C. A. SOANS.

ELECTRICAL STARTING SYSTEM FOR INTERNAL COMBUSTION ENGINES.

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1,282,969. Patented Oct. 29, 1918.

Fig. 1.

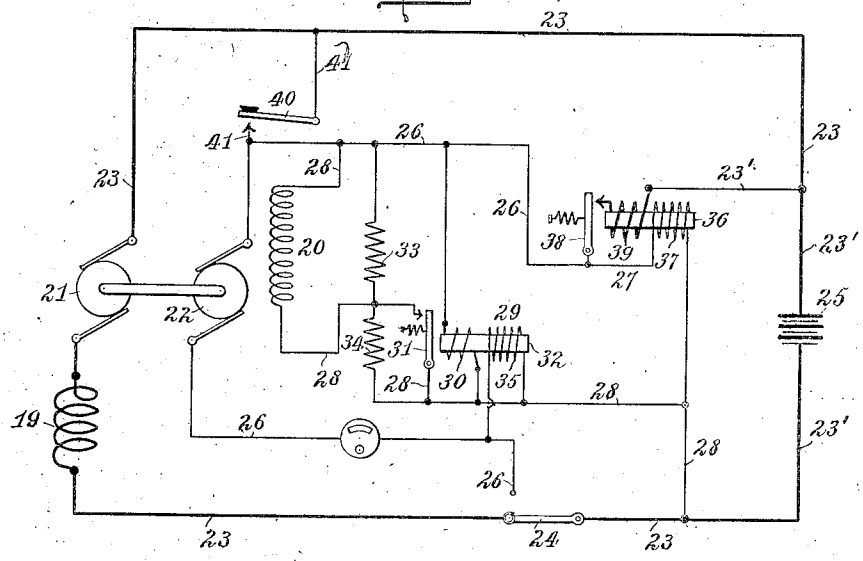


Fig. 2.

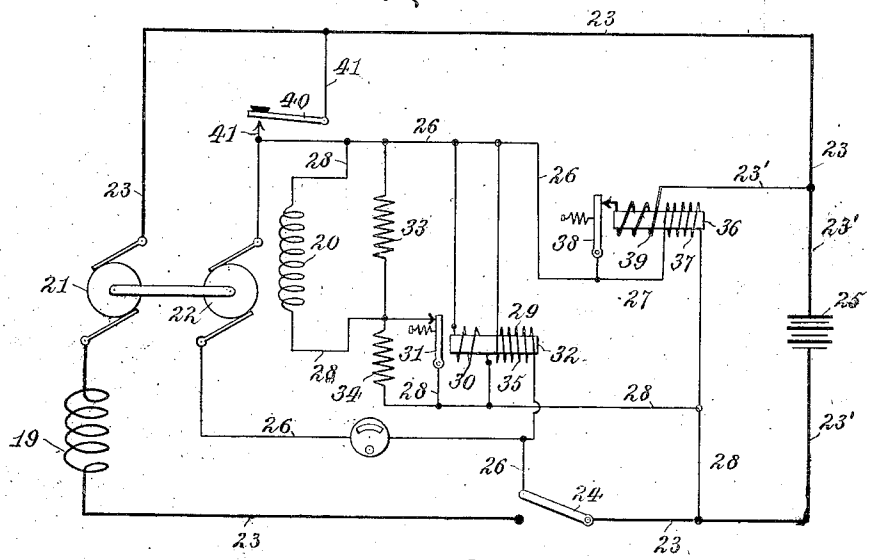
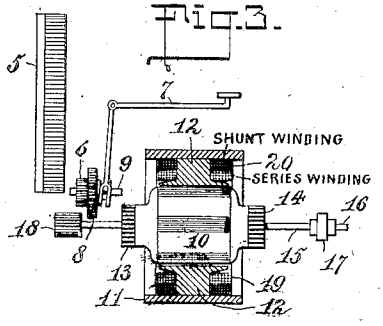


Fig. 3.



