Feb. 5, 1935. C. B. WATERS 1,989,958

METHOD AND APPARATUS FOR STARTING MOTORS

Filed Dec. 2, 1929 2 Sheets-Sheet 1

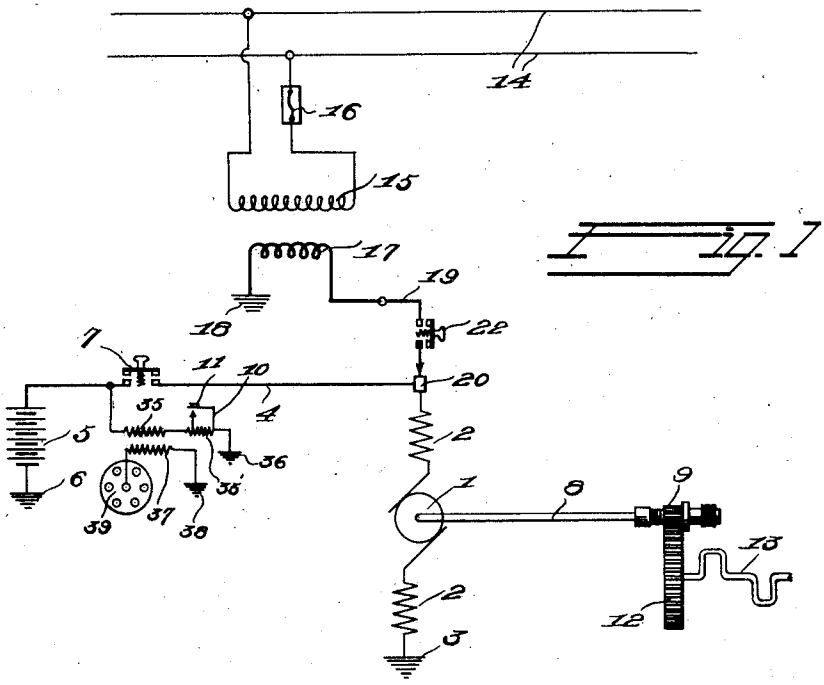


Fig. 1

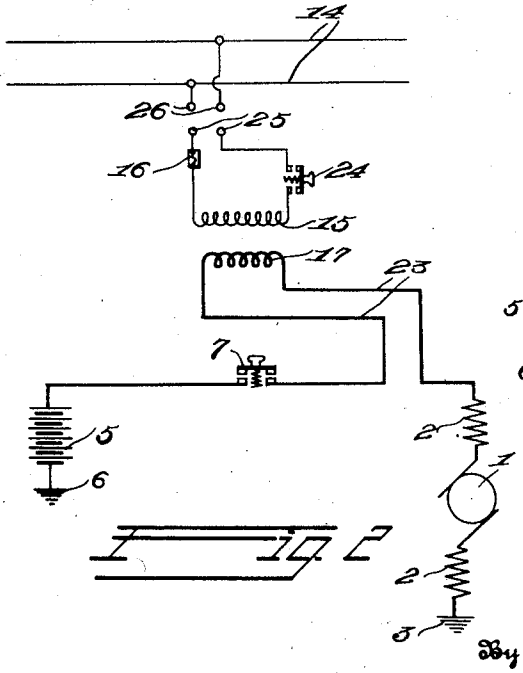


Fig. 2

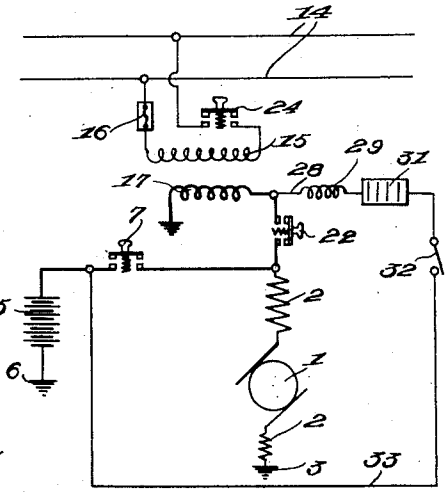


Fig. 3

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METHOD AND APPARATUS FOR STARTING MOTORS

