C. F. KETTERING.

ENGINE STARTING DEVICE.

APPLICATION FILED MAR. 5, 1915.

1,231,266.

Patented June 26, 1917.

3 SHEETS—SHEET 1.

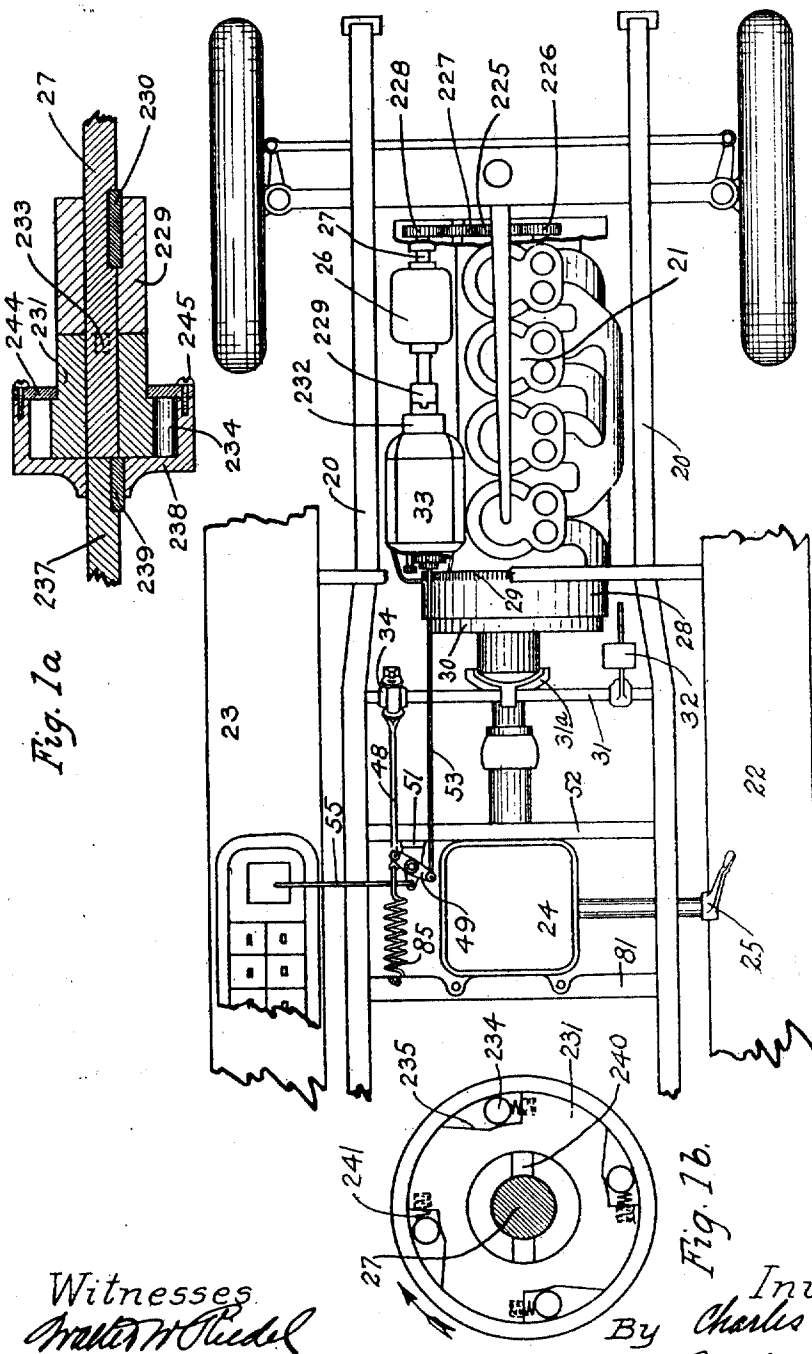


Fig. 1a

Fig. 1.

Fig. 1b.

Witnesses

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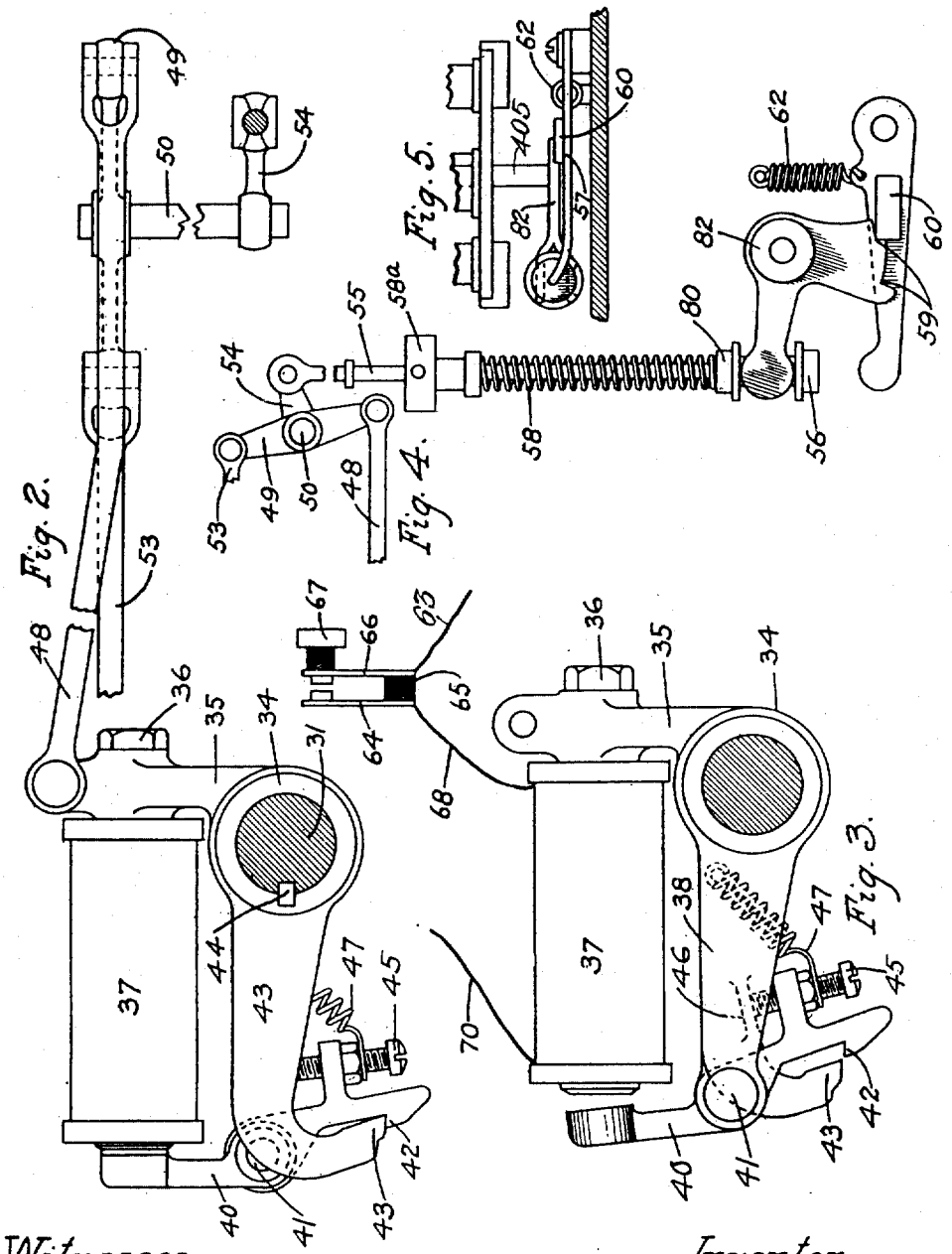
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3 SHEETS—SHEET 2.



