Oct. 30, 1956 L. PETERLIK ET AL 2,769,100

METHOD AND APPARATUS FOR STARTING INTERNAL COMBUSTION ENGINES

Filed June 23, 1954 4 Sheets-Sheet 1

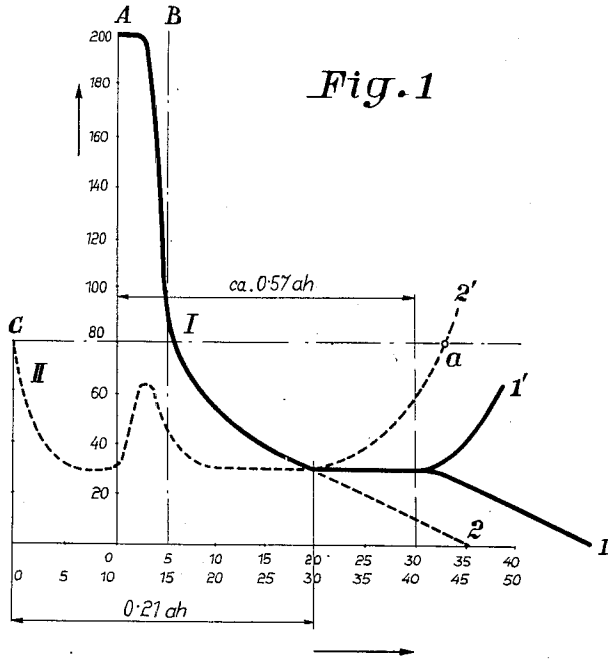


Fig. 1

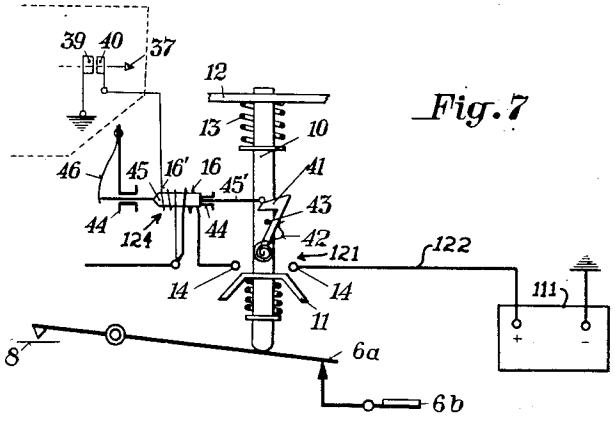


Fig. 7

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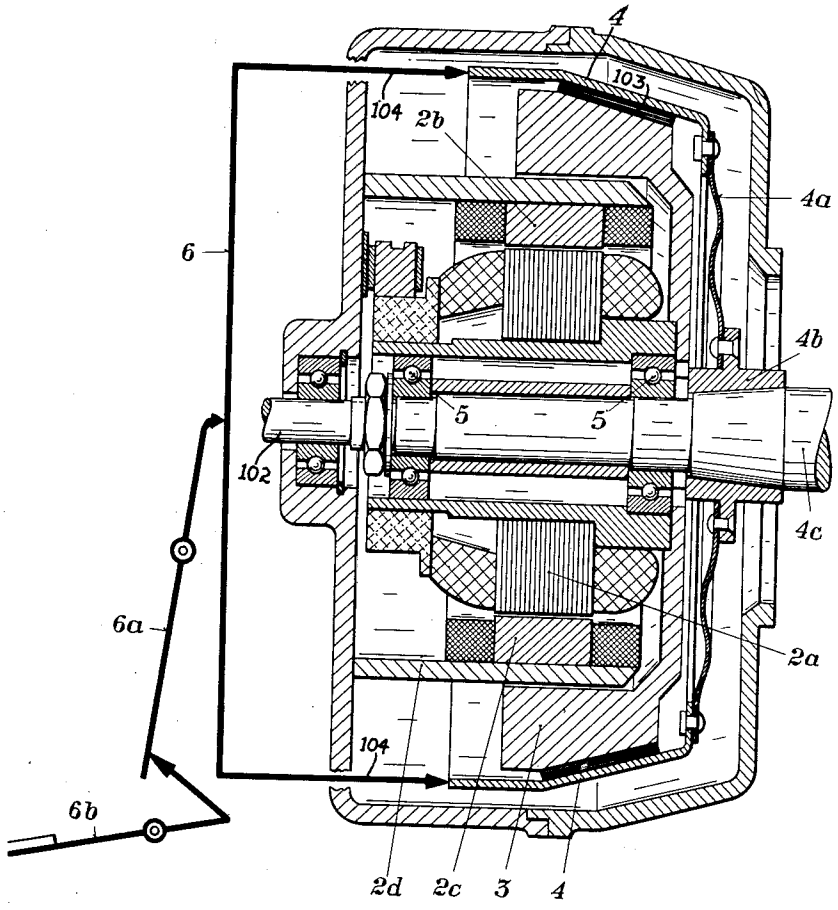
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Fig. 2



