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CYCLING AUTOMATIC ENGINE STARTER

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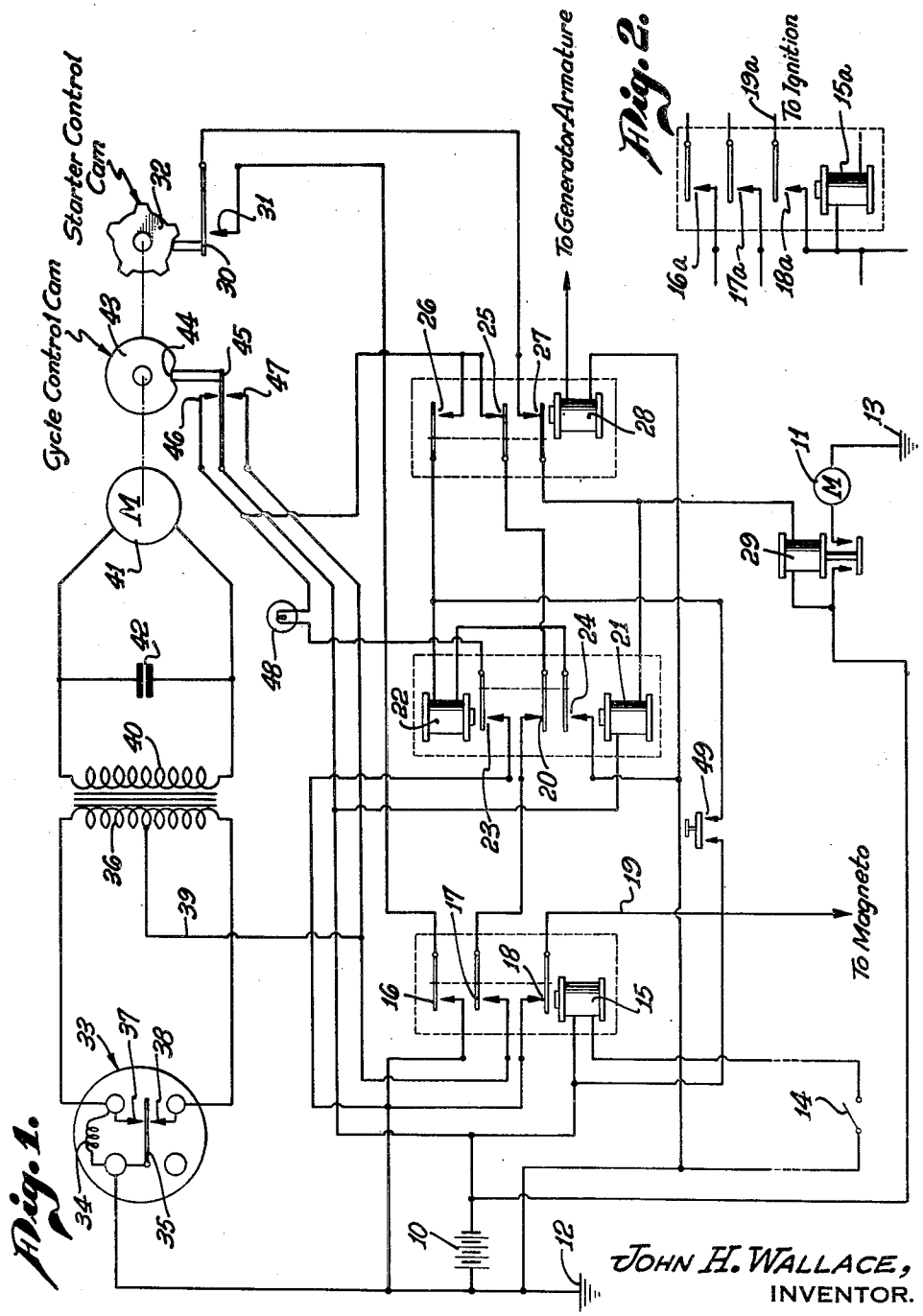


Fig. 1.

Fig. 2.

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CYCLING AUTOMATIC ENGINE STARTER

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16 Claims. (Cl. 290—38)

This invention relates to automatic starting mechanism for internal combustion engines.

An object of the invention is to provide an internal combustion engine which is equipped with a storage battery and a starter with a mechanism whereby upon the closing of a switch the starter will be periodically operated for a predetermined number of times, and should the engine fail to start during any of these periodic operations, further operation to the starter will be automatically discontinued.

