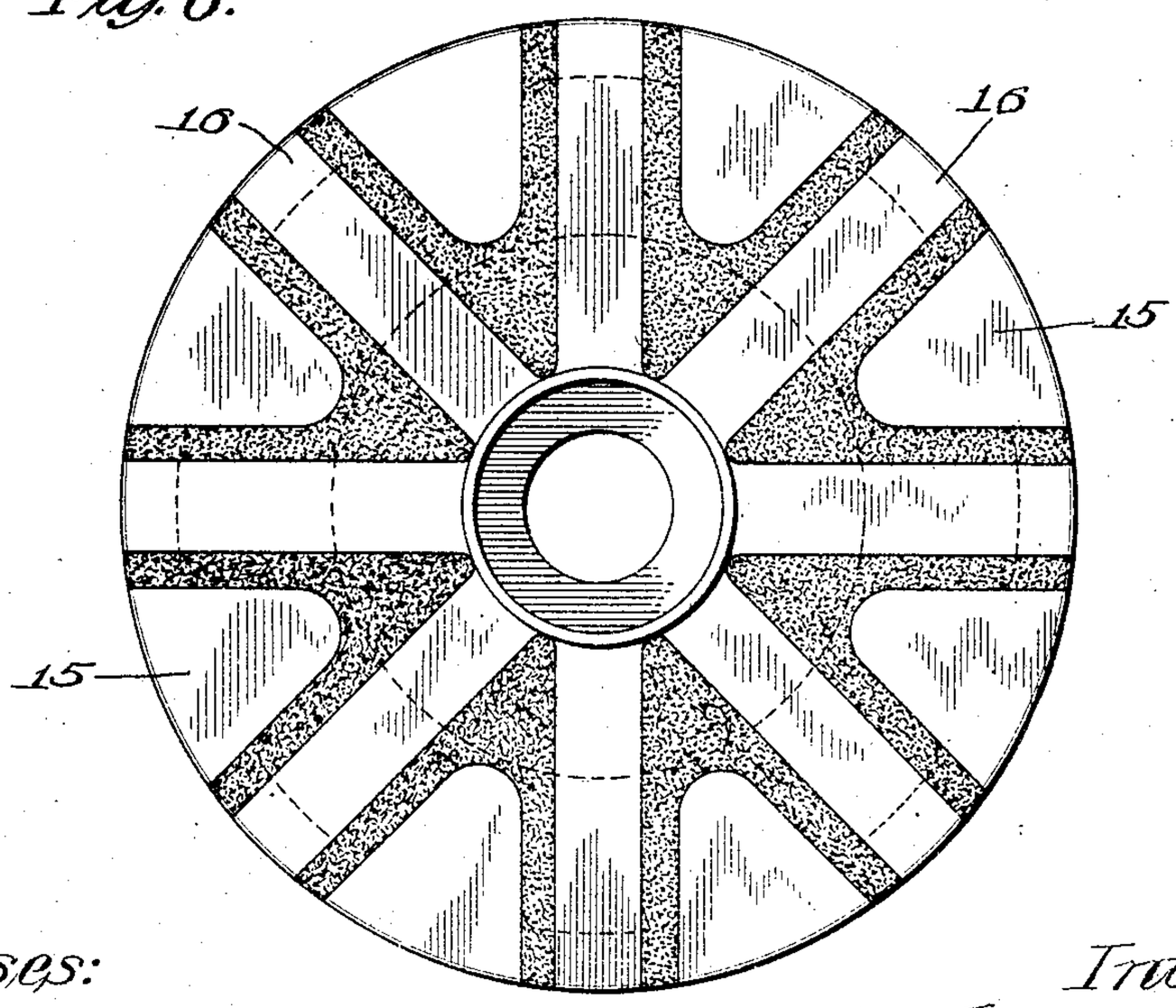


Fig. 6.



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UNITED STATES PATENT OFFICE.

HENRY H. CUTLER, OF MILWAUKEE, WISCONSIN, ASSIGNOR TO THE CUTLER-HAMMER MANUFACTURING COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF WISCONSIN.