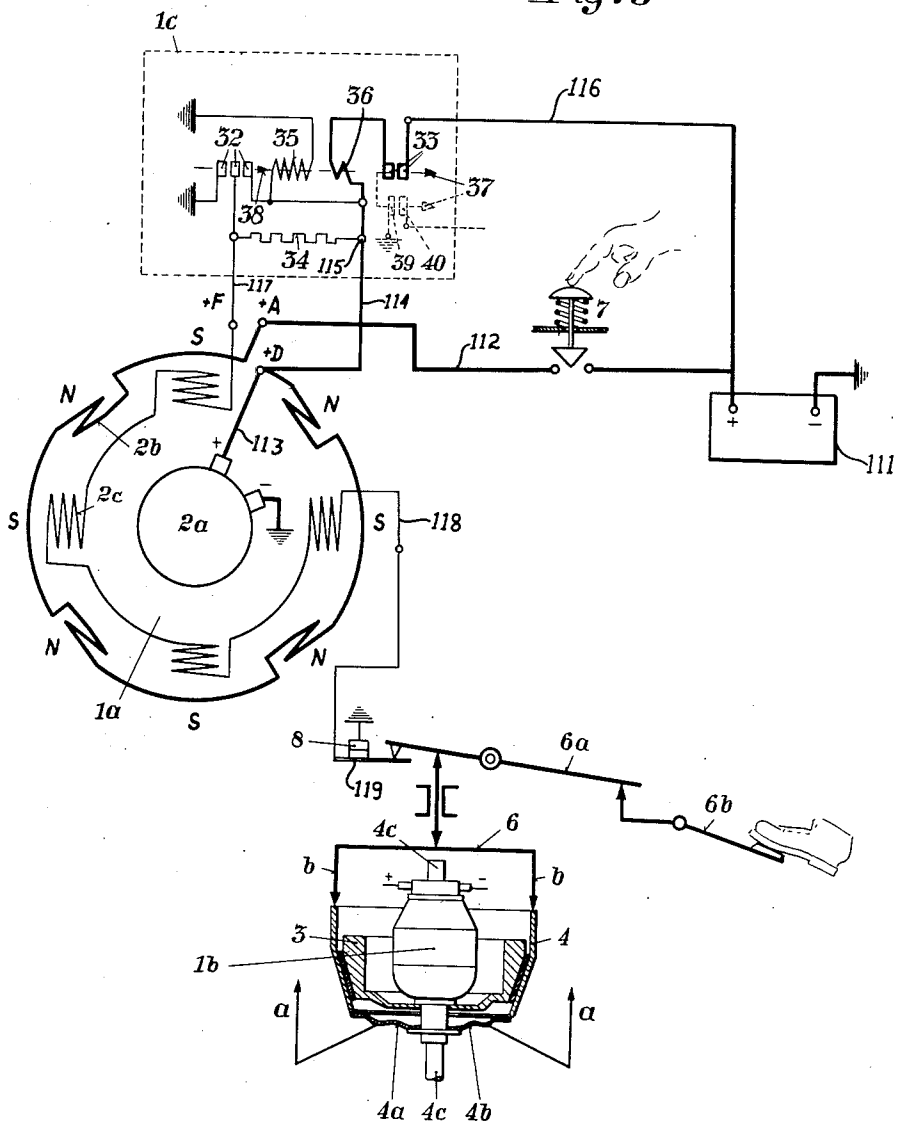
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METHOD AND APPARATUS FOR STARTING INTERNAL COMBUSTION ENGINES