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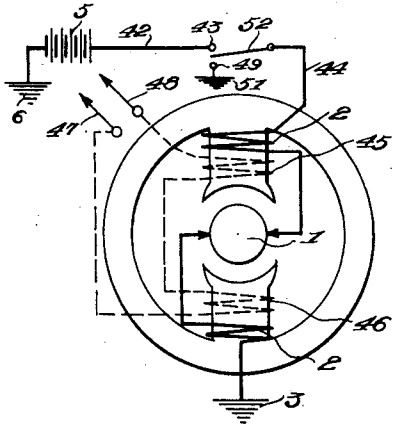


Fig. 6

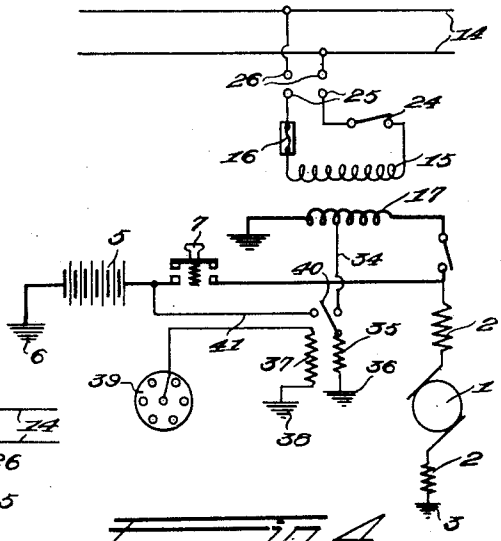


Fig. 4

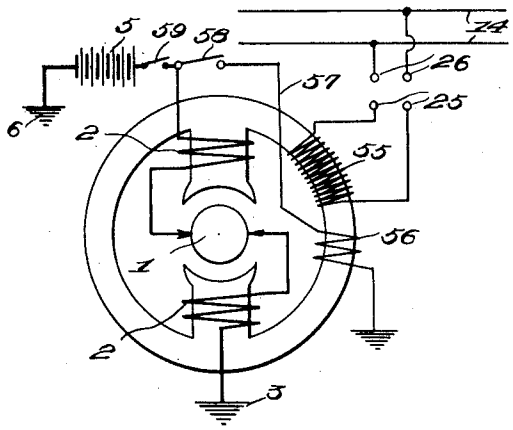


Fig. 7

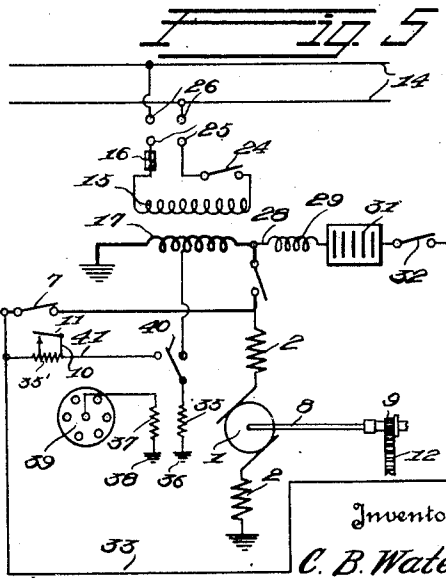


Fig. 5

Fig. 8

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UNITED STATES PATENT OFFICE

1,989,958

METHOD AND APPARATUS FOR STARTING MOTORS

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Application December 2, 1929, Serial No. 411,146

26 Claims. (Cl. 290—38)

This invention relates to the starting of internal combustion engines such as are used on automobiles, trucks, busses, rail cars, aeroplanes, boats and like uses, where the present practice is to use a direct current motor and supply, said motor being supplied with current from a low voltage battery, generally a 6 to 12 volt battery. The usual direct current starting motor is series wound.

Several systems are employed for applying the torque developed by the electric motor to the internal combustion engine for starting the same. For instance, one of the usual systems employed is known as the Bendix drive, in which the electric motor has a screw on one end of its shaft, which when it turns, works a nut forward which moves a pinion in mesh with a gear on the flywheel of the internal combustion engine. When the engine starts, the flywheel then becomes the power source and revolves the pinion which is then forced back on the screw, thus disengaging the pinion from the engine flywheel. In another system, no screw is used, but the operator presses on a lever which positively forces engagement of the pinion with the flywheel, and subsequently throws the battery current on the electric motor which thus revolves the engine. When the operator takes his foot off the pedal, the pinion is at once thrown out of mesh with the flywheel and the battery is disconnected from the electric motor.