SYSTEM FOR OPERATING ELECTRIC VEHICLES.

SPECIFICATION forming part of Letters Patent No. 786,419, dated April 4, 1905.

Application filed March 14, 1904. Serial No. 197,961.

To all whom it may concern:

Be it known that I, HENRY H. CUTLER, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented new and useful Improvements in Systems for Operating Electric Vehicles, 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.

My invention relates to improvements in alternating-current motors and means for connecting the same with a driven mechanism, my object being to provide an alternating-current motor for operating electric vehicles, electric-railway trains, interurban-railway trains, electrically-driven boats, and any devices which are adapted to be driven by electric motors, and to provide means for connecting the same with the driven mechanism thereof, whereby the motor may operate independently of the driven machinery and be connected therewith without undue strain upon the motor or the parts driven thereby.

One form of my device is illustrated in the accompanying drawings, in which—

Figure 1 is a plan view of a car-truck. Fig. 2 is a side view thereof. Fig. 3 is a diagram of the controlling-circuits in which I arrange the means for controlling the operation of the vehicle or car. Fig. 4 is a diagram of the power-circuits for supplying the propelling-motors with the operating-current. Fig. 5 is a sectional view of one of the clutches, and Fig. 6 is a face view of the primary or magnet member of said clutch.

In the drawings I have illustrated my invention as applied to an electric car or vehicle of the usual construction; but of course it may be applied to various other forms of electric vehicles.

The alternating-current propelling-motors M, which I employ to operate the vehicle, are preferably arranged upon the trucks 2, said trucks being supported upon wheels 3, having axles 4, which are journaled in suitable bearings. These motors are by preference pivoted at one side to the car-axles by bearings 5 and suspended from the car-truck at the opposite side by springs 6. Upon the shaft 7 of the rotor of the motor are preferably mounted suitable clutches C and C′, one of said clutches preferably being arranged upon each side of the motor. The magnet of primary members 8 of said clutches are preferably fastened upon the shaft 7 to rotate therewith, while the armature or secondary members 9 are loosely mounted upon the shaft. These secondary members of the clutches have connected therewith gears or pinions 10 and 11, meshing with gears 12 and 13, fastened upon the wheel-shaft 4, the gears 10 and 12 being designed to drive the wheel-shaft from the propelling-motors at a different speed from the gears 11 and 13. According to the arrangement of the clutch and gears illustrated in the drawings, the vehicle will be propelled at a high speed when the driving-wheels are connected with the motor through the high-speed clutch C and at a low speed when said wheels are connected with the motor through the low-speed clutch C′. The form of clutch which I preferably employ to connect the driving-wheels with the motor is illustrated in detail in Figs. 5 and 6 and is fully set forth in an application filed by me August 5, 1903, Serial No. 168,388. The magnet or primary member 8 of each clutch has a backing-plate 14, upon which is mounted an outer ring having inwardly-projecting pole-pieces 15 and an inner ring having outwardly-projecting pole-pieces 16. These pole-pieces are arranged in overlapping positions and preferably have the spaces between the same filled with non-magnetic material. The energizing-winding 17 for the magnet or primary member is placed within an annular channel formed between the backing-plate and the pole-pieces. The armature or secondary member 9 has a hub 18, upon which is mounted a spring-metal disk 19, which near its center is secured to said hub and at its outer edges supports an armature-plate 20, normally separated from the pole-pieces of the magnet member. This spring-disk serves to withdraw the armature-plate

from the magnet or primary member when the energizing-coil is deënergized. This form of clutch enables the load to be gradually imposed upon the motor when said motor is operating at its most effective speed without subjecting the parts of the apparatus to any undue strain or disturbing the supply-circuit and may be controlled to regulate the speed of the driving-wheels by introducing a slip between said driving-wheels and the rotor of the motor. Although I prefer to use the clutch which I have described, it is of course understood that there are various other forms of clutches which may be employed to connect the driving-wheels with the motor.