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Fig. 3



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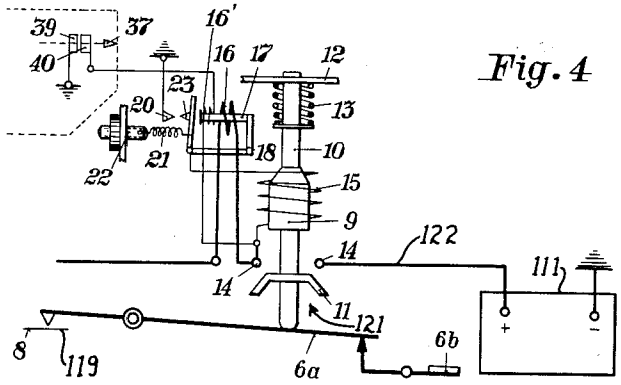


Fig. 4

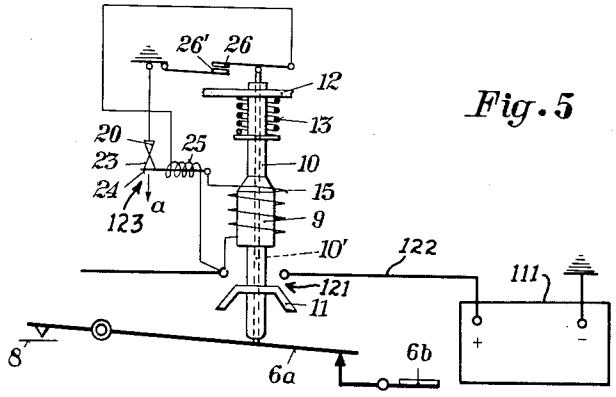


Fig. 5

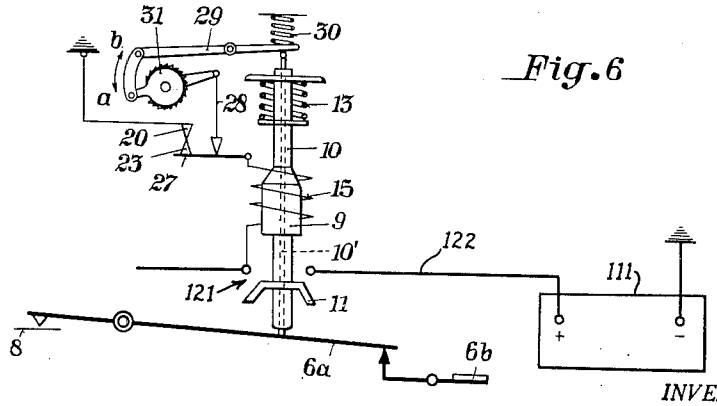


Fig. 6

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METHOD AND APPARATUS FOR STARTING INTERNAL COMBUSTION ENGINES

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Application June 23, 1954, Serial No. 438,710

Claims priority, application Austria June 26, 1953

13 Claims. (Cl. 290—38)

The present invention relates to a new and improved method and apparatus for starting internal combustion engines.

More particularly, the present invention relates to a new and improved flywheel starter motor and starting arrangement.

At the present time there are at least two conventional methods for starting internal combustion engines, one being the flywheel starter motor and dynamo assembly, and the second being the dynastarter. The conventional flywheel starter unit operates by initially disengaging the flywheel from the engine shaft. The starter motor is then energized to drive the flywheel until a high kinetic energy is stored therein. The flywheel is then coupled to the engine shaft and simultaneously decoupled from the starter motor. The kinetic energy of the flywheel is then used to turn the engine shaft until the engine starts. In this type of system it is apparent that only the kinetic energy of the flywheel is used for rotating the engine shaft. Since the initial starting torque is very high for internal combustion engines, it is apparent that this kinetic energy may easily be used up before the engine actually starts. It is apparent that at low temperatures this problem is materially increased.

The conventional dynastarter technique includes a motor permanently connected to the engine shaft. In order to overcome this high initial starting torque the motor is made oversize. Obviously, this is uneconomical under normal conditions when the engine is running.

The present invention stores kinetic energy in a flywheel disengaged from the engine shaft and then couples the flywheel to the shaft. However, the starting motor also remains coupled to the flywheel and engine shaft so that both its torque and the kinetic energy of the flywheel are simultaneously applied. This permits a decreased drain on the battery used to operate the starting motor as will be illustrated herein below.

Accordingly, it is an object of the present invention to provide a new and improved method and apparatus for starting internal combustion engines.

Another object is to provide a new and improved starting apparatus for internal combustion engines which operates more efficiently than presently known devices.

Still another object of the present invention is to provide a novel starting motor for internal combustion engines.

An object of the present invention is to provide new and improved starting apparatus which is automatically stopped after a time period independent of the starting of the internal combustion engine.