At times, particularly in winter, the electric battery has its electric energy used up faster than the energy is replaced by the generator usually associated with the internal combustion engine of an automobile, due to more night driving, congealing of lubricant, harder starting due to lowered battery voltage and weakened spark, and like conditions. The battery thus becomes low and does not have sufficient power to cause the electric motor to turn the internal combustion engine at sufficient speed to start the same while the spark becomes weak. When this condition occurs, the usual automobile operator attempts to start the internal combustion engine by hand, but such starting is dangerous particularly when the engine is cold and the spark is weak as there is a tendency to backfire, giving an impulse in the reverse direction.

One object of this invention, therefore, is to provide an auxiliary source of power which may be connected with the usual direct current starting motor, to start an internal combustion engine when the battery usually used for starting is low. More specifically, it is an object of this invention to provide means whereby the usual alternating current source of power, as found in the usual lighting circuit of a residence garage or commercial garage may be utilized as a source of power to start the internal combustion engine.

Another object of this invention is to provide a novel transformer, the primary winding of which may be connected to the usual alternating current power lines, and the secondary of which may be serially connected with the direct current starting motor of an internal combustion engine to start said engine.

In order to supply the necessary heavy spark to the spark plug of an internal combustion engine it is usual practice to provide an ignition coil having a low tension and a high tension coil to step the battery voltage up to the necessary voltage. However, in order to prevent an excessive flow of current in the low tension ignition coil, a resistance is generally connected in series therewith. When the battery is low it sometimes happens that there is insufficient current supplied to the ignition coil to cause proper sparking at the spark plugs, this condition being partly due to the resistance in the low tension coil.

Another object of this invention, therefore, is to provide means in combination with an internal combustion engine starting system whereby the resistance in series with the low tension coil may be cut out or short circuited temporarily, to thus allow more current to flow in the ignition coil for easy starting.

Another object of this invention is to provide means for temporarily utilizing a commercial source of alternating current to start an internal combustion engine by the usual direct current motor, in combination with means for short circuiting the resistance usually in series with the low tension ignition coil, whereby a battery which is almost completely discharged may supply sufficient energy to the ignition circuit for starting.

In automotive vehicles, it is usual practice to provide a generator driven by the internal combustion engine to charge the battery carried by the vehicle. However, in some instances the battery becomes so low that it is necessary to connect therewith an external source of power in order to supply sufficient energy to charge the battery.

It is a further object of this invention to provide a system including a transformer for use with an automotive vehicle, which transformer will supply sufficient power to start the internal combustion engine by means of the usual direct current motor, and will also function to provide

means whereby the battery of the vehicle may be charged, said system including a rectifier for the alternating current.

In some instances it is found that the battery on an automotive vehicle becomes so low that not only is the power thereof insufficient to turn the starting motor, but the battery will not supply enough energy to operate the ignition circuit of the internal combustion engine. A battery in this condition is usually spoken of as being "dead".

It is a further object of this invention to provide means associated with an automotive vehicle whereby the same may be connected to a source of alternating current to supply sufficient power to start the internal combustion engine by means of the usual direct current motor, said means being also capable of being connected to the ignition circuit of the internal combustion engine to supply power thereto.

It is a further object of this invention to provide a novel direct current series wound motor for starting the internal combustion engine, which motor has an auxiliary winding thereon which may be connected to a source of alternating current to function as the primary of the transformer, the usual direct current winding of the motor functioning as the secondary of said transformer, whereby the motor may be started directly from an alternating current source without the interposition of an auxiliary transformer.

Another object of this invention is to provide a specially wound direct current motor, for starting the internal combustion engines, in which motor a transformer is unitarily built, the core of the transformer being provided by the iron of the usual motor field, whereby the motor may be operated by the usual source of direct current such as the battery, or by being connected to a source of alternating current, for starting the internal combustion engine associated therewith.

Another object of the present invention is to provide a starting motor for internal combustion engines which has the usual series motor for connection to a battery, said motor having a laminated core transformer bolted to the iron of the field of the motor, said transformer being adapted for connection to a source of alternating current in the primary thereof, and having the secondary thereof arranged in series with the motor whereby said motor may be started from the usual battery or from the source of alternating current.