It is well known that in operating the starter of an internal combustion engine by a storage battery that the starter should not be operated continually because of the fact that continuous operation of the starter results in a too rapid discharge of the battery. It is consequently desirable to operate the starter for a short period of time and in the event that the engine fails to start, to afford a period of rest between the starting operation and a succeeding operation of the starter. During such period of rest conditions such as flooding of the carburetor may correct themselves so that the engine may start during the subsequent operation. If, however, the engine fails to start after a number of successive attempts it is desirable to shut off the starter entirely so that the battery will not be completely run down.

Many engine installations that are apt to be remotely located such as those that drive electric generators at beacons, light houses, pumping stations and the like, are unattended and consequently provision for making a series of successive starting attempts and then automatically shutting down in the event that the engine fails to start is highly desirable.

Heretofore mechanisms have provided for operating the starter of the engine by its storage battery for a successive number of intervals. These mechanisms have employed thermostatically controlled switches which serve to open the starter circuit after the starter has operated a desired length of time to afford a period of rest prior to a subsequent starting operation. These thermostatically controlled switch mechanisms have proven generally unsuccessful, primarily due to the fact that there is such a wide variation of ambient temperatures at the locations of the various engine installations. Frequently they also prove objectionable because of the slow opening and closing of the thermostatically controlled switches, resulting in arcing across the contacts. There are also other objections to cycling systems which employ thermostatic switches.

Another object of the present invention is, therefore, to provide a mechanism for closing and opening the starter circuit which is so designed that ambient temperatures will have virtually no effect thereon, and which can be accurately timed to cause the starter to operate for the desired length of time and then rest for the desired length of time. To this end the system embodying the present invention contemplates taking direct current from the battery, converting it into alternating current of a predetermined frequency, utilizing the alternating current to drive a synchronous motor and utilizing the synchronous motor whose speed is thus governed by the frequency to operate cam operated switches or contacts which open and close the starter circuit. In this manner as the timing of the cam operated contact is governed or controlled by the synchronous motor, the speed of which is governed by the frequency, the entire timing of the system is independent of and uninfluenced by variations in the ambient temperatures. Furthermore the opening and closing of the cam operated contacts can be done quickly and positively to reduce, if not entirely eliminate, arcing across the contacts.

With the foregoing and other objects in view, which will be made manifest in the following detailed description and specifically pointed out in the appended claims, reference is had to the accompanying drawing for an illustrative embodiment of the invention, wherein:

Figure 1 is a wiring diagram schematically illustrating the automatic cycling system embodying the present invention.

Fig. 2 is a partial wiring diagram illustrating a portion of the apparatus embodying a modification that may be employed when battery ignition is utilized.

Referred to the accompanying drawing wherein similar reference characters designate similar parts throughout, it will be understood that the engine that is to be started and which is not illustrated, is equipped with a storage battery 10 that is utilized to drive the starter of the engine indicated at 11. The system illustrated may be regarded as being in the nature of a one wire system wherein one side of the battery 10 is grounded as at 12 and correspondingly one side of the starter is grounded as at 13. It will be understood, however, that instead of grounding the battery and starter, that a two wire system may be employed if found desirable. 14 indicates the primary or main switch of the system which may be remotely located with respect to the engine installation and which may be of any desired or preferred type, such as for example a sun valve or sun switch in the case of aeroplane beacons and light houses; a radio operated switch in the case of emergency landing fields or a manually operated switch in the case of pumping stations and the like. One side of switch 14 is connected to ground 12 and the other side is connected through the winding 15 to battery 10.

The relay has three pairs of contacts, 16, 17 and 18. Contacts 18 are normally closed whereas

contacts 16 and 17 are normally open. If the engine is equipped with a magneto, the ground wire 19 thereof is connected through the normally closed contacts 18 to ground 12. Closing of switch 14 energizes winding 15 and serves to open contacts 18 and to close contacts 16 and 17. Contacts 17 are in circuit with a pair of normally closed contacts 20 of a second relay which is of the latch type having two windings or coils 21 and 22. Coil 21 serves as a set coil and coil 22 as a trip coil. The second relay in addition to having contacts 20, is equipped with normally open contacts 23 and a second set of normally open contacts 24. When the set coil 21 is energized, contacts 20 will be opened and contacts 23 and 24 will be closed. They will be held closed by the latch until the trip coil 22 is energized, which serves to trip the relay and allow the contacts to return to their normal positions shown, wherein contacts 20 are closed and contacts 23 and 24 are open. Contacts 20 are in series with contacts 25 of a third relay, these contacts being normally closed. The third relay has additional contacts 26 and 27, contacts 26 being normally open and contacts 27 being normally closed. The winding or coil of this relay indicated at 28, when energized, serves to open contacts 25 and 27 and to close contacts 26. The engine may be assumed to drive an electric generator and coil 28, is interposed in the conductor leading from the generator to ground 12.