With the above objects in view, the present invention mainly consists of a starting apparatus which includes an electric starter motor having a rotatable armature. Flywheel means are connected to the rotatable armature to be rotatable therewith. Coupling means are included for connecting the armature and flywheel to the shaft of a combustion engine and for decoupling them therefrom, whenever required. Means for energizing the motor and

rotating the armature together with the flywheel, whenever required, are provided whereby for starting of the combustion engine, the motor is energized without coupling the armature to the engine shaft until the armature together with the flywheel attains a relatively high speed, storing substantial kinetic energy, whereupon the armature and flywheel are coupled to the engine shaft thus partly using the stored kinetic energy for rotation of the engine shaft and starting of the engine.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a diagram showing the variation of current in the starting motor with time for both conventional starting units and starting units incorporating the present invention;

Fig. 2 is a transverse cross sectional view of a starting motor capable of being used with apparatus incorporating the present invention;

Fig. 3 is a diagrammatic representation of the starting circuit;

Fig. 4 is a diagrammatic representation of automatic control means for terminating the starting cycle of the present invention when the current drawn by the motor exceeds a predetermined value;

Fig. 5 is a diagrammatic representation of an automatic control means for terminating the starting cycle which is dependent upon the surrounding temperature;

Fig. 6 is a diagrammatic representation of automatic control means including a mechanical escapement mechanism for terminating the starting cycle after a predetermined time interval; and

Fig. 7 is a diagrammatic representation of an automatic control means including a mechanical interlock and an electromagnetic relay for terminating the starting cycle when a predetermined value of current is reached.

Referring now to Fig. 1 a current-time diagram is illustrated with current in amperes plotted as the ordinate and time in seconds plotted as the abscissa. The heavy line, I, represents the variation of current in the conventional dynastarter unit. As indicated above this unit is permanently connected to the shaft of the internal combustion engine. Therefore, at the beginning of the starting cycle (time line A) a high current peak is drawn from the battery used to energize the starting motor. This is due to the high starting torque needed to overcome the inherent inertia of the starter unit and the engine.

This high current peak is maintained until the engine starts to turn over which, in the example shown, occurs in about 2½ seconds. At this point the current starts to decrease rapidly until after about 5 seconds (time line B) only the turnover torque of the engine itself must be overcome. As the speed of rotation increases the current decreases until a constant value is reached equal to the starting speed of the engine crank shaft. This constant current value is maintained until ignition takes place. When the engine starts the current consumption of the starter motor decreases and finally reaches zero unless the motor is disconnected from the current-source.

If ignition of the engine does not occur the motor speed will decrease after a certain time due to a drop in the battery supply voltage. This increases the current consumption and is illustrated in Fig. 1 by the line 1'. Obviously, it is possible under certain circumstances to continue operating the starting button until the battery

is completely run down without the internal combustion engine ever being started.

The current-time relationship of apparatus incorporating the present invention is illustrated in Fig. 1 by the dotted line II. At the beginning of the starting cycle the starter motor and flywheel are disconnected from the engine shaft so that the motor need only overcome the load of the uncoupled flywheel. Therefore, at time zero (time line C) a substantially smaller current peak is produced than was necessary for the previous conventional case. As the flywheel starts to rotate the current consumption of the starter motor falls off until the time line A is reached. At this instant, in accordance with the starting method of the present invention, the flywheel and starting motor are coupled to the engine shaft. A slight increase in current consumption occurs at this point due to the starting torque needed for initiation of engine shaft rotation. It should be noted that the peak of the starting current is here much lower than the previous peak due to the use of the kinetic energy stored in the rotating flywheel.

As before, when the engine shaft starts rotating the current decreases until the constant starting speed of the engine crank shaft is reached. The starting cycle continues until the engine ignites, indicated by the decreasing line 2 or the engine fails to ignite and the current increases in accordance with line 2'.

In comparing the figures shown for the two starting arrangements, it is seen that for a 30 second starting period the convention arrangement consumes a total of 0.57 ampere hour. On the other hand, apparatus incorporating the present invention consumes only 0.21 ampere hour for a 30 second starting period. Accordingly, it is apparent that starting arrangements incorporating the present invention may be made substantially smaller than conventional starters thereby providing considerable savings in cost of material.