It would appear at first glance that the usual direct current series motor with a solid iron magnetic field will not operate when alternating current is supplied thereto, especially a motor of the size necessary and the type used to start an internal combustion engine. Eddy currents in the solid iron magnetic circuit occur, which produce heating and tend to lessen the magnetic flux produced by the impressed current. However, applicant has discovered a peculiar and fortunate chain of technical circumstances which permit the successful operation of said starting motor by alternating current. These circumstances are as follows: First, the voltage of the motor is generally low, being six to twelve volts, and the voltage between adjacent commutator bars is therefore low. Second, the armature inductors are usually solid heavy copper bars, generally without cotton insulation between them, since they are enameled to provide the necessary insulation. Third, the voltage between the armature conductors to ground is low. Fourth, the number of teeth ratio between the flywheel and the starting motor pinion is very high so that a comparatively small torque in the starting motor is sufficient to start the internal combustion engine. High speed of rotation of the internal combustion engine is not absolutely necessary, provided the starting torque is sufficient to overcome the inertia and friction of the internal combustion engine. Fifth, since the torque is approximately a product of a constant times armature current, times field current, the actual power necessary from an alternating current source is relatively small, as although the amperage is high, the voltage is comparatively low, usually from six to twelve volts. Thus it is possible to use usual lighting circuits of small capacity to supply the necessary energy. Sixth, the time necessary for use is relatively short, since ordinarily the engine will start after only a few revolutions. Seventh, the transformer necessary to step down the usual alternating current to the proper voltage may be comparatively small so that the cost thereof will not be prohibitive.

All of the above circumstances contribute to make this invention feasible and practical in spite of the accepted idea of those skilled in the electrical arts and established theories that the method of starting discovered by me is inoperative. Because of the fact that my invention is opposed to the accepted theories of those skilled in the art, I have prior to the filing of this application, made extensive tests and thoroughly demonstrated the practicability of my invention.

Several embodiments of the invention are disclosed in this application, it being understood that the invention is not limited to the specific structures shown, since various other forms of apparatus and arrangements of the circuits may be embodied within the scope of the invention.

Referring to the drawings:

Figure 1 is a circuit diagram showing the application of my invention to an internal combustion engine wherein the Bendix drive is used.

Figure 2 is a diagrammatic showing of a modification of my invention, wherein the secondary of the transformer is serially connected with the starting battery.

Figure 3 is a further modification, wherein the transformer has associated therewith a circuit for charging the battery.

Figure 4 is a further modification showing a circuit whereby the transformer may be used to supply current for ignition of the engine.

Figure 5 is a diagram wherein my improved starting transformer has associated therewith both the charging circuit for a battery, and the circuit for supplying current to the ignition of the engine.

Figure 6 is a diagrammatic showing of one form of my novel motor, for use with direct current or alternating current.

Figure 7 is a circuit modified form of motor wherein the iron of the field of the motor functions as the core of the transformer.

Figure 8 is a further modification showing an engine starting motor operable on alternating current or direct current, in which the transformer is mechanically and magnetically connected to the iron core of the motor.

Referring to Figure 1, wherein is shown one embodiment of my improved starting circuit arrangement, the usual starting motor armature 1 has the series field 2 connected therewith, one

of said fields grounded as at 3, the other field being connected by conduits 4 to the usual starting battery 5, which is grounded to the chassis at 6, the conductor 4 having interposed therein a starting switch 7. When the starting switch 7 is closed, current from the battery passes through the series motor to rotate the same, thus turning the shaft 8 of said motor to advance the pinion 9 thereon, into engagement with the flywheel 12 connected with the crank shaft 13 of the internal combustion engine.

In order to start the internal combustion engine, when the battery 5 is discharged, my invention contemplates the use of alternating current in the series motor for rotating the same and starting the engine. The alternating current lines 14 are connected to the primary 15 of a transformer, said connection including a fuse 16. The secondary 17 of said transformer is grounded to the chassis at one side as at 18 and is connected by wire 19 to one terminal 20 of the series motor, a switch 22 being interposed in line 19.

When the internal combustion engine is to be started by the motor 1 by means of the battery 5, the switch 7 is first closed the switch 22 being open. If, however, the battery is discharged and will not start the internal combustion engine, some other source of power must be supplied to turn the engine over. Usually the private automotive owner starts his automobile in his own garage, wherein there is ordinarily a light socket connected to the house current, said house current being usually one hundred ten volts, alternating current. If the automobile is stored in a commercial garage, the power lines are readily available and in the case of commercial busses, trucks or rail cars, also the same sources of power are available. However, in the past it has been considered impossible to use the alternating current source of power to start the internal combustion engine by means of the direct current motor which usually starts them. Contrary to this usual belief, applicant has found that the motors can and do start the internal combustion engines by alternating current.