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ELECTRICAL STARTING SYSTEM FOR INTERNAL-COMBUSTION ENGINES.

1,282,969. Specification of Letters Patent. Patented Oct. 29, 1918.

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To all whom it may concern:

Be it known that I, CYRIL A. SOANS, a citizen of the United States, and a resident of Chicago, in the county of Cook and State of Illinois, have made and invented certain new and useful Improvements in Electrical Starting Systems for Internal-Combustion Engines, of which the following is a specification.

My invention relates to starting systems or devices for starting an internal combustion engine from a condition of rest, and particularly to that type or class of starting device in which the engine is operated at starting by means of an electric motor which receives current from a storage battery, and which battery is in turn charged from a generator or dynamo operated by the engine after it has been started. My improved starting device or system is designed with reference to use with and to form a part of the power system of a motor vehicle, and the object thereof is to provide such improvements in and relating to starting devices as are hereinafter more specifically and at length referred to and described.

The drawings accompanying and forming a part of this application illustrate the preferred embodiment of my invention, although it will be understood that the same includes such variations and modifications of the particular embodiment illustrated as will be obvious to those skilled in the art to which my invention relates.

In the drawing:

Figure 1 is a view illustrating my improved starting device diagrammatically and arranged for operation as a motor;

Fig. 2 is a similar view showing the device arranged for operation as a generator; and slightly modified with reference to the connection of one of the shunt coils.

Fig. 3 is a view illustrating the motor-generator of my device and the driving connections between the same and the engine.

Referring to the drawing, the reference numeral 5 designates the fly-wheel of an internal combustion engine which is to be started by my improved starting device, the same having a series of gear teeth upon its periphery, and 6 designates a pinion normally out of engagement with the teeth upon the fly-wheel but which pinion may be moved into engagement with said teeth by means of any suitable operating mechanism such, for example, as the lever or pedal 7. The pinion 6 is driven by a gear 8 through an intermediate clutch which, while acting to transmit motion to the pinion, allows the pinion to move ahead of and rotate faster than the gear when the engine starts under its own power. The pinion 6 and gear 8 slide upon a suitable shaft or support 9 as the lever 7 is operated, as will be understood.

My improved starting device includes a combined motor and generator, or dynamo, shown conventionally in Fig. 3 and the motor and generator armature windings or coils of which combined devices are located upon a single rotatable armature shown at 10. The reference numeral 11 designates the yoke, and 12 two of the poles of the field magnet of the combined motor and generator, from which it will be appreciated that the motor and generator armature windings will move in a magnetic field irrespective of whether the device is operating as a motor or as a generator, and that an electro-motive force will be generated in both the motor and generator armature windings whenever the armature 10 rotates in said field. The motor and generator windings may be arranged in any way so long as a device is produced which will operate either as a generator or as a motor, and said coils are suitably connected with separate motor and generator commutators 13, 14. The armature 10 is carried by a shaft 15 supported in suitable bearings not shown, which shaft is driven from the internal combustion engine after the same has been started through a shaft 16 and clutch 17 which permits the armature to rotate independent of the shaft 16 when the combined motor and generator is operating as a motor in starting the engine. The shaft 15 is provided with a pinion 18 with which the gear 8 is made to engage by the lever 7, to thus connect the dynamo with the engine as will be understood. The field magnet of the dynamo is provided with two separate windings or coils, one of coarse wire shown at 19 for use when the device is used as a motor and which coil is commonly connected in series with the motor winding upon the armature, while the second coil 20 is of fine wire and is connected in shunt with the generator winding of the armature and is adapted for use when the dynamo is used as a generator.