Referring now to Fig. 2 a cross sectional view of one starter motor capable of being used with the present invention is shown. The motor is mounted within a motor housing *2d*. In the housing, a shaft 102 is rotatably mounted by means of bearings 5. An armature *2a* is affixed to the shaft 102. On the inner surface of the housing *2d* is mounted a series field winding *2b* and a shunt field winding *2c*. Fixedly mounted on the rotating armature is a flywheel 3 having a conically-shaped outer surface. On the outer surface of flywheel 3 is a clutch lining 103. Lining 103 may be made of any suitable material having a high coefficient of friction.

An annular ring 4 is shown mating with the clutch lining 103. Ring 4 is urged against lining 103 by a resilient member *4a* attached to a shaft hub *4b*. Hub *4b* is mounted on the internal combustion engine shaft *4c*. Lever means 6, shown in diagrammatic form, are operable against the annular ring 4 in the direction indicated by the arrows 104 to overcome the force of resilient member *4a*. Lever means 6, in turn, are remotely operable by members *6a* and *6b*.

In operation therefore the flywheel 3 and the armature *2a* may be decoupled from the engine shaft *4a* by operating the lever 6 in the direction shown. Armature *2a* is therefore free to rotate except for the starting inertia introduced by its own weight and the weight of the flywheel. At any desired time lever 6 may be operated to connect the rotating armature and flywheel to the engine shaft *4c*. The operation of the starting motor illustrated in Fig. 2 will be described hereinbelow.

Referring now to Fig. 3 the starting motor is shown diagrammatically in conjunction with the remainder of the starting apparatus. Power for the apparatus is provided by the storage battery 111. The positive terminal of battery 111 is connected to the terminal +A by a conductor 112 through a manually operable switch 7. Terminal +A is connected to one side of the series field windings *2b*. The other side of the windings *2b* being connected to the terminal +D. The terminal +D is connected to the positive terminal of the armature *2a* by a conductor 113; the negative terminal of armature *2a* being connected to ground. Terminal +D is also connected by a conductor 114 to terminal 115 of a conventional voltage regulator indicated by the dotted line *1c*. Attached to terminal 115 is a biasing resistor 34, and current coils 35 and 36. The other side of coil 35 is connected to ground and the other side of coil 36 is connected to one of a pair of contacts 33. The other contact 33 is connected to battery 111 by a conductor 116. Contacts 33 are normally open and may be closed by the magnetic field acting on core 37 and established by sufficient current flowing through the coil 36. Similarly, coil 35 is operable on contacts 32 by means of core 38.

The other side of the resistor 34 is connected to a terminal +F by means of a conductor 117. This terminal is also connected to one side of the shunt field windings *2c*, the other side of these windings being connected on conductor 118 to one of a pair of normally closed contacts 8. The other contact 8 is connected to ground. Contacts 8 form part of a switch 119 which may be operated by lever *6a*. Lever *6a*, in turn, may be operated by lever *6b* which itself is manually operable.

In operation, therefore, lever *6b* is depressed to disconnect the armature and flywhel from the engine shaft. This also opens switch 119 thereby disconnecting the shunt field windings *2c*. Switch 7 is now manually operated to send current through the field windings *2b* and the armature *2a* in series. This initiates rotation of the armature *2a* which quicky reaches high speed due to its connection as a series motor. This is the period between time lines C and A of Fig. 1. When the desired speed is reached lever *6b* is released connecting the armature and flywheel to the engine shaft and simultaneously closing the switch 119. This is the part of the time cycle indicated by the time line A of Fig. 1. Due to the sudden introduction of the stored kinetic energy of the flywheel 3 a supplementary force is available to rotate the engine shaft in addition to the torque still provided by the starter motor. Because of the conical clutch arrangement illustrated in Fig. 2, the connection between the engine shaft and the flywheel is made with the smallest possible slip.

It should also be noted that when the starter switch 7 is operated current flows through coil 35 attracting core 38 thereto and closing contacts 32. Therefore, when switch 119 is closed the windings *2c* are connected in parallel with the rotating armature *2a*. This provides an additional magnetic field in which the armature rotates thereby providing the additional starting torque available with compound operation. Therefore, by keeping switch 7 closed the engine shaft can be made to rotate at its constant ignition speed until the engine ignites. When the combustion engine starts the current consumption of the starter motor will decrease to zero. If the engine does not start the motor will continue to draw current until the battery voltage decreases with a resultant rise in current to the point *a* on line 2' of Fig. 1.