The transformer including the primary 15 and the secondary 17 may therefore be permanently mounted on the automobile with conductors leading therefrom for connection to the usual light socket, or the transformer may be mobile or it may be permanently mounted in the garage adjacent the automobile, with the conductors leading from the secondary of the transformer to the starting motor at one side and grounded to the frame of the car at the other side as shown in Figure 1. The secondary circuit of the transformer will have a switch 22 interposed therein. Therefore, when the operator wishes to start by means of the alternating current, he will plug in the transformer to the light socket, and simply close switch 22, leaving switch 7 open.

The size of the necessary transformer is small and is therefore light in weight and is readily portable.

In order to supply the necessary current to the ignition circuit of the engine, a primary ignition coil 35 is connected to the battery 5, and has a resistance 35′ connected thereto and being grounded as at 36. The secondary ignition coil 37 is grounded as at 38 and is connected to the distributor 39 for supplying current to the spark plugs in the usual manner. When the battery 5 is nearly discharged, it frequently happens that there is insufficient current to operate the ignition circuit. However, I have found that such a discharged battery usually retains sufficient energy to operate the ignition circuit if the resistance 35′ is cut out. Therefore, a short circuit 10 is connected around resistance 35′ including a switch 11. When starting the engine with a discharged battery, therefore, the switch 11 is temporarily closed to short circuit resistance 35′.

The above-described circuit arrangement may be used when the battery is partially discharged to such extent that it will not start the engine, but will start it if the switch 11 is closed, thus avoiding the use of the alternating current. However, it frequently happens that the battery not only will not turn the engine over to start it, but will not supply sufficient energy for the ignition when the alternating current is used. When this occurs then the alternating current is used for the motor, as above described, by closing switch 22 and the resistance 35′ is also cut out by closing switch 11. If desirable the switches 22 and 11 may be mechanically connected or electromagnetically connected so that closure of switch 22 will automatically close switch 11.

The primary and secondary windings of the transformer are so designed that the secondary will deliver alternating current at from 6 to 20 volts. The lead 19 of the transformer is usually made as short as possible since the current consumption is rather heavy, sometimes running from 200 to 600 amperes. However, the actual power drawn from the alternating current lines 14 is not excessive, since the voltage is materially reduced and therefore the usual lighting circuit wires are sufficient to carry the current.

As a general rule, an internal combustion engine will start after a comparatively small number of revolutions. It is therefore desirable to associate with the transformer, a time element fuse or cut-out which will open the circuit after a set interval of time, such as one minute to thus prevent damage to the starting motor if the circuit is inadvertently left closed for an excessive time. Such a fuse is designated diagrammatically at 16 and is not shown in detail since this fuse per se forms no part of the present invention. It will be noted that the secondary of the transformer shown in Figure 1, comprises a complete and separate circuit from the usual starting circuit by means of the battery.

Referring to Figure 2, wherein like reference characters designate like parts, the transformer is permanently mounted on the vehicle, the secondary 17 thereof being connected by lead 23 in series with the usual starting circuit between the battery 5 and the motor. A switch 24 is interposed in the circuit of the primary of the transformer, said circuit including a plug-in device 25 such as an attachment plug, for cooperation with taps 26 connected with the alternating current line 14. When the internal combustion engine is to be started by means of the battery 5, the switch 7 is closed, switch 24 being open and the plug 25 usually, but not necessarily, being disconnected. The secondary 17 does not interfere seriously with the flow of current from the battery to the motor, since the resistance of the secondary is very low and therefore no appreciable loss of current occurs. If the engine is to be started by alternating current, the plug 25 is inserted and switches 24 and 7 are both closed. Low voltage alternating current therefore passes serially through the field and armature of the

motor and through the battery to ground, to start the motor. Although this alternating current is rather high in amperes, the time during which it is applied is rather short and no damage will result to the battery 5 from the use as above described.

In this modification the core of the transformer must be made sufficiently large so as to prevent saturation thereof by the battery current.