Referring now to the diagram, Fig. 1, the reference numerals 21, 22 represent in a conventional manner the motor and genera-

tor armatures of the combined motor and generator, and the starting device as a whole is shown as arranged to operate as a motor. The motor circuit 23 is closed by a two-point switch 24, and the dynamo is operated by current from a storage battery 25. At this time the external circuit 26 of the generator portion of the dynamo is broken at the contacts of a battery cut-out switch 27 to be hereinafter described, and at the switch 24; while the switch 31 of a combined voltage regulator and resistance short circuiting means opens a shunt around the resistance 34 and inserts this resistance in a shunt field coil 20 of the generator portion, and which coil serves to magnetize the field magnets of the dynamo when the same is used as a generator, all as more fully set forth below. This will break the shunt about a resistance 34 and thus weaken the current in the field circuit in which the latter is serially connected. It will therefore be obvious that the combined motor and generator will be operated as a motor to start the engine, and that no flow of current can occur either in the external circuit above referred to of the generator portion of said device, nor any considerable current through the main shunt circuit thereof; although it will be appreciated that an electro-motive force is necessarily being generated in the armature winding of the generator portion because of the fact that it is rotating in the motor field. A slight flow of current will, however, occur in the arrangement shown in this figure, through the shunt coil 20, the high resistance coil 34 to be hereinafter described, and the coil 35 of the voltage regulator 29, because of the fact that these coils are connected in series with one another across the external circuit 26. This flow, however, is so small as to be negligible, and is, moreover, incidental to the use of the coil 35 and is dependent upon the manner in which the coil 35 is connected in the system. Thus, in the arrangement shown in Fig. 2, no flow of current occurs through the coil 20 when the switch 31 opens a shunt around resistance 34 and inserts this resistance in the shunt field and the dynamo being used as a motor, although at such times a small flow will occur through the coil 35 of the voltage regulator as the same is shown as connected directly across the external circuit 26, in the scheme illustrated in this last-mentioned figure.

Referring now to the diagram, Fig. 2, the various parts of my improved starting device are shown as arranged so that the combined motor and generator will operate as a generator (driven from the engine through the clutch 17 as above explained) to charge the storage battery 25, the switch 24 having been moved into a position to break the motor circuit 23 and close the external generator circuit 26. The main shunt circuit 28 in which the shunt coil 20 is included will be closed at the terminals of the combined voltage regulator and shunt coil cut-out 29, and current will flow through the exterior generator circuit 26, the battery cut-out 27 and a common portion 23′ of the motor circuit, to thus charge the battery.

My improved starting device, as above stated, is designed with special reference for use for starting the engine of a motor-propelled vehicle, and, as the combined motor and generator are driven from the engine, it will be obvious that the speed at which the same is driven will vary within wide limits according to the speed of the engine. The motor-generator must therefore be so constructed and arranged as to generate sufficient electro-motive force, when operating as a generator, to charge the battery at speeds of rotation of the dynamo armature varying between wide limits, according to the speed at which the vehicle is being propelled by the engine, which electro-motive force should be constant or substantially constant.

The means provided for regulating the electro-motive force generated by the combined motor and generator when the same is operating as a generator comprises the voltage regulator 29 hereinbefore referred to and which is designed and arranged to cause switch 31 to open a shunt around the resistance 34 and insert this resistance in the shunt field whenever the said electro-motive force exceeds a predetermined maximum; which maximum, it will be appreciated, is much below the electro-motive force which might be generated by the dynamo when operating as a generator; for such maximum electro-motive force must be generated when the vehicle is being propelled slowly, and may not be exceeded when the vehicle is being propelled rapidly. This action will reduce the current flowing through the shunt coil 20 to a negligible amount; although it will be appreciated that in the system illustrated in both Figs. 1 and 2 a slight current will flow through the high resistance coil 34 when the dynamo is used as a generator, even though the said circuit is broken at the terminals of the voltage regulator 29; because of the fact that the coil 34 is connected in shunt across the terminals of the voltage regulator. It will be appreciated, however, that this slight flow is incidental to the use of the coil 35, which coil, as will hereinafter appear, is not an indispensable element of my improved starting system, and may be dispensed with. The reduction of current flowing through the shunt coil 20 will be accompanied by a reduction of the magnetization of the field magnets of the dynamo, although said magnets will in practice not be entirely demag-

netized because of magnetic hysteresis in the cores of the magnets, even though the flow of current through the coil in question be reduced to a negligible quantity.