In the above described method of operation the length of time during which the flywheel and motor are uncoupled from the engine shaft is determined only by the operator starting the engine. This is advantageous since the flywheel may be made to store additional kinetic energy by longer decoupled operation. In lower temperatures it is known that the starting torque of the engine is much higher due to the thickness of the oil in the bearings and cylinders. Therefore the individual operator may determine the length of time for this uncoupled operation depending on the extraneous temperature conditions.

In the embodiment shown in Fig. 3 it is possible by continuous operation of switch 7 to rotate the combustion engine until the battery 111 is exhausted. However, by means of the circuit arrangements described below, it

is possible to automatically deenergize the starter motor after a time period independent of the starting of the combustion engine.

Referring now to Fig. 4 one embodiment for automatically terminating the energization of the starting motor is shown. Only the automatic circuit elements are illustrated in Fig. 4, the remainder of the parts remaining as illustrated in Fig. 3. In place of the starter switch **7**, a switch indicated by the arrow **121** is provided. Switch **121** is maintained in the normally open position by a compression spring **13** acting against the abutment **12**. The remainder of switch **121** includes a rod **10**, a winding **15** about a magnetic core **9**, contacts **14** and a contact closing element **11**. One of the contacts **14** is connected to the positive terminal of the battery **111** by a conductor **122**. The other contact **14** is connected to one side of coils **15**, **16** and **16'**. The other side of coil **16** is connected to the armature **2***a* so that coil **16** is in series with this armature. The other side of coil **16'** is connected to auxiliary contacts **39** and **40** and thereby to ground when these contacts are closed.

The other side of the winding **15** is connected to a movable armature **19** on which is mounted a contact **23**. Contact **23** mates with grounded contact **20** and is held in the normally closed position by means of spring **21** and adjustable set screw **22**. The remainder of the relay about which coil **16** is wound includes the core **17** and the yoke **18**.

In operation depression of the lever **6***b* raises lever **6***a* closing switch **121** against the pressure of the spring **13**. As before, this also opens switch **119**. Current is supplied from the battery to the armature on conductor **122** through switch **121** and coil **16**. The contacts **20** and **23** are maintained closed by the spring **21** which is adjusted to overcome the force of the magnetic field set up by the coil **16** as long as the current through the coil **16** goes no higher than the value indicated at time line C of Fig. 1. Therefore, winding **15** is connected to ground and is energized to hold the magnetic core **9** in its displaced position, maintaining switch **121** closed. Now, if lever **6***b* is released this will close switch **119** but will not have the effect of opening switch **121**.

Under these circumstances if the engine does not start within a certain time period, the current drawn by the armature **2***a* will increase to the point *a* of Fig. 1. As soon as the current exceeds this point the magnetic force set up by coil **16** will overcome the spring **21**, opening the contacts **20** and **23**. This will deenergize the holding winding **15** thereby opening switch **121**. In the event that the engine starts before point *a* is reached the current through the armature will decrease toward zero. By this time the shunt field windings have been connected in parallel and the machine being rotated by the combustion engine, now acts as a generator. The generated voltage causes the coil **36** of Fig. 3 to close contacts **33**, **39** and **40** of Fig. 4. This sends current through the auxiliary **16'** providing enough magnetic force to open contacts **20** and **23** and release holding winding **15**.

Therefore, with the above described arrangement we have provided means for automatically deenergizing the rotating motor after a time period, regardless of whether or not the engine starts. In the above case the period is ended when the current through the motor reaches a predetermined value.

Referring now to Fig. 5 a second automatic arrangement is shown for deenergizing the rotating motor at the end of a time period. The parts of Fig. 5 bearing the same numbers as parts of Fig. 4 have similiar functions. However, in place of the windings **16** and **16'**, a thermally operated switch indicated generally by the arrow **123** is provided. The switch includes a heater winding **25** and a bi-metallic spring **24**. One side of the heater winding **25** is connected to ground through normally closed contacts **26** and **26'**.

The switch **121** also includes a switch rod **10'** through the center of its shaft **10**. When the lever **6***a* is raised, closing the switch **121**, the switch rod **10'** is raised opening the contacts **26**, **26'**. When the lever **6***a* is released the switch **121** remains closed due to the action of the holding coil **15**. However, the switch rod **10'** drops, thereby closing contacts **26**, **26'**. Current now flows through the heater winding **25** heating the bi-metallic element **24** until it bends sufficiently to separate contacts **20** and **23**. This opens the circuit of the holding coil **15** and opens switch **121**.