Witnesses

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3 SHEETS—SHEET 3.

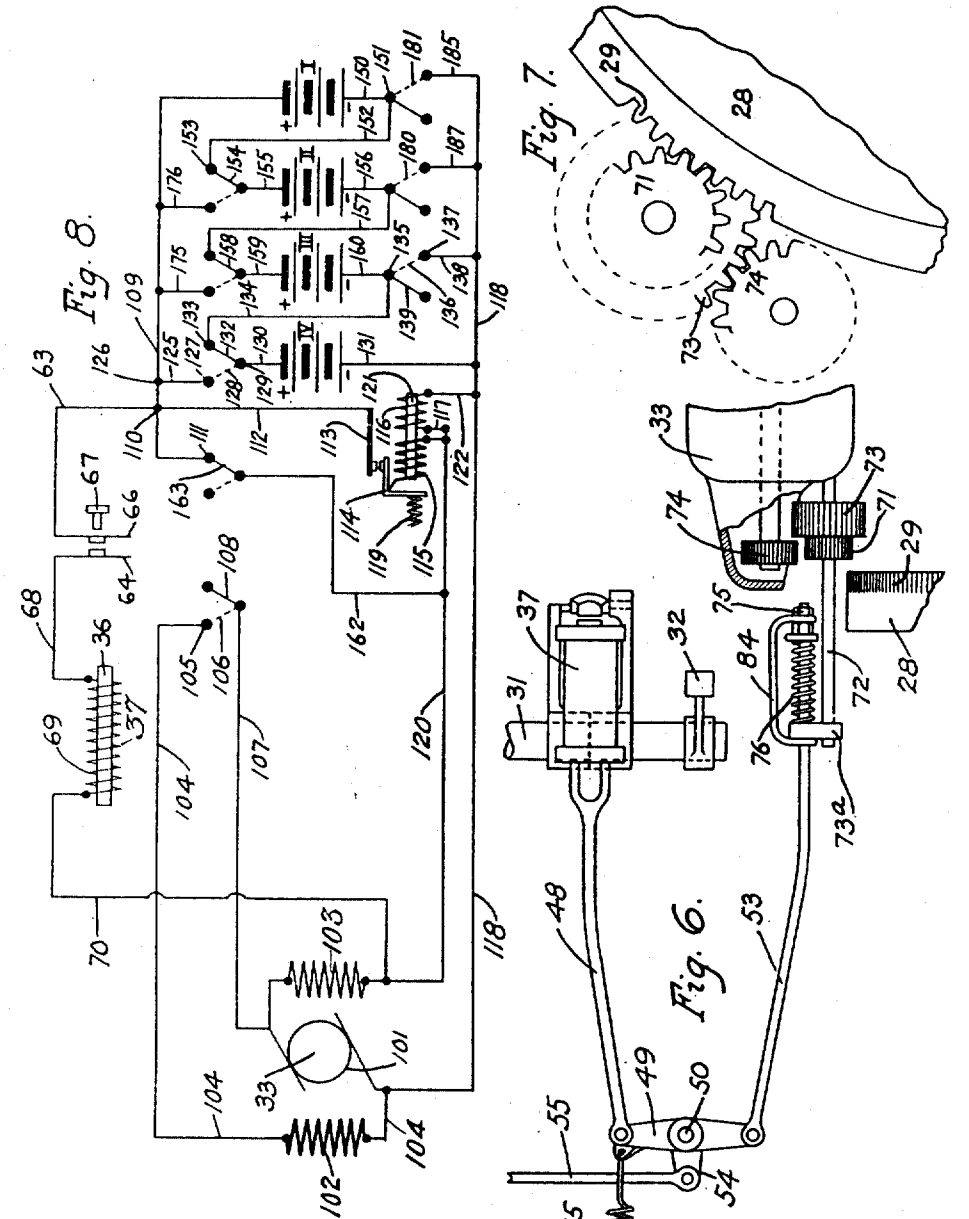


Fig. 8.

Fig. 7.

Fig. 6.

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UNITED STATES PATENT OFFICE.

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ENGINE-STARTING DEVICE.

1,231,266. Specification of Letters Patent. Patented June 26, 1917.

Original application filed June 15, 1911, Serial No. 633,443. Divided and this application filed March 5, 1915. Serial No. 12,309.

To all whom it may concern:

Be it known that I, CHARLES F. KETTERING, a citizen of the United States, residing at Dayton, county of Montgomery, State of Ohio, United States of America, have invented certain new and useful Improvements in Engine-Starting Devices, of which the following is a full, clear, and exact description.

This invention relates to a system of devices for use in connection with starting mechanisms for engines, and is also applicable to such a system where the engine when started, is adapted to store up power to be used for similar future starting operations and various other purposes.

The present application is a division of my co-pending application, Serial No. 633,443, filed June 15, 1911, now U. S. Patent No. 150,523, issued Aug. 17, 1915, which relates to a starting system wherein the power unit or starting device is preferably an electric motor which is adapted to be connected to the engine for starting purposes.

It is among the general objects of the present invention to provide novel combinations of mechanisms for facilitating the starting of engines of the non-self starting type and other types of apparatus, wherein it is necessary to transmit initial operating power to the apparatus, in order that the normal actuating power thereof may be brought into action.

In the form which I have adopted for the present instance, as one of the preferred embodiments for illustrating my present invention, I make use of a motor-generator, in combination with an accumulator having a plurality of sets of electrical connections therebetween. The accumulator comprises a plurality of units, each unit consisting of an equal number of cells. The several units are provided with two sets of electrical connections, running to the mechanically operated controller switch, which in turn has two distinct operations. When the controller switch is thrown into its first position, which will be termed "starting position", the cells of the accumulator, that is, these units, will be connected up in series with the motor-generator. When the controller is thrown into its second, or charging position, the series connections are broken, and the several units of the accumulator are connected in series multiple with the motor-generator.

It is to be understood that the term "motor-generator" is used herein for convenience, as referring to a style of dynamo electric machine, wherein the machine at one time operates as a motor to crank the engine, and at another time as a generator to store current in the storage batteries or accumulators. The claims in the present application relate to a system wherein the electric machine operates both as a motor for starting purposes and as a generator for charging purposes; whereas the claims in my above mentioned co-pending application embody my inventions with reference merely to the electric machine operating as a starting motor.

This motor-generator is of the small type, capable of operation as a motor at a high speed and connected through suitable gearing to crank the engine at a comparatively low rate of speed, whereby a powerful starting torque will be developed with a comparatively small type electric machine. This same electric machine is then adapted to be connected to the engine through a different set of gearing, whereby the engine will operate the electric machine as a generator to store current back into the accumulator, or to supply current for lighting, ignition, or other work purposes.

As pointed out in my application above referred to, the engine stands normally disconnected from the starting motor, so that an operating member or pedal is provided which establishes this gearing connection. But in order that these gears may be properly enmeshed or brought into alinement for engaging each other, the motor-generator is given an initial turning movement to facilitate the proper coupling. This initial movement is a slow speed and also a low torque movement.

It is therefore one of the features of the present invention to arrange this electrical apparatus so that the dynamo electric ma-

chine shall be capable of operation under three different phases or sets of conditions,—viz, an initial movement to facilitate and effect the proper coupling, then a cranking operation, and finally a generating condition.

That is, in the first two phases, the machine is operating as a motor, first with the initial movement of slow speed and low torque effect, and then a change to the high torque effect for cranking. Whereas in the third phase the status of the machine is changed to that of a generator for the purposes above referred to.