The propelling-motors M are preferably inductive motors having squirrel-cage or spider armatures. Such motors as at present constructed are sufficiently narrow to permit the clutches and gearing to be arranged between the same and the sides of a truck of standard size. Furthermore, the spider-armatures have a central opening or space, in which the collecting rings and brushes for conveying current to the clutch-windings may be arranged. With the construction I have illustrated the car may be quickly started, as four motors will serve to propel a car or vehicle having two trucks.

The operation of the motors and clutches may be controlled through a system illustrated in Figs. 3 and 4, the former illustrating the controlling-circuits and the latter the power-circuits. Viewing Fig. 3, at each end of the car may be arranged a controller *k*, having a centrally-pivoted operating-lever *k'*, which carries brushes K^2 K^3. These brushes are adapted to engage suitable contacts to close the controlling-circuits, as will be hereinafter set forth.

A suitable direct-current generator G, having an armature *g* and a field *g'*, is situated in the car to supply direct current to the controlling-circuits. This generator may be driven in any way, as by a continuously-running single-phase alternating-current motor. The armature *g* of the generator has one terminal connected with the terminal g^2 and the other terminal connected with resistances 23 24 25 of the controller through wire 22, said resistances being divided into sections which are suitably connected with contact-terminals. For the purpose of convenience a set of resistances is shown in the controller at each side of the lever-arm; but in practice only one set of resistances would be employed. The winding of the field has one of its terminals connected with the terminal g^2 and the other terminal connected by conductor 26 with a contact-segment 27.

Through each car extends a set of wires or conductors 28, 29, 30, 31, 32, and 33, which in practice would preferably be formed into a single cable and insulated from one another. At each end of said cable may be provided a coupling 34 for connecting the conductors of said cable or train-line with the corresponding conductors of a train-line in another car where it is desired to operate a train of cars upon the multiple-unit plan. The conductor 28 is connected with the terminal g^2 of the generator and has a conductor 35 connected therewith, so that it constitutes a common return-wire, as will hereinafter be apparent. The conductor 29 is connected by conductor 36 with one terminal 37 of the solenoid-switch R', said terminal 37 being connected with one terminal of the winding of said solenoid, the opposite terminal thereof being connected with the return-wire 35 by conductor 38. The terminal 39 of said solenoid-switch is connected with one terminal of the solenoid R through the conductor 40, the opposite terminal thereof being connected, through a suitable switch 41, with the return-wire 35. Inserted between the conductors 36 and 40 is a suitable resistance 42. The conductor 30 is connected by conductor 43 with one terminal of the solenoid-winding F, the opposite terminal thereof being connected, through switch 44, with one terminal 45 of the solenoid-switch 46 by conductor 47. The opposite terminal 48 of said switch is connected by conductor 38 with the return-conductor 35. The conductor 31 is connected by conductor 49 with one terminal of solenoid-winding B, the opposite terminal thereof being connected, through switch 58, by conductors 51 and 47 with the terminal 45 of the switch 46.

The clutches C and C', the former being the high-speed clutch and the latter the low-speed clutch, have the windings thereof connected between the conductors 35 and 32 and 35 and 33, respectively, the windings of the clutch C' being connected with the conductor 32 by conductor 52 and the windings of the clutch C being connected with conductor 33 by the conductor 54.

For the present only the controller at the left-hand side will be considered in tracing the circuits. Assuming that the handle of the controller-arm K be moved in the direction of the arrow until the brush K^2 engages the first terminal of the resistance 23, the circuit of the generator will then be closed from the armature *g* through the conductor 22, all the resistance 23, brush K^2, contact-segment 27, conductor 26, field *g'*, terminal g^2 to the armature. The shunt field-circuit is thereby connected across the commutator-brushes of the armature and the armature begins to generate current. This current is delivered to the various train-wires as follows: Current may be traced from the upper brush of the armature through conductor 22, conductor 55 to contact-segment 56, from thence through contact-shoe K^3 to contact-segment 57, through conductor 58, conductor 59, train-line 30, conductor 43, solenoid-winding F, switch 44, conductor 47 to terminal 45 of the switch 46 on