Therefore, in the embodiment of Fig. 5 the rotating motor is automatically deenergized by means of the thermally controlled switch **123**. One obvious advantage of such a thermal device is that heater **25** will take longer to reach the opening temperature when the surrounding temperature is low, that is, the lower the temperature, the longer will the circuit operate to start the engine.

Referring now to Fig. 6 a mechanical escapement mechanism **31** is shown in place of the switch **123** of Fig. 5. Here the lever **6***a* closes the switch **121** which now winds the mechanism **31** in the direction of the arrow *a* by means of the switch rod **10'** and the lever **29**. When the escapement mechanism is wound the rod **28** is displaced from the lever **27** containing contact **23**. This permits contacts **23** and **20** to close connecting winding **15** to ground to hold switch **121** in the closed position.

When the lever **6***a* is released, the switch **121** remains closed but the switch rod **10'** is lowered and the escapement mechanism **31** unwinds until the rod **28** bears on the lever **27** and opens contacts **20** and **23**. This opens the circuit of the holding winding **15** and opens switch **121**. Therefore, in the above described embodiment the time interval **15** is controlled by the setting of the escapement mechanism.

Referring now to Fig. 7 another means for automatically terminating the energization of the motor is shown. In this arrangement a purely mechanical blocking is provided for holding switch **121** in a closed position.

On the shaft **10** of the switch **121** is mounted a hook **41** which is urged by a spring **42** against a fixed pin **43**. Associated with the switch **121** is an auxiliary relay indicated generally by the arrow **124**. This relay includes a core **45** surrounded by winding **16** and auxiliary winding **16'**. A push rod **45'**, made of a magnetic material, projects through the core **45** contacting a spring **46** at one end and the hook **41** at its other end.

In operation, closing of the switch **121** slides the hook **41** up over the horizontal push rod **45'**. Upon release of the actuating lever **6***a* the shaft **10** of the switch **121** is prevented from moving downward by the engagement of push rod **45'** with hook **41**. The spring **46** bearing on rod **45'** keeps this rod and hook **41** in positive engagement. The relay windings **16** and **16'** are connected in the same manner as discussed for Fig. 4. Therefore if after a period of time the engine does not start, current through the winding **16** will increase to a point where the magnetic push rod **45'** will be horizontally displaced against the action of the spring **46**, releasing hook **41** and opening switch **121**. Therefore in the above arrangement an automatic deenergization means is provided wherein the switch is mechanically locked and electrically opened when the current through the motor reaches a predetermined value.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of starting devices differing from the types described above.

While the invention has been illustrated and described as embodied in a starting apparatus for an internal combustion engine, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can

by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. Apparatus for starting an internal combustion engine comprising, in combination, an electric starter motor having a rotatable armature; flywheel means fixedly connected to said rotatable armature; coupling means for connecting said armature and said flywheel to the shaft of a combustion engine and for decoupling them therefrom, whenever required; a first field winding arranged in series with said armature; first actuating means for energizing said first field winding, whenever required; a second field winding arranged in parallel with said armature; and second actuating means for energizing said second field winding, whenever required, whereby for starting of the combustion engine said first field winding is energized by said first actuating means without coupling said armature to the engine shaft until said armature together with said flywheel attains a relatively high speed, storing substantial kinetic energy, whereupon said second field winding is energized by said second actuating means and said armature and flywheel are coupled to said engine shaft.

2. A starting motor for internal combustion engines which comprises in combination, a motor housing; a first and a second field winding mounted on the inner surface of said housing; a shaft rotatably mounted in said housing; an armature affixed to said shaft in operable association to said field windings; a flywheel fixedly mounted on said armature; an annular ring positioned adjacent the outer surface of said flywheel; resilient means for urging said annular ring against said flywheel, said resilient means being connected to both said annular ring and the shaft of said engine; and means for urging said annular ring away from said flywheel.

3. A starting motor for internal combustion engines which comprises, in combination, a motor housing; a first and a second field winding mounted on the inner surface of said housing; a shaft rotatably mounted in said housing; an armature affixed to said shaft in operable association to said field windings; a flywheel fixedly mounted on said armature; said flywheel having an outer conical surface; a clutch lining attached to the outer surface of said flywheel; a conically shaped annular ring arranged adjacent said brake lining; resilient means for urging said annular ring against said flywheel, said resilient means being connected to both said annular ring and shaft of said engine; and means for urging said annular ring away from said flywheel.