Some of the parts of the apparatus in the present invention are also shown in my Patent No. 1,171,055, issued Feb. 8, 1916; but in the present instance certain modifications have been made to secure adaptability to the present improvements.

Further objects and advantages of the present invention will appear from the following description, reference being had to the accompanying drawings, wherein a preferred form of my invention is clearly illustrated.

In the drawings:

Figure 1 is a top plan view of the chassis of an automobile, to which my improved system is applied. Certain parts of the chassis and automobile, are removed for the sake of clearness, the parts of my system which are shown therein, being the particular arrangement and location of the motor-generator and the mechanical connections for controlling the operation of the same.

Figs. 1ª and 1ᵇ are detail views of the friction clutch mechanism which couples up the motor-generator and the engine.

Fig. 2 is a detail view in side elevation of the electrically controlled interlocking mechanisms which are normally loosely mounted upon a transverse shaft, which will hereafter be termed the clutch shaft of the automobile. This view also shows the pivoted armature or latch mechanism, in engaging position with the curved arm, rigidly carried by the clutch shaft.

Fig. 3 is a view similar to that of Fig. 2, but taken from the opposite side of the said mechanism, the pivoted armature, in this instance, being shown in disengaged position.

Fig. 4 is a fragmentary detail view of the mechanism which shifts the controller switch, from "charging" position to "starting" position and vice versa.

Fig. 5 is a fragmentary view of the pawl and ratchet mechanism and its connection with the controller switch shaft.

Fig. 6 is a fragmentary view of the coupling gearing, for coupling up the motor-generator with the engine, and the mechanism controlling the operation thereof.

Fig. 7 is a detailed view of the coupling gearing, in coupled position.

Fig. 8 is a diagrammatic view, disclosing the electrical connections and circuits of the present system.

Referring to the drawings and more particularly to Fig. 1 thereof, it may be stated that the type of automobile in which this improved system is shown, as applied, is the "Cadillac" which is a well known automobile, on the market at the present time. In this view the chassis is shown, having the side frames 20, which together with certain transverse supporting members, carry and support the engine 21, which is of a four cylinder type, ordinarily used in automobiles. 22 and 23 indicate the running boards. 24 is a casing, containing the transmission gears, and 25 is a transmission lever which, when moved back and forth, controls the selection of the transmission gears, in the well known manner, whereby the various speeds, forward or the reverse speed, may be selected as desired.

26 represents a casing, containing the ordinary oil pump, such as is customarily used in a car of this type. This oil pump is operated by the shaft 27, ordinarily employed to operate the magneto and which because of its location, is advantageously made use of in the present system, as will appear hereinafter.

28 designates the engine flywheel, secured in the usual manner to the engine shaft and having a series of gear teeth, formed on or secured to its periphery, as at 29.

The transmission clutch 30 is of the usual construction and is adapted to be moved into and out of engagement with the conical surface of the interior of the flywheel.

The movement of this clutch is controlled through the medium of a yoke member 31ª, by movement of the transverse shaft 31, which may be termed the clutch shaft, to which said yoke is secured, and the operation or movement of the ordinary clutch pedal 32, whereby the engine will be connected and disconnected with the transmission gears of the vehicle, in a well known manner.

The motor-generator 33, is constructed and arranged to serve as a motor, for starting the engine, and as a generator for charging the accumulator or storage batteries. This motor-generator is controlled as to its status, as a motor or generator, by the clutch pedal, or operating member 32.

The means by which the clutch pedal controls the status of the motor-generator, will now be described: Adjacent to one end of the clutch shaft 31, a bracket 34 is loosely mounted thereon; that is, the said bracket normally permits relative oscillatory movement of the clutch shaft 31, relative thereto, but is held in fixed position relative to any transverse or lateral movement thereon.

This bracket is provided with an arm 35,

having a bearing, which receives a stem 36, of the magnet 37. The stem 36 not only acts as a means for securing the magnet to the bracket 35, but also forms the core of the magnet. The bracket 35 also is provided with the forwardly extending portion 38, to the outer end of which, the armature or latch 40 is pivotally secured at 41. One end of the armature 40 is normally positioned in alinement with, but spaced from the core 36 of the magnet 37 (see Fig. 3). The opposite end of the armature 40 is formed in the shape of a hook or latch, as at 42, and is adapted to engage, when the armature is moved into the position shown in Fig. 2, with the curved arm 43, which in turn is rigidly secured to the clutch shaft 31, by means of a key or other suitable locking device 44.

In order that the position of the armature may be changed to suit the various conditions, a small thumb screw 45 is journaled in a lug, formed on the armature, and is adapted to abut against the projection 46, shown in the dotted lines, in Fig. 3. It will be obvious that by turning the said thumb screw, the distance which normally exists between the contact end of the armature and the core of the magnet, may be increased or decreased, as the conditions warrant. A small coil spring 47, one end of which is secured to the arm 38 and the other end of which engages with the thumb screw 45, normally tends to hold the armature in disengaged position, as in Fig. 3.

The arm 35 of the bracket 34, has a pivotal connection with the link 48, which extends rearwardly and is connected to the straight arm lever 49, which in turn is rigidly mounted upon the vertical shaft 50.

The bracket or supporting member 51 is rigidly secured on the cross brace 52 and forms a support for the vertical shaft 50. An operating lever 53 is connected to the opposite end of the straight arm lever 49, and extends forwardly and is connected with an intermediate gearing which will be referred to hereinafter as the coupling or multiplied gearing, which couples up the motor-generator and the engine, for starting purposes (see Fig. 6).

Inasmuch as it is desirable to shift the controller switch, which selects the electrical connections between the accumulator and motor-generator, with substantially the same operation as that which shifts the coupling means, between the motor-generator and the engine, suitable mechanisms are arranged which are operated by the same movement of the clutch pedal, as that which shifts the coupling means, between the engine and the motor-generator, and comprises a small link 54, mounted upon and movable with the vertical shaft 50 (see Figs. 2 and 5). This link connects with the end of the plunger 55, which has an enlarged head 56, secured to its free end and is adapted, under conditions, which will be explained hereinafter, to strike against and operate the locking pawl 57.

The coil spring 58 is mounted intermediate the ends of the plunger 55, one end thereof abutting against the fixed shoulder 58^a, while the opposite end of the said spring, pushes against the pressure block 80, slidably mounted upon the rod or plunger 55.

The above described mechanism is adapted to be employed with the mechanically operated switch controller, which is of substantially the same construction as the controller switch described in my aforesaid Patent No. 1,171,055, and which is adapted to control the shifting of the various electrical connections.

Inasmuch as the specific structure of this switch does not enter into the present improvements, the detail structure will be neither shown or described, this omission of the description being made simply for the sake of brevity.

In Figs. 4 and 5, the combination of the elements which are directly connected to the shaft of the controller switch, and by means of which the controller is shifted, is clearly shown. The controller shaft 405 (see Fig. 5) connects with an operating handle 82, comprising a right angle lever arrangement, one portion of which is bifurcated to engage with the plunger 55, between the enlarged head 56 and the pressure block 80, while the opposite portion thereof, is provided with a series of notches or teeth 59, which are adapted to engage with the block 60, rigidly mounted upon the locking pawl 57, being normally held so that the block 60, will be in position to engage with said teeth by means of a small spring 62.

Referring for the present, to the diagrammatic showing in Fig. 8, it will be seen that the magnet 37, which as has been explained, is mounted upon the clutch shaft, is included in an independent circuit which connects with the multiple series connections between the accumulator and generator. This circuit is normally open and is provided with a suitable circuit closer, in the shape of a pair of contacts, adapted to be closed by means of a push button.