In the modification shown in Figure 3 the starting circuit is arranged quite similarly to that shown in Figure 1, the primary of the transformer, however, having interposed therein a switch 24 similar to that shown in Figure 2. The starting of the motor by either the battery 5 or the alternating current source of power is the same as that described in connection with Figure 1. In cases where the battery has become completely discharged or is so low that it needs charging, an auxiliary charging circuit is associated with the transformer secondary 17 so that the battery may be charged. Said circuit includes the wire 28 connected to the secondary 17, above switch 22, said lead being connected to a choke coil 29 serially connected with a rectifier or a one-way valve 31, such as the type marketed as a Kuprox rectifier or any other rectifying device, said circuit further including a switch 32. Switch 32 is connected to the battery 5 by a wire 33. When it is found desirable to charge the battery 5, the transformer switch 24 is closed, switch 22 and switch 7 being open and switch 32 is closed. Since the windings of the transformer are so designed as to supply the voltage within the range of 6 to 20 volts, the battery is charged by a pulsating curent in one direction, the choke coil 29 preventing excess current to the battery.

The above charging circuits may be permanently built into the vehicle and the transformer may also be permanently mounted on the vehicle, with means such as the plug 25 and 26 of Figure 2, being used to connect the transformer to the wires 14.

In the modification shown in Figure 4, the starting circuits for the motor are arranged similarly to those shown in Figure 1, similar reference characters designating like parts, and the circuits are further arranged to provide the ignition current for the internal combustion engine, when the battery is too low to supply such current. Conductor 34 is tapped off the secondary 17 of the transformer, said conductor having serially arranged therein one coil 35 of the ignition coil, coil 35 being grounded at 36 and arranged adjacent coil 37, coil 37 being also grounded at 38, and being connected to the center terminal of the distributor 39. By proper positioning of the wire 34 along the secondary 17 of the transformer, and by proper design of the high and low tension coils 35 and 37 of the ignition coil, I have found that sufficient current can be supplied to the distributor 39 to start the engine. The double throw switch 40 is provided to connect the ignition coil direct to the battery by wire 41 or to secondary 17 by wire 34.

In Figure 5, a composite diagram of connection is shown wherein the source of alternating current may be used to start the motor, to supply sufficient current for ignition, and also may be used to charge the battery.

It will of course be understood that the charging circuit for the battery is not used simultaneously with the starting and ignition circuit. In this figure, the circuit for charging the battery is arranged similarly to that shown in Figure 3, and the starting and ignition circuits are arranged similarly to those shown in Figure 4, like reference characters designating like parts. The double throw switch 40 is used as in Figure 4.

With the circuits as above described, the transformer may be permanently mounted on the vehicle, or in the garage. If mounted on the vehicle, the switches controlling the starting, charging and ignition may be arranged in the usual manner such as on the instrument board, and the various circuits permanently connected and it is only necessary to plug in contacts 25 when using alternating current. If the transformer is mounted in the garage, the various circuits for charging, starting and ignition may be permanently built into the vehicle, with detachable means for connecting the secondary of the transformer to these circuits.

All of the circuit arrangements as above described are designed for use with the usual direct current motor as installed on automotive vehicles today. However, it is possible and more economical to incorporate a transformer action right into the starting motor when the same is built. In this way the use of a separate transformer is avoided and the same advantages are present; namely, that the motor may be started by the usual battery, or by connection to a source of alternating current. Several embodiments of how this transformer action may be built into the motor are disclosed in Figures 6, 7 and 8, but many other arrangements will readily be apparent to those skilled in the art, and the disclosures of Figures 6, 7 and 8 are therefore illustrative only and not restrictive.

Referring to Figure 6, the usual battery 5 is provided which is grounded at 6, the lead 42 being connected to contact 43 of a switch. From the switch a wire 44 connects with the serially arranged field 2 of the motor including the armature 1 thereof and being grounded at 3. The primary of the transformer is wound around the pole pieces for the field of the motor adjacent the series field 2 thereof, such primary including winding 45 and 46 serially connected with leads 47 and 48 adapted to be connected to a source of alternating current. A contact 49 grounded at 51 is arranged adjacent the movable contact 52 of the switch. When the motor is to be started by the battery 5, the switch 52 is moved to contact with terminal 43, thus completing the circuit in the usual manner for starting the motor. If the battery is low and it is desired to start by the alternating current source, the switch 52 is moved to contact with the terminal 49 and the leads 47 and 48 are connected to the alternating current source. Alternating current is thus passed through the primary 45 and 46 to induce current in the series field of the motor, this series field thus functioning as the secondary of the transformer, the circuit being from the ground 3 through the series coils 2, including the armature 1, wire 44, switch 52, contact 49, and to ground at 51. Thus it is necessary to provide only the auxiliary windings 45 and 46 in the motor, which windings function as the primary of the alternating current transformer, the poles of the motor functioning as the core of said transformer, and the usual series field of the motor functioning as the secondary of the transformer. When the leads 47 and 48 are disconnected from the source of alternating current,

the windings 45 and 46 do not interfere in any way with the normal operation of the motor started by the battery 5.