4. The method of starting internal combustion engines which comprises disengaging the shaft of said engine from the starting motor; energizing said starting motor in series operation until it acquires the desired kinetic energy; and coupling said starting motor to said engine shaft while simultaneously connecting said motor in compound operation until said engine starts.

5. The method of starting internal combustion engines which comprises disengaging the shaft of said engine from the starting motor; energizing said starting motor in series operation until it acquires the desired kinetic energy; coupling said starting motor to said engine shaft; and deenergizing said motor after a time period independent of the starting of said engine.

6. A method of starting internal combustion engines which comprises disengaging the shaft of said engine from the starting motor; energizing said starting motor in series operation until it acquires the desired kinetic energy; coupling said starting motor to said engine shaft; simultaneously connecting said motor in compound operation; and operating the starting motor as a generator after the engine starts.

7. Apparatus for starting an internal combustion engine comprising, in combination, a motor housing; a series field winding mounted on the inner surface of said housing; a shunt field winding also mounted on the inner surface of said housing; a shaft rotatably mounted in said housing; an armature affixed to said shunt in operable association to said field windings; a flywheel fixedly mounted on said armature; an annular ring arranged adjacent the outer surface of said flywheel; resilient means for urging said annular ring against said flywheel, said resilient means being connected to both said annular ring and the shaft of said engine; manually operable lever means for urging said annular ring away from said flywheel; means for energizing said field windings and thereby rotating said armature together with said flywheel, whenever required, whereby for starting of the combustion engine said lever means is operated to urge said annular ring away from said flywheel; and said first field winding is simultaneously energized to rotate said armature and said flywheel until they attain a relatively high speed, storing substantial kinetic energy, whereupon said lever means is operated to permit contact between said annular ring and said flywheel thus partly using the stored kinetic energy for rotation of the engine shaft and starting of the engine.

8. Apparatus for starting an internal combustion engine, comprising in combination, an electric starter motor having a rotatable armature, a series field winding and a shunt field winding; first actuating means for energizing said series field winding, whenever required; second actuating means for energizing said shunt field winding, whenever required; flywheel means fixedly connected to said rotatable armature; coupling means for connecting said armature and said flywheel to the shaft of a combustion engine and for decoupling them therefrom, whenever required, whereby for starting of the combustion engine said first actuating means energizes said series field winding to energize said motor as a series motor with said flywheel and said rotatable armature being decoupled from the engine shaft until said armature together with said flywheel attains a relatively high speed, storing substantial kinetic energy, whereupon said flywheel is rapidly coupled to said engine shaft and said second actuating means simultaneously energizes said shunt field winding to operate said motor as a compound motor thereby using the stored kinetic energy as well as the compound motor for rotation of the engine shaft; and means for automatically deenergizing said field windings of said motor after a time period independent of the starting of said engine.

9. The apparatus of claim 8 wherein said automatic deenergization means includes a relay for disconnecting said motor energizing means when the current through said motor reaches a predetermined value.

10. Apparatus of claim 8 wherein said automatic deenergization means includes a thermally controlled switch for disconnecting said motor energization means.

11. Apparatus of claim 8 wherein said automatic deenergization means includes a switch operated by a mechanical escapement mechanism for disconnecting said motor energization means after a predetermined time interval.

12. Apparatus of claim 8 wherein said automatic deenergization means includes a mechanically locked switch and a relay for unlocking said switch to disconnect said motor energization means when the current through said motor reaches a predetermined value.

13. Apparatus for starting an internal combustion engine, comprising, in combination, an electric starter motor having a rotatable armature, a series field winding and a shunt field winding; first actuating means for energizing said series field winding, whenever required; second actuating means for energizing said shunt field

winding, whenever required; flywheel means fixedly connected to said rotatable armature; coupling means for connecting said armature and said flywheel to the shaft of a combustion engine and for decoupling them therefrom, whenever required, whereby for starting of the combustion engine said first actuating means energizes said series field winding to energize said motor as a series motor with said flywheel and said rotatable armature being decoupled from the engine shaft until said armature together with said flywheel attains a relatively high speed, storing substantial kinetic energy, whereupon said flywheel is rapidly coupled to said engine shaft and said second actuating means simultaneously energizes said shunt field winding to operate said motor as a compound motor thereby using the stored kinetic energy as well as the compound motor for rotation of the engine shaft; and means for automatically deenergizing said

series field windings of said motor after said internal combustion engine starts.

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