In Fig. 3, one line of the electrical circuit is designated by the numeral 63, which connects with the contact plate 66, which in turn is mounted upon an insulating block 65, opposite to the spring contact plate 64. A suitable push button 67 is carried by the said plate 66, and is adapted, when pressure is applied thereto, to close the circuit through the contact plates 64 and 66. The branch wire 68 leads from the spring contact plate 64 to the magnet 37, and connects

with the coil or winding 69 thereof, (see Fig. 8); the opposite end of said coil or winding being connected to the series field of the motor-generator through the wire 70.

The arrangement and connections of this independent electrical circuit, permit the carrying out and accomplishment of a various number of novel functions, one of which will now be explained.

Supposing that the engine 21, (see Fig. 1) is at rest and that the coupling or multiplied gearing, which constitutes the driving connection between the motor-generator 33 and the said engine, is in disengaged or non-driving position; and that it is desired to start the engine 21; the push button 67, which in actual practice, is mounted at any convenient point, which is readily accessible to the driver or operator of the vehicle, is moved so as to close the contact between the plates 64 and 66.

This of course closes the independent circuit through the magnet 37, and inasmuch as this circuit is connected with the parallel or multiple series connections of the accumulator, the current that will pass through the said circuit, is of substantially the same volume as that of which the accumulator is charged, when the motor-generator is being driven as a generator, for charging purposes.

With the present arrangement of the accumulator, as shown, the pressure of the current will be substantially constant at 6 volts.

The current passing through this independent circuit will instantly energize the magnet 37, whereby the contact end of the pivoted armature or latch 40 will be attracted to the magnet core or stem 36, against the tension of the spring 47. Upon the movement of the contact end of the armature, the latch end 42 thereof, will consequently be swung outwardly and into engagement with the curved arm 43, which as has been explained, is rigidly connected to the clutch shaft 31.

By the above arrangement, it will be obvious that the magnet 37 and bracket 34 will also be secured in fixed relation to the clutch shaft 31, throughout the engagement of the armature 40 with the fixed arm 43.

It will be apparent from the above that when the clutch pedal 32 is ordinarily operated, without having first operated the push button 67, the arm 43 will rock up and down, without any effect upon the adjacent arm 38, and this of course permits the ordinary operation of the clutch pedal to disconnect the engine from the running gear of the vehicle, by the actuation of the transmission clutch. But, if the engine has stopped and the operator desires to crank the engine, he first presses the push button 67, which thereupon closes the supplemental circuit, and causes energization of the magnet 37, which will effect the operation of the latch 40, so that the pressing of the clutch pedal and the movement of the arm 43 also rocks the arm 38, and thus connects up the mechanism hereinafter referred to.

Inasmuch as this electrical circuit, wherein the magnet is included, connects with the series field of the motor-generator, it will be understood that the current passes into the series field and tends to operate the motor-generator as a motor, at a voltage of substantially 6 volts, this, together with whatever effect may be due to the resistance of the magnetic circuit, gives a relatively low amperage, so that the motor-generator rotates slowly, and develops a comparatively low torque as compared to that developed subsequently in cranking the engine.

Upon pressure being exerted upon the clutch pedal, to move the same in a forward direction, the clutch shaft together with the magnet 37 and the link or lever 48 will also be moved in a like direction, said clutch through the medium of the yoke 31^a, being consequently disconnected from its driving engagement with the flywheel of the engine, whereby the running gear of the vehicle will be absolutely disconnected from the propelling unit, during the starting operation of the vehicle.

It will therefore, be appreciated that the disengaging of the transmission clutch, simultaneously with or during the starting operation of the vehicle engine, constitutes a safety device, inasmuch as it is impossible to start the vehicle until the clutch has been again moved into engagement with the engine flywheel.

As has been stated, the forward movement of the clutch pedal necessarily imparts like movement to the lever 48, which in turn tends to shift the straight arm lever 49, and this lever by its pivotal connections with the lever 53, will pull said lever 53 rearwardly, and thus tend to bring the multiplied gearing of the motor-generator into position, to mesh with the driving gear of the engine. This multiplied gearing seen in Figs. 6 and 7, comprising a small pinion 71, is mounted upon the shaft 72, which in turn may have a flexible connection with the rod or lever 53. The function of this flexible connection and the specific structure thereof, will be more fully described hereinafter.

The small pinion 71 is adapted to engage with the flywheel gearing of the engine and is connected with the larger pinion 73, which engages with and is driven by the motor pinion 74 of the motor-generator.

During the intervals that the multiplied gearing, comprising the pinions 71 and 73, is out of driving connection with their respective gear wheels, the gear teeth of the respective enmeshing gears, may rest in

such a position that the end faces of the coadjacent teeth of the respective enmeshing gears may be out of their proper alinement; that is, they may be in such position that when the multiplied gearing is moved to enmesh the said gears, the end faces thereof will come in conflict.

By the initial rotation of the motor-generator, as a motor at a low speed, this difficulty is overcome, inasmuch as the motor pinion 74 will be slowly rotated, and the pressure exerted upon the multiplied gearing, will cause the large pinion 73 thereof to readily mesh with the pinion 74. By referring then to Fig. 6, it will be seen that the clearance between the small pinion 71, of the multiplied gearing and the flywheel gearing, is greater than the clearance between the large pinion 73 and the motor driven pinion 74. The object in having a variance in the clearance at these points, is to permit the picking and rotation of the multiplied gearing by the motor gear wheel 74, before the enmeshment of the pinion 71, with the flywheel; this sequential action tending to facilitate the shifting of the gears into coupled position.

In order to protect the different parts of the system, however, against the abuse in case the multiplied gear connections should stick or for some unusual reason should fail to go into enmeshment, when pressure has been applied to the controlling levers, the flexible connection heretofore mentioned, is interposed between the lever 53 and the rod 72. This connection comprises a block 73^a, rigidly carried by the rod 72, but slidably mounted upon the lever 53. The transverse movement of the said block 73^a, and therefore of the rod 72, relative to the lever 53, is positively limited in one direction, by means of one end of the yoke 84, which is of U-shaped construction, the opposite end thereof being made fast to the lever 53, by means of suitable nuts 75.

The coil spring 76 is interposed between the secured end of said yoke and the slidable block 73^a; and normally tends to exert sufficient pressure against said block to hold the same in its proper position.

However, if under unusual conditions as referred to, the multiplied gearing fails to mesh with the motor-generator gear and the flywheel gearing, any pressure which may be exerted on the clutch pedal 32 and which is duly transmitted to the lever 53, through the intermediate connections, the lever 53 will be drawn back, relative to the rod 72, against the resistance of the spring 76, thereby preventing any undue pressure on and the consequent strain or jamming of the said connections as a result thereof.

When the clutch pedal 32 is operated, as has been described above, to connect or couple up the multiplied gearing with the motor pinion and the flywheel gearing of the engine, it is desirable to also shift the controller or switch which controls the electrical connections of the system, from its normal charging position, whereby the accumulator and motor-generator are connected in series multiple, to the starting position; in which position the accumulator and motor-generator are connected in series.

However, it is further desirable that the shifting of the controller from charging to starting position shall not take place simultaneously with the coupling up of the motor-generator and the engine, but that a sufficient time should elapse between the two operations, so that the coupling of the engine and the motor-generator will be properly completed previous to the operation of the motor-generator as a motor, at a multiplied voltage or high torque, which it is necessary to utilize in order to overcome the torque of the engine shaft and thereby start the engine.