The voltage regulator in question is shown as comprising a coil 30 arranged in shunt with reference to the external circuit 26 of the generator and which coil is arranged to act upon a vibrating spring-retracted armature 31 which carries one of the two co-operating terminals which make and break the main line of the circuit in which the shunt coil 20 is included as said armature vibrates, in the same way as in an ordinary relay. The coil 30 is preferably placed upon a suitable iron core 32 to thereby form an electro-magnet which is magnetized by the coil and in turn attracts the armature 31, although it will be understood that the coil may be used as a solenoid without a core, as in either case the coil forms, in connection with the armature 31, an electro-magnetically operated device adapted to break the main line of the circuit in which the shunt coil 20 is included and thus interrupt or greatly decrease the flow through said coil.

It therefore follows that switch 31 opens the shunt around resistance 34, inserting this resistance in the shunt field whenever and as often as the electro-motive force generated by the dynamo when used as a generator rises above a predetermined maximum. This action will be accompanied by a substantial reduction of the magnetization of the field magnets of the generator, and, consequently, by a reduction of the electro-motive force generated thereby to a point below the constant electro-motive force to be maintained by the voltage regulator. Thus the electro-motive force generated is kept from rising above a predetermined maximum and a substantially constant voltage is maintained; and it may be remarked that when the dynamo is in use as a generator the armature 31 of the voltage regulator vibrates at high speed, thus making and breaking the circuit in which it is included many times per second. The voltage regulator will in practice be made adjustable as by varying the tension of a spring acting upon the spring-retracted armature thereof, so that the magnitude of the constant voltage maintained by it may be varied.

The reference numeral 34 designates an auxiliary shunt coil of high resistance connected across the switch 31 and the auxiliary shunt coil 33 of high resistance is connected in parallel with the coil 20.

These coils, however, are not indispensable to the operation of my device and may be dispensed with if the sparking at the terminals in question is found to be not objectionable or injurious to a prohibitive extent.

Assuming that the starting device is operating as a motor as shown in Fig. 1, and remembering that the armature winding of the combined motor and generator which is used when the device operates as a generator is rotating in the motor field (and usually at excessive speed as the dynamo armature is commonly driven as a motor at a much higher speed when the engine is being started than it is driven as a generator from the engine in charging the storage battery) it will be appreciated that an electro-motive force will be generated in the generator armature winding of the dynamo much greater and commonly several times the constant electro-motive force maintained by the voltage regulator. If now the coil 35, which is an important feature of my invention, were not present, it will be appreciated that the spring-retracted armature 31 of the voltage regulator would close the main shunt circuit 28 in which the shunt coil 20 is included at the terminals of the voltage regulator; but no current would flow through either the shunt coil 20 of the generator portion of the dynamo, the external circuit 26 thereof, or the coil 30 of the voltage regulator, as all of these circuits are open because of the position of the switch 24. If under such conditions the switch 24 were moved from the position shown in Fig. 1 into the position shown in Fig. 2 to convert the dynamo from a motor to a generator, the high electro-motive force generated in the generator armature winding would cause an excessive current to flow through the shunt coil 20 and through the coil 30 of the voltage regulator, thus breaking the shunt circuit 28 at the terminals of the voltage regulator. The current flowing through the shunt circuit at this time would be much greater and perhaps several times the current which normally flows therein, and the result would be that excessive sparking or arcing would occur at the terminals of the voltage regulator each time the dynamo was converted from a motor to a generator.