the top of the solenoid R', across switch 46 to terminal 48, conductor 38, return-conductor 35, conductor 28, and back to the opposite side of the generator. A current of low voltage is thus supplied to the solenoid-winding F, which attracts its armature and starts the rotors of the motors, as more fully hereinafter explained, at the same time opening the small switch 44, shown at the top of the winding, thus inserting some external resistance in series therewith for the purpose of cutting down unnecessary flow of current through its windings. A continued upward movement of the operator-lever will cut out the resistance 23 in the shunt field-circuit of the direct-current generator, and the shoe K^3 will finally make contact with the segment 60, thus delivering current at a higher voltage over the conductor 61, train-line 29, conductor 36, to terminal 37, across the contact-switch on the lower end of the solenoid-winding R', conductor 40, through the solenoid-winding R, through the resistance-switch 41 at its top, return-conductor 35, train-line 28 and back to the opposite side of the generator G. Solenoid R will thus become energized and cut out the inductive and non-inductive resistance, as hereinafter described, and at the same time by opening switch 41 will introduce external resistance into the winding thereof to cut down the unnecessary amount of current flowing therethrough. All the rotors of the motor will now be running at full speed in a forward direction, and the train can be started by a further movement of the operating-lever, which will supply a current of low voltage to the low-speed clutch C', which current may be traced as follows: The current will flow from the generator through the conductor 22, through conductor 55, contact-segment 56, contact-shoe K^3 to segment 62, from thence through the conductor 63, conductors 64 and 65, through train-line 32, conductor 53, clutch-winding C', conductor 35, conductor 28, back to the opposite terminal of the generator. This connection would cause a current of low voltage to flow through the exciting-coil of the slow-speed clutch. The resistance 24 will also be inserted in the circuit of the field g, thereby reducing the voltage impressed by the generator. This reduction in voltage will not be sufficient, however, to allow the solenoids R and R' to release the switches controlled thereby. The driving-wheels now being connected with the motors by the low-speed clutch C', the vehicle will be started, its movement being slow, due to the slippage which is permitted between the members of the clutches when the voltage of the current is low. The increase in current supplied to the clutch C' following the removal of the resistance 24 from the circuit by onward movement of the controller-arm causes the slippage between the members of the clutch C' to be diminished, thereby gradually increasing the speed of the car. When the slippage between the members of the clutches entirely ceases, the car will be running at the highest speed attainable through the low-speed gear. At this stage of the operation of the car the low-speed gear is disconnected from the motor and the high-speed gear connected therewith. This comes about by the passage of the brush K^3 of the controller from contact-segments 62 to contact-segments 66, thereby opening the circuit of the low-speed clutch and closing the circuit of the high-speed clutch. By starting at one terminal of the armature of the generator the current of the high-speed clutch C may be traced from the generator G through conductor 22, conductor 55, to contact-segment 56, contact-brush K^3, to contact-segment 66, through conductor 67, conductors 68 and 69, train-line 33, through conductor 54, clutch-winding C, return-conductor 34, and by conductor 28 to the opposite side of the generator. The resistance 25 being in circuit with the field-winding g', slippage will take place between the members of the high-speed clutch C. The change of the connection of the driving-wheels of the motor will make a difference in the speed of the car, and then as the resistance 25 is removed from circuit to cause the members of the high-speed clutch to move in unison the speed of the car will further increase. According to the foregoing description of the operation of my system it will be observed that after the propelling-motors have been started and are running at full speed the power thereof may be gradually applied to the driving-wheels, since the clutch or accelerator for connecting the driving-wheels with the motors admit of being controlled by regulating the current supplied thereto. This enables the car to be started without jarring and imposing strains upon the various mechanism too suddenly. As more torque is required to start the car than to keep it in motion, this system utilizes the power of the motors to the best advantage, since to impart the initial movement to the car in starting the driving-wheels will operate by the low-speed gearing, and then when the car has been in motion the high-speed gearing is employed to operate the driving-wheels. If the controller arm or lever K were moved in the opposite direction, then the brush K^3 would engage a contact 70, thereby closing the circuit to the solenoid B of the backward switch. This circuit may be traced from one side of the generator through conductor 22, contact-segment 56, brush K^3, contact-segment 70, conductors 71 72 31 49, solenoid B, through the switch 50, conductor 51, terminal 45, switch 46 on top of the solenoid 71, terminal 48, conductor 38, and by conductors 35 and 28 back to the opposite side of the generator. The movement of the controller-arm in this direction will close the circuit to the resistance solenoids and clutches