When the clutch pedal 32 is moved forward and thereby carries or moves the intermediate connections, as has been heretofore stated, the straight arm lever 49, which is rigidly mounted upon the vertical shaft 50, will tend to rotate the shaft 50, and thus impart a forward movement of the plunger 55 through the link 54. It will be seen, by referring to Fig. 5, that the only effect of the initial movement of the plunger 55 for certain predetermined distance, is to bring the head 56 of the said plunger into proximity with the locking pawl 57, so that in the meantime the engine and motor-generator may be coupled up by the means controlling the movement of the multiplied gearing, as has been heretofore described.

The continued movement of the plunger 55, however, will force the locking pawl out of locking engagement with the ratchet teeth, formed on the controller handle, at which time the spring 58, which has, throughout the previous movement of the plunger, been compressed by the stationary position of the bifurcated or yoked portion of the controller handle and the forward movement of fixed shoulder 58^a, which is carried forward by the plunger 55, will exert sufficient pressure upon the yoked end of the controller handle, to quickly shift the controller from charging to starting position, whereby the motor-generator and accumulator will be connected in series. This shifting of the controller, under the compression of the spring, occurs so quickly that the danger of arcing at the separation of the contact fingers of the controller, is reduced to a minimum.

As soon as the current is fed into the motor-generator at an increased voltage, through the series connection, the motor will instantly operate at a greatly increased

speed, and high torque, and will tend to turn the engine shaft through the medium of the multiplied gearing at a low speed, thus automatically "cranking" the engine.

The engine, when once it becomes self-actuating, quickly increases in speed and because of the ratio between the engine flywheel gearing and the coupling gearing and motor pinion, would soon tend to drive the motor-generator at a prohibitive rate, as a motor. The means for preventing the existence of conditions of this character, have been fully explained in my co-pending application hereinbefore referred to, and will not therefore be described in the present case. However, as soon as the engine has become self-actuating, a suitable clutch mechanism will connect the motor-generator, as a generator, with a train of gears located at the front end of the engine, which may be termed "generator gearing".

This operation of the motor-generator as a generator, is secured in the following manner. The front end of the crank shaft of the engine is provided with a gear wheel 225, which meshes on one side with the pinion 226, to operate the cam shaft of the engine, and thus actuate the engine valves in a well known manner.

This gear wheel 225 also meshes on the opposite side with the intermediate gear 227, which in turn drives a pinion 228 secured to the end of the shaft 27.

Inasmuch as it has been found advisable to drive the motor-generator as a generator at substantially engine speed, the size of these connecting gear wheels is such that the armature of the motor-generator and the crank shaft of the engine will be operated at a substantially 1 to 1 ratio.

It will be noted that the motor-generator must rotate always in the same direction, whether it is operating as a motor to crank the engine, or as a generator, driven by the engine; therefore, in selecting one set of gears at one end of the motor-generator for the cranking operation and another set of gears at the opposite end of the generator for the generating operation, the intermediate pinion 227 serves the purpose not only of securing the proper location and size of gearing to give the desired generator driving ratio with respect to the engine, but it also preserves the proper driving direction of the motor-generator.

The shaft 27 has heretofore been utilized to drive the magneto, on a car of this type, and also to operate the oil pump. Because of a previous existence of a shaft of this character, in a car of this type, it has been found advantageous to use this shaft as one connecting means for one set of gearing between the engine and motor-generator.

Referring to Figs. 1, 1^a and 1^b, it will be seen that the shaft 27 passes through the oil pump 26, and on one end, as has been heretofore described, there is secured the small pinion 228. Adjacent the opposite end of said shaft, a collar 229 is rigidly secured by means of the pin or key 230. This collar is mounted a short distance from the end of said shaft, so as to leave a short section thereof to enter into a bearing formed in the ratchet member 231 of the friction roller clutch 232, which connects up the motor-generator with the shaft 27, when the motor-generator is to be run by the engine as a generator for charging purposes.

The ratchet member 231 of the roller clutch 232, has an annular collar extending therefrom provided with oppositely disposed slots or recesses 240, wherein lugs 233 formed on the collar 229, shown in dotted lines in Fig. 1^a, fit, and thus secure the shaft 27 to the ratchet member 231.

This ratchet member is provided on its periphery with a plurality of beveled depressions 235, wherein bearings 234, of either the ball or roller type are placed. These bearings have suitable small springs 241 mounted on the ratchet member 231, which normally tend to force the said bearings into the proper position.

The motor-generator shaft 237 (see Fig. 1^a), is extended outwardly from the casing of the motor-generator and is keyed to an annular casing 238 by means of the pin or key 239. This casing 238 forms one of the coöperating members of the friction roller clutch and is adapted to receive the ratchet member of the clutch 231, as is clearly shown in Figs. 1^a and 1^b.

A small cover plate 244 fits over the annular collar of the ratchet member 231 of the roller friction clutch, and is secured to the casing 238 by any suitable means, such as the small screws 245, and prevents the entrance of dirt etc., into the moving parts of the clutch.

The operation of this friction clutch is as follows:

When the motor-generator is connected with the engine as a motor to start the same, the armature or motor-generator shaft 237 will, of course, be rotated and will carry with it the friction clutch casing 238, in the direction shown by the arrow in Fig. 1^b. This will permit the casing 238 to rotate freely, relative to the ratchet member 231, inasmuch as the roller bearings 234 will be maintained in the enlarged portions of the depressions 235. However, as soon as the engine becomes self-actuating and the crank shaft is revolving, the generator gears comprising the gears 225, 227 and the pinion 238 will drive the magneto shaft, and as soon as the speed of the engine picks up, the ratchet member 231 of the friction clutch will be carried forward in the direction of the arrow, as shown in Fig. 1^b, thus moving

the bearings 234 into the V-shaped portion of the depressions or recesses between the ratchet member 231 and the interior of the casing 238, thereby coupling these two members together through the friction of the bearings 234, so that the armature of the motor-generator will be driven by the engine, in such a manner that the motor-generator will be operated as a generator for charging purposes.

As soon as the engine becomes self-actuating, the operator of the vehicle releases the pressure upon the clutch pedal, and by means of the spring arrangement, described hereinafter, the clutch pedal together with its shaft and the controlling mechanism is brought back into normal position, whereby the transmission clutch will be moved into engagement with the flywheel of the engine and the vehicle will be ready to start, as soon as the proper adjustment of the transmission gearing has been made.

With the addition of the several connecting elements, which are carried by the clutch shaft and operated by the movement of the clutch pedal, it has been found advisable to supplement the action of the ordinary spring which tends to return the clutch pedal to normal position, by means of an additional spring 85, of suitable strength, one end of which is secured to the transverse beam 81, while the other end thereof is secured to the end of the straight arm lever 49, which connects with the link 48 (see Fig. 1), so that upon the forward movement of the link or rod 48, the spring will be tensioned, and as soon as the pressure is released from the clutch pedal, the said spring 85 will tend to return the several elements, to their normal position.

The shifting of the controller switch from starting position to its normal charging position, is accomplished positively by the enlarged head 56 of the plunger 55, engaging with the yoked end of the switch handle 82, whereby the rearward or return movement of the plunger 55 will automatically shift the controller switch from starting to charging position.

In Fig. 8 is shown the diagrammatic form of the connections for re-arranging the batteries for starting and for charging, such that they are in series for starting the motor and in multiple for being charged by the generator. And the motor is used with its series winding alone for starting as a motor, but with the shunt series arrangement for generating. In this connection, it may be stated that the controller switch, which is substantially the same as that described in detail in my aforesaid Patent No. 1,171,055, issued February 8, 1916, will not be described other than as in the diagrammatic showing in Fig. 8, inasmuch as the detail structure thereof does not enter into the present invention, except as has heretofore been stated.