Contacts 27 are connected to the starter solenoid switch 29, one side of which is constantly connected to battery 10. This solenoid switch when energized or operated serves to connect battery 10 directly to starter 11. Contacts 27 are also in circuit with a cam operated contact 30 engageable with contact 31. The contacts 30 and 31 are normally open or disengaged, but may be caused to engage on rotation of the cam 32 illustrated as having five high points, although the number of high points may be varied. Contact 31 is connected to one of contacts 16, the other contact 16 being connected to ground 12 so that on rotation of cam 32 to close contacts 30 and 31, ground is conducted through contacts 16 if these are closed, through contacts 31, 30 and 27 to the solenoid switch 29 closing the switch and thus energizing starter 11.

As above explained it is desirable to be able to rotate cam 32 at a definite speed so that the speed of rotation of the cam will be uninfluenced by ambient temperature conditions. To this end a vibrator is provided generally indicated at 33, having a magnet 34 which is effective to operate an armature 35. One side of the armature and one side of the coil 34 are connected to ground 12. The other side of coil 34 is connected to one side of a primary winding 36 of a transformer. Contacts 37 and 38 are arranged on opposite sides of the armature 35 so as to be alternately engageable thereby through the vibration of the armature. These contacts are connected to opposite sides of the primary winding 36. A conductor 39 is connected to the primary winding 36 adjacent the center thereof and is connected to one of contacts 17. The secondary 40 of the transformer is connected to synchronous motor 41 and preferably a condenser 42 is connected across the secondary winding 40 for the purpose of improving the power factor of the secondary circuit. The synchronous motor drives a shaft on which cam 32 is mounted. Some speed reduction mechanism is generally employed so that the shaft that turns cam 32 rotates it but a fraction of the speed of rotation of the synchronous motor. On the shaft there is a second cam 43 which rotates with cam 32 and which has a single low point 44. The periphery of the cam 43 engages and operates a contact 45 interposed between contacts 46 and 47. These contacts are so adjusted as to close before opening. That is, in the position shown, contact 46 is in engagement with contact 45 while contact 47 is open. On rotation of cam 43 to move contact 45 into engagement with contact 47, contact 46 remains in engagement with contact 45 until the circuit 46—47 is closed. Thereafter contact 46 is open by disengaging contact 45.

Contact 46 is in circuit with an indicator light 48, which in turn is in series with one of contacts 23. The other of contacts 23 is connected to ground 12. Contact 46 is also connected to the normally closed contacts 25 and one of contacts 26. The other contact 26 is connected to the trip coil 22 and through it to one of contacts 24, and also to a reset button 49 which in turn is connected to battery 10 and to winding 15. Contact 45 is connected to battery 10 and also through winding 21 to the starter solenoid switch 29.

The operation of the above described apparatus is as follows. To start the engine, switch 14 is closed, thus closing the circuit through relay winding 15 and operating the first relay to open contacts 18 and thus open the ground wire circuit from the magneto and to close contacts 16 and 17. The closing of contacts 17 serves to supply battery through conductor 39 to the primary winding 36 of the transformer, this being accomplished by battery current flowing from battery to contact 45 through contact 46, thence to contacts 25, contacts 20, contacts 17 and through condenser 39. With battery thus supplied to the primary winding of the transformer, current may flow through the vibrator winding 34 to ground 12, energizing the vibrator winding 34 and attracting armature 35. When armature 35 engages contact 37, battery current is thus shorted through half of the primary winding. However, when armature 35 engages contact 37, the vibrator winding 34 is thus shunted, losing its effectiveness on the armature and thus allowing armature 35 to disengage contact 37. Its return movement causes it to momentarily engage contact 38 which serves to momentarily cause battery current to flow through the other half of the primary winding to ground 12. In this manner vibration of armature 35 causes battery current to alternately flow in opposite directions through the primary winding 36, inducing an alternating current in the secondary 40, frequency of which is determined by the rate of vibration of armature 35. I prefer to have the windings of armature so designed as to step up the voltage from 6 volts (the normal battery voltage) to 115 volts. A suitable frequency of the secondary circuit as governed by the rate of vibration of the armature 35 is 105 cycles. With alternating current of this character supplied to the synchronous motor 41, the shaft is rotated and rotates cams 43 and 32 simultaneously. Rotation of cam 43 causes contact 45 to engage contact 47 and to thereafter disengage contact 46. The opening of the circuit 45—46 prevents battery from being supplied to the primary 36 via the path previously described, and thereafter battery is supplied from contact 45 to contact 47, directly to conductor 39. As cam 32 rotates, its first high point engages con-