Another embodiment of a novel form of motor in which the transformer action is built therein, is shown in Figure 7. In this modification the iron of the motor field is used as the transformer core, the primary 55 of the transformer being wound around the core of the field with the secondary 56 wound adjacent thereto. Thus the iron of the field of the motor functions as the core of the alternating current transformer. The secondary 56 of the transformer is connected to ground at one side and is connected by wire 57 to a switch 58 whereby the series field 2 and the armature 1 may be connected to the secondary 56. If the engine is to be started by means of the battery 5, the switch 58 is left open and switch 59 is closed thus closing the normal starting circuit for the motor. In this modification, as in the other transformers shown, the primary and secondary windings are so designed as to deliver between 6 and 20 volts on the series motor, which then acts as a series alternating current motor to start the engine. The most efficient operation of the above motor is obtained when the field is laminated, thus providing a laminated core for the transformer, but the motor is fully operative if the field is of solid iron.

In the embodiment shown in Figure 8, the transformer is mounted on the exterior of the motor frame and is mechanically and magnetically connected to the field of said motor. In this modification, the movable switch 61 is connected to contact 62 when the battery 5 starts the engine, the circuit then passing through the series field 2, armature 1, and secondary 63 of the transformer to ground as at 64. When the alternating current source of power is used to start, plug contacts 65 are engaged with the alternating current lines 14, the primary 66 of the transformer inducing current in the secondary 63 thereof, switch 61 being connected to the contact 67 and thus to ground. The core of the transformer is provided by the portion 68 which is preferably laminated and is mechanically and magnetically connected to the frame 69 which is in the field of the motor. The primary and secondary are designed to deliver approximately 6 to 20 volts in the secondary thereof.

It will be obvious to those skilled in the art that the various other types of transformers may be directly incorporated into the starting motor, to deliver the proper voltage and current to the motor when the primary of the transformer is connected to an alternating current source.

The above embodiments are shown for purposes of illustration only, and are not to be construed as limitations since various other arrangements fall within the scope of this invention.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What I claim and desire to secure by United States Letters Patent is:—

1. The method of starting an internal combustion engine provided with a direct current starting motor and mechanical means to connect the motor to the engine, which comprises sending an alternating current of commercial frequency through said motor to thereby rotate the engine and start the same.

2. The method of starting an internal combustion engine provided with a low voltage direct current starting motor and mechanical means to connect the motor to the engine, which comprises sending an alternating current of commercial frequency through said motor, the voltage of said alternating current being approximately that of the direct current motor to thereby rotate the engine and start the same.

3. In combination, an internal combustion engine, a direct current starting motor, means to mechanically connect said motor and said engine, a transformer said transformer having a primary and a secondary, said primary being designed for connection to a commercial alternating current line said secondary having a low voltage, and means for connecting the primary of said transformer to an alternating current line and the secondary to said starting motor whereby said internal combustion engine may be started with commercial alternating current.

4. The invention as defined in claim 3 wherein said secondary delivers alternating current of the order of 6 to 20 volts.

5. The invention as defined in claim 3 wherein said motor is a series wound motor of low voltage.

6. The invention as defined in claim 3 wherein an electric switch is in series with the primary of said transformer.

7. The invention as defined in claim 3 wherein a delayed-action circuit opening device is connected with said transformer to open the circuit thereof after a definite time interval.

8. The invention as defined in claim 3 wherein the said means to connect the primary of the transformer to the alternating current line includes an attachment plug.

9. The invention as defined in claim 3 wherein said transformer is permanently mounted on said vehicle, a storage battery on said vehicle, and means for selectively connecting the battery or the transformer secondary to said motor.

10. The invention as defined in claim 3 wherein the engine and starting motor are mounted on a vehicle and said transformer is permanently mounted on said vehicle, a storage battery on said vehicle connected to said motor, the secondary of said transformer being serially connected with said battery and said motor.