The arrangement of the storage batteries, which form the accumulator, is shown at the right, in Fig. 8, with the batteries grouped in four sets of three cells each. This makes 12 cells in all, which at the approximate voltage of 2 volts each, gives practically 24 volts, when the cells are connected in series. As has heretofore been stated, these cells are connected in series to give this 24 volts for starting purposes; that is, for driving the motor-generator as a motor to start the engine. Whereas in charging, the cells are arranged in multiple series, having four groups or units, each unit comprising three cells in series, and these groups being arranged in parallel for charging, so that the charging takes place at practically 6 volts.

In the arrangement of the connections shown in Fig. 8, for accomplishing the shifting of the storage batteries in this manner, the dotted line connections represent the positions of the shifting switch controller, when the device is arranged for charging, while the heavy line connections represent the positions of the switch controller, for the starting arrangement; that is, when the batteries are all in series.

The motor-generator 33, comprises a shunt compound differential wound motor-generator, having a rotating armature 101, provided with the shunt and series fields 102 and 103 respectively.

One of the lead wires 104 extending from the shunt winding of the motor-generator, connects with the contact point 105, which is shown in Fig. 8, as being connected by the dotted line or electrical connection 106, which it will be understood only connects said wire 104 with the wire 107, when the motor-generator is being employed as a generator for charging purposes. The solid black line or electrical connection 108, illustrating the position into which the connection 106 is shifted, when the motor-generator is operating as a motor.

It will therefore be seen that the solid lines and the dotted lines really represent one and the same element, shiftable into two distinct positions.

The lead wire 109 extends from the point 110 to form the common wire for connecting up one side of the batteries when arranged in multiple series, for charging purposes. At the point 110 on this wire 109, there extends downwardly a lead wire 112, which connects with the contact strip 113, which is embodied in the automatic cut-out device. The armature 114 of this cut-out device is connected to the coil 115, to which the opposite end of the coil 116 is connected by means of the short branch wire 117, leading from the line wire 120, while the other end

of this coil 116 is connected to the other line wire of the system 118. The armature 114 is normally held out of engagement with the contact strip 113 by means of a small spring 119 (see Fig. 8).

The function of this cut-out device will now be described.

When the motor-generator 33 is being employed as a generator to supply current to the accumulator or storage batteries, the rotation of the armature 101 thereof, causes the current to build up in the shunt field 102 and gradually to also enter and build up in the series field 103 to such a point that a balancing or regulating effect will be obtained between the two fields. The initial flow of current through the series field and wire 120, first has to enter the high resistance coil 116, inasmuch as the armature is in open position and will continue in this path until the core 121 of the cut-out device has become energized sufficiently to attract the armature 114 against the resistance of the spring 119. The initial flow of current from the generator is therefore through the series coil or field 103, wire 120, through the high resistance coil 116, branch wire 122, into the main line wire 118, back into the opposite side of the generator.

The resistance of the coil 115 is much lower than that of the coil 116 and therefore, as soon as the core 121 of the cut-out device has become sufficiently energized to attract the armature 114, thus making the contact between the said armature and the contact plate 113, the current will pass through low resistance coil 115, the armature 114, contact plate 113, wire 112 to the common line wire 109, instead of passing through the high resistance coil 116.

This cut-out device operates to prevent the current, from the storage battery, discharging back through the generator, in case the generator should slow up, so as to reduce this current by the slackening of its speed. That is, the kick-back of the current, from the storage battery, running through the coil 115 reversely, would break the circuit connection between the armature 114 and the strip 113, the armature being immediately restored to its open position, by means of the spring 119. This cuts the storage battery out of the generator circuit and leaves the generator circuit running through the high resistance coil 116, wherein the current is now too weak, on account of the slow speed of the generator, to energize the core sufficiently to restore the contact between the strip 113 and the armature 114.

Going back to the battery connections, it will be seen that when the cut-out device is closed and the current is passing therethrough, into the wire 112 and wire 109, it will be distributed among three various groups of cells or units of the storage battery. In Fig. 8 it will be seen that the branch wire 125 leads from the point 126 on the wire 109 to the point 127. This point is connected by the dotted line or electrical connection 128 to the contact point 129. From this point 129, the connecting wire 130 extends to the positive pole of the left hand set or unit No. IV, of the storage battery. The four different sets of cells are designated by roman numerals, in Fig. 8, also with their positive and negative terminals, for the sake of convenience. From the opposite side of this set of cells or unit No. IV, the lead wire 131 extends downwardly to and connects directly with the wire 118, which in turn leads back to the motor-generator.

Leading from the contact point 129, is a heavy line or connecting strip 132, which connects with the contact point 133. As previously stated, this heavy line connection represents the shifted position of the dotted line connection 128 and vice versa.

The lead wire 134 connects the contact point 133 with the contact point 135, which is located on the opposite side of the third set of the accumulator cells or unit No. III. From this point 135, a dotted line connection is shown connecting with the contact point 137, which in turn is connected by the wire 138 to the line wire 118. The heavy line connection 139 indicates the shifted position of the dotted line connection 136, when the connections of the battery are shifted to starting position.

Without repetition of the details of the connections of the other sets of cells of the storage battery, it is thought that a brief description will make it clear, just what the system of connections is, making use of the dotted and heavy lines for the respective shifting positions.

It having been stated that the heavy lines of these V-shaped shifting elements represent the positions of those parts for the starting operation, it will be assumed that first, the heavy lines in such cases represent the actual connection, and that where the corresponding dotted lines are shown, there are no cross connections. The circuit may for instance, start at the lower side of the right hand set of batteries or cells; that is, set No. I, the current running through the lead wire 150 to the point 151, thence through the connecting wire 152 to the point 153, which is connected by the heavy line connection 154, to the wire 155, which connects with the opposite or positive terminal of unit No. II, thence across the battery through the wire 156, to wire 157, and thence into the unit No. III, through the medium of the heavy connecting strip 158, and wire 159. The current then passes through the unit No. III, into the wire 160 through the point 135, wire 134, heavy con-

nection 132, wire 130, through unit No. IV, into wire 131, thence through the main line 118, into the motor-generator 33, thus operating the motor-generator as a motor, under the combined voltage of all of the units of the battery. The circuit is completed through the series field 103, wire 120, branch wire 162, which short-circuits the cut-out device heretofore mentioned through the heavy connecting strap 163 into wire 109, through which it passes into the positive side of unit No. I.

When in this connection, it will be noted that the shunt field or winding is cut out, because of the gap, which is represented by the dotted line 106, this arrangement causes high voltage through the motor for starting, and a straight series wound motor to give torque for the purposes, and with the advantages heretofore referred to.

Immediately upon the motor-generator creating sufficient power to turn or crank the engine and thus automatically start the same, the mechanical switch or controller is shifted as has been heretofore explained, through certain mechanical connections, so that the series connections of the accumulator are withdrawn and the connections for the charging are drawn into place. This condition of the switch or controller, as shown in the diagrammatic connections of Fig. 8, for the charging operation, will now be explained.

Starting at the generator, the current divides into two circuits, the first of which passes into the shunt field, through the wire 107, through the dotted line or electrical connection 106, wire 104, shunt field coil 102, wire 104, into the opposite brush of the generator. This energizes the shunt field. The other divided circuit starts from the positive brush of the generator and goes through the series coil 103 to the lead wire 120. Until the engine speeds up, there is not sufficient current passing into the coil 116 to attract the armature 114, to the core 121. The current will therefore pass through the coil 116, wire 122, into the main line wire 118, thus making the complete circuit. As soon as the engine speeds up and the series and shunt fields of the generator have been brought to a point where the voltage is sufficient to over come the battery voltage, then sufficient current will pass through the coil 116, of the cut-out device to energize the core 121 to such a degree that the armature 114 will be attracted thereto and thus make contact with the plate 113. As soon as this action occurs, the current will immediately pass through the low resistance coil 115, thence through the armature 114, and contact plate 113 respectively into the wire 112 and into the line wire 109.