In order to prevent excessive sparking at the terminals of the voltage regulator when the dynamo is converted from a motor to a generator I provide means for breaking the main shunt circuit 28 in which the shunt coil 20 is included when the dynamo operates as a motor, and for keeping said circuit broken at such times; said means being illustrated as comprising an electro-magnetically operated device responsive to the excessive electro-motive force generated in the generator armature winding when the motor-generator operates as a motor, but not responsive to the electro-motive force generated when the same operates as a generator; from which it follows that no rush of current can occur through the shunt coil and terminals of the

voltage regulator when the dynamo is converted from a motor to a generator because of the fact that the main shunt circuit in which the coil and terminals are included will then be broken. This circuit breaking device is preferably combined with the voltage regulator and acts to break the circuit in question at the terminals of the voltage regulator, although the circuit breaking device referred to may be entirely independent of the voltage regulator, or may be used in systems in which no voltage regulator is employed.

As illustrated in the drawing, the circuit breaking device referred to includes a coil 35 commonly of high resistance wound upon the core 32 of the voltage regulator and electrically connected with the dynamo in such a way that a flow of current may occur therethrough when the motor-generator is used as a motor. Thus in Fig. 1 the coil 35 is connected in series with the voltage regulator coil 30 when the dynamo operates as a motor, whereby the coils reinforce one another, and a current will flow through both coils due to the high electro-motive force generated in the generator armature winding when the dynamo is used as a motor, notwithstanding the fact that the external generator circuit is broken at the switch 24 at such times. The armature 31 of the voltage regulator will therefore be attracted, and the circuit in which the shunt coil 20 is included will be broken at the terminals of the voltage regulator. The same result will be secured with the arrangement shown in Fig. 2 in which the coil 35 is connected in parallel with the coil 30. In this last-mentioned arrangement, when the dynamo operates as a generator very little current flows through the coil 35, because of its high resistance and the low electro-motive force maintained at such times by the voltage regulator; so that while the coils 30 and 35 reinforce one another when the dynamo operates as a generator, the magnetization of the core 32 is due for the most part to the coil 30. When the dynamo operates as a motor, however, the magnetizing effect of the coil 35 is greatly increased because of the increased electro-motive force then generated in the generator armature winding, and is sufficient to break the main line of the circuit in which the shunt coil 20 is included, notwithstanding the fact that no current is then flowing in the coil 30.

It will be understood that the functions performed by the voltage regulator and by the circuit breaker responsive to the excessive electro-motive force generated in the generator armature winding when the dynamo is used as a motor, are independent of one another, and utilize in part a single concrete structure merely for the purpose of convenience. Thus, if the coil 30 were omitted, the voltage regulating function would no longer be performed, but the circuit in which the shunt coil 20 is included would nevertheless be broken when the dynamo operates as a motor, precisely as hereinbefore explained. The electro-motive force generated by the dynamo when operating as a generator would not be maintained constant in such a case, but a storage battery could nevertheless be charged with a considerable degree of success, particularly if the battery used was of a type which may be charged at widely varying rates, or if the speed at which the dynamo was driven from the engine was fairly constant as is the case in stationary and marine work, and in motor-driven trucks for comparatively heavy service.

The battery cut-out 27 hereinbefore referred to may be of usual or ordinary construction, and forms no part of the invention to which this application relates. As shown, it comprises a core 36 of iron upon which a coil 37 of high resistance is wound and which coil is connected in parallel with the storage battery 25 when the dynamo is charging the battery. The core 36, when magnetized by the coil 37, will attract a pivotally supported spring-retracted armature 38 which carries one of the terminals of the cut-out, the other being stationary, and thus close the circuit 23′ in which the battery is included when it is being charged, and which circuit includes a coil 39 also wound upon the core 36 of the battery cut-out.

It therefore follows that when the motor-generator commences to operate as a generator and when the electro-motive force thereof has become sufficiently high to charge the storage battery, a current, small in amount because of the high resistance of the coil, will flow through the coil 37 and magnetize the core 36 of the battery cut-out; whereupon the armature 38 will be attracted, the circuit 23′ in which the battery is included will be closed at the terminals of the battery cut-out, and current will flow through the coil 39 and circuit 23′ to charge the battery. The coils 37 and 39 are so wound as to reinforce one another, from which it follows that the terminals of the cut-out are held in contact with increased force after the current begins to flow through the coil 39. If the speed of the motor-generator falls to such an extent that the electro-motive force generated by the generator armature winding is less than the electro-motive force of the battery, a current in a reverse direction will be established through the coil 39 of the battery cut-out, thus releasing the armature 38 and breaking the circuit in which the battery is included, as will be understood.