in the same manner as hereinbefore described. When the car or vehicle is running in one direction, to reverse the same the operator moves the lever K′ of the controller K to a full "off" position, as indicated in the drawings. When the lever is in this position, it opens the circuit to all the solenoid-switches, and thereby disconnects the driving-motors from the supply-circuit. Connection, however, is made to the winding of the slow-speed clutch by contact-points 56^a, brush k^3, contact 56^b, conductor 56^c, and thence by conductors 64, 65, 32, and 52 to the clutch-windings C′, whereby a current of low voltage is supplied to the windings by the controlling-generator, thereby connecting the rotors of the driving-motors with the car-wheels. The operator then applies the air-brakes and stops the train, together with the rotors of the motors, since they are connected with the car-axle by means of the slow-speed clutch, as previously explained. The operator then continues to move his controlling-lever in the same direction that he moves it for stopping the train, whereby connection will be made with the back-up solenoid-switch B, thus starting all the rotors of the driving-motors in the opposite direction and bringing them up to full speed. The operator then releases the air-brake, and a further movement of the controller-lever K′ will again admit current to the slow-speed clutch and gradually accelerate the train in the opposite direction.

The other controller illustrated in the drawings may be operated to control the operation of the car the same as the one previously described. By providing the car with two controllers, one at each end thereof, the motorman may operate the car from either end.

When it is desired to operate a train of cars on the multiple-unit plan, the train lines or cables of the several cars may be connected by the coupling 34, so that the motorman may control the operation of all of the cars from the controller at the forward end of the car. This is of course only one of the ways that my system may be utilized to operate a train on the multiple-unit plan.

In Fig. 4 are shown the power-circuits from which the propelling-motors for driving the vehicles are supplied. In these circuits are arranged suitable switches operated by solenoids in the controlling-circuits. These switches will be designated in connection with the description of the power-circuits. In said figure I have shown four eight-pole single-phase inductor-windings m, m', m^2, and m^3, each inductor-winding being provided with sixteen coils connected in series between the trolley and the rail, and as it would be impracticable to obtain exactly the same amount of induction in the stator-windings of each motor I have provided reactive coils 73 and 74, connected across the terminals of each set of stator-windings on each motor, so as to compensate for the slight difference in the inductance of each individual stator-winding, thereby dividing up the load equally between the four motors on the car. I do not claim in this application, broadly, the use of these reactive coils, and therefore disclaim the same. Assuming that the forward switch F has been operated by the energization of its circuit, circuit may be traced from the trolley T, through the switch 75, conductor 76, to conductor 77, where it is divided into four paths. Following out the first path, the circuit may be traced from conductor 77, over conductor 78, through the coils W of the winding of the motor m, by conductor 79 through the windings W′ of the motor m', by conductor 80 through the winding W^2 of the motor m^2, by conductor 81 through the winding W^3 of the motor m', thence by conductor 82 to the terminal block 83, by conductor 84 to terminal 85 of the solenoid-switch F, across the contact-plate 86 of said switch to the opposite terminal block 87 of the same, thence by conductor 88 to terminal 89, through the inductive resistance 90 to terminal 91, conductor 92, and across the switch 75 to the ground. A second path for the current may also be traced from the conductor 77, where the current first divides itself, through conductor 93, the winding W^4 of the motor m, by conductor 94 through the winding W^5 of the motor m', by conductor 95 through the coils W^6 of the motor m^2, thence by conductor 96 through the coils W^7 of the motor m^3, through conductor 97 to the terminal block 98, across the contact-plate 99 of the switch mounted upon the upper part of the solenoid F to terminal block 100, thence by conductor 101 through the non-inductive resistance 102, by conductors 103 92 across the switch 75 to the ground. As the current in one path will be retarded in phase, due to the resistance therein being different from that in the other, a rotating field will be produced by the stator-windings, thereby starting the motors. When the motorman of the car or vehicle manipulates the master-controller K to increase the voltage impressed upon the controlling-circuit by the generator to a sufficient degree, the solenoid R will respond and operate the switch-contacts 104 105. The contact 104 will bridge terminals 106 and 107 to short-circuit the non-inductive resistance 102, and the contact 105 will bridge the terminals 89 and 91 and short-circuit the inductive resistance 90, thus connecting all the stator-windings directly across the trolley and the rail. This enables all the rotors to assume full speed and places them in condition to do work as soon as the load is applied, as hereinbefore described. A third path which the current takes when it divides in passing over the conductor 77 may be traced from the conductor 77, through the conductor 108, through reactive coil 73, through the conductor 109 to terminal block 98, through the contact-plate 99 to terminal 100, thence by