From thence the current flows through the wire 125, through the dotted line connection 128, wire 130, through the fourth unit of the battery, out through the wire 131, into the main line wire 118, and thence back to the generator. At the same time, the other three units of the battery are being charged in substantially the same manner, by reason of the fact that from the common wire 109 there extends the lead wires 175 and 176, to the upper side of the said group of cells, while the lower sets of these groups are connected to the main line wire 118, through the wires 150, 156 and 160, dotted line connections 181, 180 and 136, and branch wires 185, 187 and 138 respectively.

Thus under these dotted line connections, it being understood that the heavy line connections are eliminated when the system is in charging position, the generator is now in its condition for charging the batteries in multiple series arrangement of four groups in parallel, with three cells in series in each group and the generator has its field wound with a shunt compound differential winding arrangement.

The above described connections for operating the motor-generator as a motor, at a multiplied voltage at 24 volts, and to permit the motor-generator to act as a generator, to charge the accumulator at substantially 6 volts, are absolutely controlled by the shifting of the controller switch.

There is, however, an additional electrical connection between the accumulator and motor-generator, which is provided so that the motor-generator may be operated as a motor at a reduced voltage as compared with the voltage at which the motor-generator operates as a motor for starting purposes, or at substantially the same voltage as that at which the accumulator is charged by the motor-generator, acting as a generator, namely 6 volts.

This additional electrical connection also has several other important functions, among which may be mentioned the control of the connections which couple up the means for shifting the mechanical and electrical connections heretofore described, and which are operated through the medium of the clutch pedal in the present instance.

This electrical connection comprises a wire 63 which is tapped off of the main line wire 109 and leads to the contact plate 66 (see Fig. 3 as well as Fig. 8). This contact plate carries a push button arrangement 67, which is mounted at any convenient place, preferably directly below the driver's seat on the vehicle, so that it may be readily accessible to the driver without necessitating any change in his position from that ordinarily assumed in the driving of the vehicle.

The contact plate 66, as has heretofore

been described, is mounted upon an insulating block 65, to which is also secured the stationary contact plate 64. The lead wire 68 extends from the contact plate 64 to one end of the magnetic coil 69, surrounding the core 36, which is adapted to attract, when energized, the pivoted magnet 40 which effects the coupling up of the mechanical connections heretofore described. The wire 70 extends from the coil 69 to the series field 103 of the motor-generator.

The entire circuit just described, which embodies the additional electrical connections for permitting the driving of the motor at low speed, is of a higher resistance than the circuit which conducts the current from the cut-out device to the batteries through the wires 112 and 109 respectively, and inasmuch as the magnet comprises the coil 69, it will follow that the resistance in said circuit, is such that the amount of current passing through said circuit will be reduced below the amount of current which is normally charged into the accumulator, when the motor-generator is operating as a generator. It thus appears that these devices for varying the flow of current from the batteries, which include this arrangement of effecting high resistance for the initial movement, and relatively low resistance for the cranking movement, serve to bring about the change in torque, so that there is the low torque movement referred to. for effecting the proper coupling, and then the high torque movement for cranking, when the proper enmeshment is accomplished.

The difference in resistance, between this additional electrical circuit and the charging circuit, also effectually provides a safety device, inasmuch as the current will not flow through this circuit, even though the circuit is closed through the operation of the push button, at any time while the motor-generator is operating as a generator, or at least at any time while the cut-out device is closed to permit the passage of current therethrough.

This same arrangement, consequently acts as a safety device in preventing the coupling up of the mechanical connections and the operation thereof, at any time except when the motor-generator is at rest, and the cut-out device is open.

From the connections of this supplemental or additional electrical circuit, it will be understood that the closing of the push button switch is necessarily the initial operation of the system, and takes place while the controller switch is in charging position, so that the voltage of the several units in multiple series, is transmitted through this circuit into the motor-generator, to operate the same at a low voltage, for the purposes hereinbefore set forth.

While I have set forth the various operations of the system as the description has progressed, a brief description will now be given of the sequence of operations as they occur when it is desired to start the engine of the vehicle.

Supposing that the motor vehicle, together with the engine and motor-generator are at rest, and that the connecting elements thereof are in their normal or home position, the operator of the car, first closes the push button switch through the supplemental electrical connection between the accumulator and motor-generator, to actuate the same as a motor, at a low speed and at low torque. The passage of current through this circuit, causes the connection or coupling up of the controlling mechanism, which is mounted upon the clutch shaft, with the clutch pedal or operating member, as well as to actuate the said motor-generator at a low speed. Immediately upon pressure being applied to the clutch pedal, the shifting gears which couple up the motor-generator with the engine, are brought into enmeshment and the controller switch, immediately after is shifted from charging to starting position. Simultaneously with the coupling up of the motor-generator and the engine, the transmission clutch, which connects the driving gear of the vehicle with the engine, is positively disconnected from the driving connection with the engine.

As soon as the controller switch is shifted into starting position, the combined voltage of the storage batteries passes into the series field of the motor-generator and actuates the same at a multiplied voltage with sufficient power to turn or crank the engine and thus automatically start the same.

As soon as the engine has become self-actuating, the operator releases the clutch pedal which is returned to its home position, by means of any suitable spring arrangement, and also releases the pressure upon the push button, so that the circuit which will be termed "the push button circuit," is open and the flow of current therethrough is stopped. It will, of course, be understood that as soon as the flow of current through this independent electrical circuit is stopped, the magnet 37 will become de-energized, and the pivoted armature 40, which in its attracted position forms a coupling means between the magnetic device of the clutch pedal and shaft, will be released from its attracted position and moved to its uncoupled position, through the medium of the spring 47, (see Figs. 2 and 3).

Simultaneously with the return of the clutch pedal to its home position, the gears which couple up the motor-generator and the engine, will be forced out of their driv-

ing position and the controller switch will be so shifted that the series connections will be broken and the charging connections brought into operative position. The transmission clutch will also be forced back into engagement with the flywheel of the engine.

After the engine has been started and the connections shifted as just described, it will be obvious that the transmission clutch of the engine may be connected and disconnected from engagement with the flywheel of the engine, without affecting in any way, the other mechanism, inasmuch as this mechanism is normally, loosely mounted on the clutch shaft, and is only brought into operative position at such times as the magnet 37 is energized, under which condition, it causes the coupling up of the pedal shaft with the magnetic device.

While I have described and shown a preferred form of embodiment of my present invention, it will be understood that detailed changes in structure and location may be made without departing from the spirit and scope of the present invention.

What I claim is as follows:

1. In an engine starting device, the combination with a motor-generator, of an accumulator, connections therebetween for operating the motor-generator, as a generator, to charge the accumulator at one voltage, and to operate said motor-generator, as a motor, at a different voltage; and auxiliary means for connecting the motor-generator with the accumulator for operation as a motor, at substantially the same voltage as that at which the motor-generator charges the accumulator.

2. In an engine starting device, the combination with an engine, of a motor-generator having connections therewith, for operating the engine to start the same, and being operated by the engine to generate power; of an electric accumulator, having electrical connections with said motor-generator, for receiving power from the motor-generator at one voltage and delivering the stored power to the motor-generator at a different voltage for starting purposes; and auxiliary electrical connections for initially delivering current to the motor-generator at a lower voltage than is delivered thereto for starting purposes, whereby the motor-generator, as a motor, will be given a slow initial movement.