The reference numeral 40 designates a

switch used preliminary to starting the engine for the purpose of facilitating the bringing of the gears intermediate the motor-generator armature shaft and the fly-wheel of the engine into mesh. At such times the armature of the motor-generator will be at rest, the battery cut-out terminals will be separated, the voltage regulator terminals will be in contact, and the switch 24 will be in the position shown in Fig. 2. If now the switch 40 be moved to close the circuit 41 controlled by it, current will flow from the storage battery through the generator armature winding and shunt field coil of the dynamo, which current, however, will be small in quantity because of the high resistance of the generator portion of the motor-generator, that is, the generator armature winding thereof and the shunt coil 20. The armature of the dynamo, however, will be rotated slowly, and with little power, and, while this is occurring, the lever 7 is operated to move the pinion 16 and gear 8 as hereinbefore explained, whereupon the train of gearing between the dynamo armature and the fly-wheel of the engine is brought into engagement at low speed and quietly and without shock or danger of stripping the teeth. After the gears are in mesh, the switch 24 is moved into the position shown in Fig. 1 and the dynamo operates as a motor as hereinbefore explained.

Having thus described and explained my invention, I claim and desire to secure by Letters Patent:

1. In apparatus of the class described, in combination, a dynamo machine, a battery, the dynamo being provided with a motor winding for starting and a generator winding for charging and means controlled by the generator winding during motor operation to protect the generator winding against the high voltage developed therein due to the operation of the machine as a motor.

2. In apparatus of the class described, in combination, a dynamo machine, a battery, said dynamo including a motor armature winding for starting and a generator armature winding for charging, and electromagnetic means energized by said generator winding during motor operation to weaken the field of said dynamo preparatory to generator action.

3. In apparatus of the class described, in combination, a dynamo electric machine, conducting means comprising a shunt field circuit adapted to lead current from said machine as a generator, said circuit providing excitation during generator operation and including an automatic regulating switch, a storage battery, conducting means comprising a series field winding adapted to lead current to said machine as a motor, means adapted alternatively to connect said battery with said first and with said second conducting means, and means to prevent an opening action of said regulating switch when the motor connection is changed to the generator connection.

4. In apparatus of the class described, in combination, a dynamo electric machine, conducting means comprising a shunt field circuit adapted to lead current from said machine as a generator, said circuit providing excitation during generator operation, a storage battery, conducting means comprising a series field winding adapted to lead current to said machine as a motor, means adapted alternatively to connect said battery with said first and with said second conducting means, and means adapted to weaken said shunt field winding when said machine is connected with said battery as a motor, said last means comprising a normally shunted resistance in series with said shunt field winding, and means adapted to break the shunt.

5. In apparatus of the class described, in combination, a single dynamo electric machine, including a motor armature winding and a generator armature winding, a motor field and a generator field, means for shifting from a motor to a generator connection, an automatic regulating switch associated with said latter field, and an electromagnetic coil actuated by said generator winding during motor operation to maintain said regulating switch in open position when the motor connection is shifted to a generator connection.

6. In apparatus of the class described, in combination, a dynamo electric machine, a storage battery, conducting means adapted to lead current from said machine as a generator, an automatic switch associated with said means, conducting means adapted to lead current to said machine as a motor, means alternatively connecting said battery with said first and with said second conducting means, means adapted to maintain said automatic switch in open position while said machine is operating as a motor, and means to render said last means inoperative when said machine is operating as a generator.

Signed at Chicago in the county of Cook and State of Illinois this 25th day of October A. D., 1913.

CYRIL A. SOANS.

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