conductor 101 to terminal 106, across contact-plate 104, terminal 107, and thence by conductors 103 and 92 across the switch 75 to the rail. A fourth path which the current takes when it divides in passing over the conductor 77 may be traced by conductor 110 through the second reactive coil 74, conductor 111, by conductor 82 to contact-terminal 83, by conductor 84 to contact-terminal 85, across the contact-plate 86 to contact-terminal 87, by conductor 88 to contact-terminal 89, across the contact-plate 105 to contact-terminal 91, and thence by conductor 92 and switch 75 to the ground.

One set, W^4, of the stator-windings of the motor m is connected in parallel with the reactive coil 73 by the conductors 108, 93, 94, and 112. The corresponding set of windings W^5 of the motor m' is connected in parallel with the reactive coil 73 by the conductors 112, 94, 95, and 113. The corresponding set W^6 of the stator-windings of the motor m^3 is connected in parallel with the reactive coil 73 by conductors 113, 95, 96, and 114. The corresponding set W^7 of the motor-windings m^3 is connected in parallel with the reactive coil 73 by conductors 114, 96, 97, and 109. The other set of stator-windings, W, on the motor m is connected with the reactive coil 74 by the conductors 110 77 78 79 115. The corresponding set W' on the motor m' is connected in parallel with the reactive coil 74 by conductors 115, 79, 80, and 116. The corresponding set W^2 on the motor m^2 is connected in parallel with the reactive coil 74 by conductors 116, 80, 81, and 117, and the corresponding set of windings W^3 on the motor m^3 is connected in parallel with the reactive coil 74 by conductors 117, 81, 82, and 111. By thus connecting the reactive coils 73 and 74 across the terminals of each set of stator-windings on each motor I compensate for the slight differences in the inductance of each individual stator-winding, thereby dividing up the load equally between the four motors of the car.

After the motors have been started by the manipulation of the master-controller the driving-wheels of the vehicle may be connected thereto through the agency of the clutches C and C' in the manner hereinbefore explained.

When it is desired to operate the cars or vehicles in a reverse direction, the controlling-circuit would be closed through the solenoid B of the backward switch, and the solenoid would respond and operate the switch-contacts 118 and 119. The contact 118 will bridge the terminals 83 and 120, and the circuit may be traced through the windings W, W', W^2, and W^3 of the motors, as previously described, by conductor 82 to terminal 83, thence across contact 118 to terminal 120, and thence by conductors 121 101, through the non-inductive resistance 102, and by conductors 103 and 92, through switch 75, to the rail. At the same time the contact 119 will bridge terminals 122 and 123, and circuit may be traced through the windings W^4, W^5, W^6, and W^7 of the motors, as previously described, to terminal 98, thence by conductor 124, terminal 122, contact 119, terminal 123, conductors 125 and 88, through inductive resistance 90, and thence by conductor 92 and switch 75 to ground. A rotating field will thus be set up opposite to that previously described, and the rotors of the motors will be caused to operate in an opposite direction. The resistances 90 and 102 after the rotors have nearly reached normal speed may then be cut out, as previously described, and the motors will attain full speed, when the load may be applied.