3. In an engine starting device, the combination with an engine, of a starting device, differential mechanical connections therebetween; of an accumulator having selective series and parallel connections with said motor-generator whereby said motor-generator will be actuated as a motor through the series connections, and will act as a generator through the parallel connections, to charge the accumulator; and auxiliary electrical connections, connecting the motor-generator and accumulator in parallel for initially actuating said motor-generator, as a motor, at a voltage substantially the same as the voltage, at which the motor-generator, as a generator, charges the accumulator.

4. In an engine starting device, the combination with an engine and a motor-generator; of an accumulator, comprising a plurality of electrical cells connected with said motor-generator; means for arranging said cells in series for operating the motor-generator as a motor, for starting, and in multiple for charging by the motor-generator; and an auxiliary electrical connection between the motor-generator and the accumulator and connected to said multiple connections, said auxiliary connection being normally open; and a circuit closer for closing said auxiliary connection, whereby the motor-generator will be operated as a motor, at a voltage substantially the same as that at which the motor-generator charges the accumulator.

5. In an engine starting device, the combination with an engine, of a motor-generator; means for coupling the engine therewith; an accumulator having electrical series and multiple connections with said motor-generator for starting and for charging; a controller switch for selecting said electrical connections; an auxiliary electrical connection between the accumulator and motor-generator connected to said multiple connections but of a higher resistance than said multiple connections; and an auxiliary switch for opening and closing said auxiliary electrical connection, whereby a flow of current will be permitted from the accumulator to the motor-generator through the auxiliary electrical connection to facilitate the said coupling operation, said resistance of the auxiliary connection being so proportioned with reference to the resistance of the multiple connections that when the controller switch is in position for selecting the multiple connections, the current flowing through said auxiliary connections upon operation of said auxiliary switch, will be insufficient to allow the said coupling operation.

6. In an engine starting device, the combination with an engine, of a motor-generator adapted to be connected therewith and operable as a motor to start the engine and to be driven by the engine as a generator for charging purposes; an accumulator having a plurality of cells adapted to be connected to the motor-generator; and means for arranging said cells in parallel or multiple series to operate the electric machine as a motor, with a slow initial movement, and also for charging purposes, and in series when the electric machine is to op-

erate as a motor to actually start the engine.

7. In an engine starting device, the combination with an engine, of a motor-generator operable as a motor to start the engine and as a generator for charging; an accumulator having a plurality of cells; means for arranging said cells in parallel or multiple series for the charging operation and in series when the motor-generator is to operate as a motor for starting the engine; and auxiliary means for connecting the cells when arranged in parallel or multiple series to the motor-generator for operating the motor-generator as a motor with a slow initial movement to facilitate the starting operation.

8. In an engine starting system, the combination with an engine and a starting device therefor normally disconnected therefrom, including a motor-generator operable as a motor for starting purposes, and as a generator for charging purposes; of an accumulator; connections therebetween for permitting operation of the motor-generator as a generator to charge the accumulator at one voltage, and to operate as a motor at a different voltage; means for establishing certain of said connections for initially operating said motor-generator as a motor at a voltage substantially the same as that at which it charges the accumulator; and means for establishing the connection between the engine and the motor-generator during said initial operation of the latter.

9. In an engine starting system, the combination with an engine, of a starting device including a motor-generator operable as a motor for starting purposes, and as a generator for charging purposes; an accumulator having motor and generator connections; and means for establishing the generator accumulator connections to initially operate the machine as a motor, to facilitate its connection with the engine.

10. In an engine starting system, the combination with an engine and a starting device including a motor-generator normally disconnected from said engine; an accumulator having motor and generator connections; coupling means for connecting the motor-generator with the engine; means for establishing the generator accumulator connections to initially operate the motor-generator as a motor to facilitate the coupling of the motor-generator to the engine; and means for subsequently establishing the accumulator motor connections for cranking purposes.

11. In an engine starting system, the combination with an engine and a starting device normally disconnected therefrom, including a motor-generator operable as a motor for starting purposes, and as a generator for charging purposes; an accumulator having motor and generator connections; a controller normally closing said generator accumulator connections, but shiftable to break said connections and establish the motor accumulator connections; and auxiliary means effectively operable only when the generator accumulator connections are made to actuate the motor-generator as a motor with low torque effect to facilitate the connection of the motor-generator to the engine for starting purposes.

12. In an engine starting system, the combination with an engine, of a starting device including a motor-generator operable as a motor for starting purposes, and as a generator for charging purposes; an accumulator having motor and generator connections; and means for controlling said connections to impart three phases of movement to said motor-generator, first an initial phase to facilitate coupling of the engine and motor-generator, secondly a cranking phase operating as a motor to crank the engine and thirdly a generating phase wherein the motor-generator operates as a generator to charge said accumulator.

13. In an engine starting system, the combination with an engine, of a starting device including a motor-generator operable as a motor for starting purposes, and as a generator for charging purposes; an accumulator having motor and generator connections; and a switch mechanism having a starting position and a charging position controlling respectively said motor and generator accumulator connections for cranking the engine and charging the accumulator, with auxiliary circuit connections operable when the generator accumulator connections are established, for imparting an initial movement to the motor-generator to facilitate its coupling to the engine.

14. In an engine starting system, the combination with an engine, of a starting device including a motor-generator operable as a motor for starting purposes, and as a generator for charging purposes; an accumulator having motor and generator connections; a switch mechanism having a starting position and a charging position controlling respectively said motor and generator accumulator connections for cranking the engine and charging the accumulator, with auxiliary circuit connections operable when the generator accumulator connections are established, for imparting an initial movement to the motor-generator to facilitate its coupling to the engine; and an operating lever for controlling said switch mechanism and for coupling the motor-generator to the engine during said initial movement of the motor-generator.

15. In an engine starting system, the combination with an engine, of a starting device including a motor-generator operable

as a motor for starting purposes, and as a generator for charging purposes; an accumulator having motor and generator connections between the accumulator and the motor-generator; and a switch mechanism having a starting position and a charging position controlling respectively said motor and generator accumulator connections for cranking the engine and charging the accumulator, with an auxiliary circuit of relatively higher resistance than the cranking or starting circuit and operable through said generator accumulator connections for imparting an initial movement of low torque to the motor-generator to facilitate its coupling to the engine.

16. In an engine starting system, the combination with an engine, of a motor-generator normally disconnected therefrom and operable as a motor for starting purposes, and as a generator for charging purposes; an accumulator; circuit connections for imparting to the motor-generator two phases of motor movement, one of low torque to facilitate the coupling of the motor-generator, as a motor, to the engine, and one of high torque for cranking the engine; and an operating member having connections for controlling both the coupling of the motor-generator as a motor to the engine, and the change from low to high torque movement, said operating member being constructed to produce said change to high torque when the proper enmeshment of said coupling has been accomplished, and also being constructed to establish generator connections between the accumulator and the motor-generator, at such times as the said coupling of the motor-generator and the engine is broken.

17. In an engine starting system, the combination with an engine, of a starting device including a motor-generator, operable as a motor for starting purposes and as a generator for charging purposes; means for coupling the motor-generator to the engine as a motor; an accumulator adapted to be electrically connected with the motor-generator; and devices for controlling the electrical connection of the accumulator and the motor-generator, whereby a motor movement of low speed may be imparted to the motor-generator to operate the same as a motor to facilitate the coupling thereof to the engine, and other devices for effecting the motor connections to effect the actual starting movement of the motor-generator and to connect the motor-generator as a generator to the accumulator, after the starting operation has been effected.

In testimony whereof I affix my signature in the presence of two subscribing witnesses.

CHARLES F. KETTERING.

Witnesses:
J. W. McDONALD,
O. D. MOWRY.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."