11. The invention as defined in claim 3 wherein the engine and starting motor are mounted on a vehicle, a storage battery is mounted on said vehicle and a circuit connected to said secondary and to said battery and including a rectifier for charging said battery from the alternating current line.

12. The invention as defined in claim 3 wherein said internal combustion engine includes an ignition system and means for connecting said ignition system to the secondary of said transformer.

13. The invention as defined in claim 3 wherein said internal combustion engine includes an ignition system, a storage battery, and means for selectively connecting said ignition system to said battery or the secondary of said transformer.

14. The invention as defined in claim 3 wherein said internal combustion engine includes an ignition system, a storage battery, means for selectively connecting said ignition system to

said battery or the secondary of said transformer, and a circuit connected to said secondary and to said battery including a rectifier for charging said battery from the alternating current line.

15. The invention as defined in claim 3 wherein the means to mechanically connect said motor and said engine comprises a gear on said engine shaft, a pinion on said motor shaft, and means to engage said pinion with said gear to cause rotation of said engine shaft by said motor.

16. The invention as defined in claim 3 wherein the starting motor is series wound, and one side thereof is grounded, and means grounding one side of said secondary.

17. In combination, an internal combustion engine, an ignition circuit therefor, a direct current starting motor, a battery, means to mechanically connect said motor and said engine, a transformer having the primary thereof designed for connection to a commercial alternating current line and having a low voltage secondary, means for connecting the primary thereof to a source of alternating current and the secondary to said starting motor to supply low voltage alternating current to said motor for starting said engine, and means for temporarily decreasing the resistance of said ignition circuit to assist the battery in starting the engine.

18. The combination of an internal combustion engine, an electric motor, a source of low voltage power, a source of high voltage power, means for transforming said high voltage power, and means for connecting either said low voltage source of power or said transformed source of power to said motor when operating to start said engine.

19. In combination an internal combustion engine, an electric starting motor associated with the engine, an accumulator, a switch for closing a circuit from said accumulator to said motor, another circuit for a second source of electric power, a transformer in said circuit, a switch for closing the second circuit from said source of power to said motor, and a mechanism providing a driving connection between said motor and the engine when the motor is energized by either of said sources of power to start said engine.

20. An auxiliary starting system for internal combustion engines having an electric starting motor normally operated by a battery, said auxiliary system comprising an electrical supply circuit, a secondary circuit including said starting motor, and means for transforming the current in said supply circuit into the form of current required in said secondary circuit to operate said starting motor.

21. An auxiliary starting system for internal combustion engines having an electric starting motor normally operated by a battery, said auxiliary system comprising an electrical supply circuit, a secondary circuit including said starting motor but not including said battery and means for transforming the current in said supply circuit into the form of current required in said secondary circuit to operate said starting motor.

22. In combination, a vehicle including an internal combustion engine, a source of current, an electric starting motor having a single motor winding, and circuit connections between said source and said winding, a second source of current external to said vehicle differing in characteristic from said first source of current, and circuit connections arranged and adapted to transmit electrically energy to said winding from said second source and transform said electrical energy into the form of current required to operate said starting motor.

23. In combination, a vehicle including an internal combustion engine, a source of current, an electric starting motor having a single motor winding, and circuit connections between said source and said winding, a second source of current external to said vehicle differing in characteristic from said first source of current, and circuit connections arranged and adapted to transmit electrical energy to said winding from said second source and transform said electrical energy into the form of current required to operate said starting motor, said second named connections being in part carried by said vehicle.

24. A vehicle including an internal combustion engine, a source of current, an electric starting motor having a single motor winding, circuit connections between said source and said winding, and additional circuit connections arranged and adapted to transform and transmit electrical energy to said winding to actuate said motor from another source of current external to said vehicle having a characteristic different from said first source of current.

25. An auxiliary starting system for an internal combustion engine having an electric starting motor, a battery, and a switch for connecting said starting motor and said battery, comprising an electrical supply circuit, a converter for transforming the current in said supply circuit into a form suitable to operate said motor, and a secondary circuit including said motor, said switch, and said converter.

26. In combination, an internal combustion engine, a direct current starting motor, a transformer having a primary designed for connection to a commercial alternating current line and having a low voltage secondary, and means for connecting said primary to such a line and said secondary to said starting motor whereby said internal combustion engine may be started with commercial alternating current.

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