Where my system is employed an alternating current of the most efficient voltage and frequency may be supplied to the feeders for the railway. At suitable intervals—say every ten miles—a step-down transformer may be located to supply current to the trolley of a reduced pressure. If desired, those transformers may be arranged farther apart and only partially reduce the voltage of the current supplied to the trolley, said current being further reduced before entering the motors by transformers carried on the cars.

Although I have herein illustrated a system which is designed for a single-phase alternating current, my invention may be applied to a system which is designed for a polyphase alternating current. In practice it is preferable in most instances to use a system designed for a single-phase alternating current, as the cost of installing such a system is not so great as where the system is designed for a polyphase current.

It is evident that the embodiment of my invention herein set forth is susceptible of being modified and changed in various ways without in any way departing from the spirit or scope of my invention as set forth in the claims appended hereto, and while I have shown the motors as operating a plurality of drive-wheels it will be understood that the same may be arranged to operate only one wheel as a driving-wheel.

Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, and an inherently gradually accelerating clutch for connecting said wheel with said motor.

2. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, an inherently gradually accelerating clutch for connecting means with said motor to drive said wheel at one speed, and a second controllable gradually-accelerating clutch for connecting means with

said motor to drive said wheel at a relatively higher speed.

3. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, an inherently gradually accelerating clutch for connecting said wheel with said motor and a controller for said clutch.

4. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same, an inherently gradually accelerating clutch for connecting said wheel with said motor, and means for supplying a direct current to said clutch.

5. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a clutch for connecting said wheel with said motor, and an electrically-operated controller for controlling the operation of said motor.

6. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a clutch for connecting said driving-wheel with said motor, a controlling-circuit, and suitable instrumentalities connected with said controlling-circuit for controlling the operation of said motor.

7. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a controlling-circuit having means connected therewith for controlling the operation of said motor, a clutch for connecting said wheel with said motor, and means for supplying a direct current to said clutch and said controlling-circuit.

8. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a controlling-circuit having means connected therewith for controlling the operation of said motor, a clutch, and means for controlling said circuit and the circuit of said clutch.

9. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating said wheel and capable of running independently thereof, a controllable clutch for connecting means with said motor to drive said wheel at one speed, a second controllable clutch for connecting means with said motor to drive said wheel at a relatively higher speed, a controlling-circuit having means connected therewith for controlling said motor, and means for controlling said circuit and the circuit of said clutches.

10. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a controllable clutch for connecting means with said motor to drive said wheel at one speed, a second controllable clutch for connecting means with said motor to drive said wheel at a relatively higher speed, a controlling-circuit having means connected therewith for controlling the operation of said motor, means for supplying a direct current to said clutches and to said controlling-circuit, and means for controlling said circuit and the circuits of said clutches.

11. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, an alternating-current-supply circuit having said motor connected therewith, a controlling-circuit having means connected therewith for controlling the operation of said motor, means for converting the alternating current upon said supply-circuit into a direct current for said controlling-circuit, and a suitable clutch for connecting said driving-wheel with said motor.

12. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a clutch for connecting said wheel with said motor, a controlling-circuit having means connected therewith for controlling the operation of the motor, and means for first closing said circuit to start the motor, and later closing the circuit of said clutch to connect said wheel with said motor.

13. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a clutch for connecting means with said motor to operate said wheel at one speed, a second clutch for connecting means with said motor to operate said wheel at a relatively higher speed, a controlling-circuit having means connected therewith for controlling the operation of said motor, and a controller for first closing said circuit to start the motor, then closing the circuit of the first-mentioned clutch, and finally opening the circuit of said first-mentioned clutch and closing the circuit of the last-mentioned clutch.

14. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a controlling-circuit having means connected therewith for controlling the operation of said motor, a clutch for connecting said wheel with said motor, means for supplying a direct current to said controlling-circuit and said clutch, and means for first closing said controlling-circuit to start the motor and later closing the circuit to said clutch.

15. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a controlling-circuit having means connected therewith for

controlling the operation of said motor, a clutch for connecting means with said motor to operate said driving-wheel at one speed, a second clutch for connecting means with said motor to drive said wheel at a relatively higher speed, means for supplying a direct current to said controlling-circuit and said clutches, and means for first closing said controlling-circuit to start the motor, then closing the circuit to the first-mentioned clutch and later closing the circuit to the last-mentioned clutch.

16. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a controllable clutch for connecting said wheel with said motor, a controlling-circuit having means connected therewith for controlling the operation of said motor, and a controller for first closing said controlling-circuit to start the motor and later closing the circuit of said clutch, said controller being adapted to vary the current supplied to said clutch.

17. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a controllable clutch for connecting means with said motor to drive said wheel at one speed, a second controllable clutch for connecting means with said motor to drive said wheel at a relatively higher speed, a controlling-circuit having means connected therewith for controlling the operation of said motor, and a controller for first closing said controlling-circuit to start said motor and later closing the circuit of said clutches successively, said controller being adapted to vary the current supplied to said clutches.

18. The combination with the driving-wheel of an electric vehicle, of a suitable motor for operating the same and capable of running independently thereof, a controlling-circuit, suitable instrumentalities connected with said circuit for controlling the operation of said motor, a clutch for connecting said wheel with said motor, and means for first closing said controlling-circuit to start the motor and later closing the circuit of said clutch.

19. The combination with the driving-wheel of an electric vehicle, of a motor for operating said wheel and capable of running independently thereof, a controlling-circuit, electromagnetic windings connected in said circuit, suitable instrumentalities adapted to be operated by said windings to control the operation of said motor, a clutch for connecting said wheel with said motor, and means for first closing said controlling-circuit and later closing the circuit of said clutch.

20. The combination with the driving-wheel of an electric vehicle, of an electric motor for operating said wheel and capable of running independently thereof, a controlling-circuit, electromagnetic windings arranged in said controlling-circuit and adapted to respond to variations in voltage, suitable instrumentalities adapted to be actuated by said windings to control the operation of said motor, means for varying at will the voltage impressed upon said circuit, and a clutch for connecting said wheel with said motor.

21. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a controlling-circuit, electromagnetic windings connected with said circuit and adapted to respond to variations in voltage, suitable instrumentalities adapted to be actuated by said windings to control the operation of said motor, a generator for supplying a direct current to said circuit, means for varying the voltage impressed upon said circuit by said generator, and a clutch for connecting said wheel with said motor.

22. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a controlling-circuit, electromagnetic windings connected with said circuit and adapted to respond to variations in voltage, the elements of a phase-splitter adapted to be operated by said windings to start said motor, means for varying the voltage impressed upon said circuit, and a clutch for connecting said wheel with said motor.

23. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, a controlling-circuit, electromagnetic windings connected with said circuit and adapted to respond to variations in voltage, suitable instrumentalities adapted to be operated by said windings to control the operation of said motor, a clutch for connecting means with said motor to drive said wheel at one speed, a second clutch for connecting means with said motor to drive said wheel at a relatively higher speed, means for supplying a direct current to said controlling-circuit and said clutches, and means for varying at will the voltage impressed upon said controlling-circuit.

24. The combination with the driving-wheel of an electric vehicle, of a plurality of alternating-current motors connected in series for operating the same and capable of running independently thereof, means to cause said motors to divide the load proportionately and a controllable clutch for connecting said wheel with said motors.

25. The combination with the driving-wheel of an electric vehicle, of a plurality of alternating-current motors connected in series for operating the same and capable of running independently thereof, means to cause said motors to divide the load proportionately, a controllable clutch for connecting means with said motors to drive said wheel at one speed, and

a second controllable clutch for connecting means with said motors to drive said wheel at a relatively higher speed.

26. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof and an inherently gradually accelerating clutch for connecting the wheel with said motor.

27. The combination with the driving-wheel of an electric vehicle, of an alternating-current motor for operating the same and capable of running independently thereof, an inherently gradually accelerating clutch for connecting means with said motor to drive said wheel at one speed and a second gradually-accelerating clutch for connecting means with said motor to drive said wheel at a relatively higher speed.

In witness whereof I have hereunto subscribed my name in the presence of two witnesses.

HENRY H. CUTLER.

Witnesses:
THOS. E. BARNUM,
L. D. ROWELL.