tact 30, causing it to engage contact 31 and thus supply ground through the closed contacts 16, contact 31, contact 30 and normally closed contacts 27 to the solenoid switch 29. As the opposite of the solenoid switch is permanently connected to the battery, the supplying of ground to the solenoid switch causes it to operate and thus supply battery directly to starter 11 which is operated as long as the first high point on cam 32 holds contacts 30—31 in engagement. If the engine fails to start during this period, the continued operation of synchronous motor 41 causes the cam 32 to rotate sufficiently to enable contacts 30 and 31 to disengage, thus cutting supply of ground to the solenoid switch 29 and opening the starter circuit for starter 11. After a period of rest between sucessive high points on cam 32, contact 30 and 31 re-engage and the starter circuit is again closed for a successive period of operation.

If the engine starts during any period when contacts 30 and 31 are in engagement, its generator is started which causes winding 28 to be energized. This opens contacts 25 and 27 and closes contact 26, so that although the synchronous motor 41 continues to operate until cam 43 has made one complete revolution and contacts 45, 46 and 47 have returned to the initial position shown, then the apparatus will not thereafter recycle as long as the engine is running despite the fact that switch 14 may remain closed. When contact 45 disengages contact 47, contacts 25 being open due to the operation of the generator, battery current is no longer supplied to the primary winding 36 and consequently the vibrator 33 is no longer operated and the motor 41 is allowed to stop.

If the synchronous motor has caused cam 32 to make one complete revolution without the engine having started, it is desirable to then automatically shut down operation of the entire apparatus so that there will not be a recycling thereof for an indefinite period which would ultimately exhaust battery 10. Consequently if the engine is not started it will be noted that on the supplying of ground to the solenoid switch 29, that ground is also supplied to the set coil 21 of the second relay. The other side of this set coil is connected to battery and the set coil being thus energized, contacts 20 are opened thereby. Simultaneously contacts 23 and 24 are closed. With contacts 20 open and remaining open, the circuit from contacts 17 to 25 is thus broken. Consequently after cam 43 has completed its first revolution, battery cannot be supplied from contact 45—46 through contact 25, 20 and 17 to the primary winding, to start a recycling of the apparatus even though switch 14 may remain closed. In this manner after five consecutive operations of starter 11 occasioned by one complete revolution of the five pointed cam 32, the apparatus automatically shuts down and will not recycle until manually adjusted by an attendant. In this condition of the apparatus, it will be noted that battery can then be supplied from contact 45 to contact 46 to the indicator light 48, whose circuit is closed by the closing of contacts 23. The continued burning of this indicator light indicates that the apparatus has once completely cycled, but that a starting of the engine has not been accomplished. In order to reset the apparatus for a recycling, the push button or switch 49 must be closed. This supplies battery to the trip coil 22 which is connected to contact 25, which at this time will have been closed by the energizing of the set coil 21. These contacts as will be noted are connected to ground 12. The energizing of the set coil serves to open contacts 23 and 24 and to again close contacts 20. When the apparatus is thus restored to its initial condition, a recycling is permitted upon the closing of switch 14, or as may be assumed this switch may have remained closed.

In the above described manner it will be appreciated that the improved apparatus permits of a predetermined number of periodic operations of the starter 11. If the engine fails to start after such number of periodic operations, the apparatus is automatically shut down to preserve the battery. If the engine starts the synchronous motor continues to operate until cam 43 returns to its initial position and is then stopped. If the apparatus has gone through one complete cycle of operations and the engine has not started, a reset of the entire apparatus is accomplished by closing the switch 49. Inasmuch as the invention contemplates the converting of battery current into alternating current of a predetermined frequency in a manner that is unaffected by ambient temperatures. The speed of rotation of the synchronous motor 41 and consequently the speed of rotation of the cams 32 and 43 may be accurately controlled. As the contacts operated by the cam are positively actuated, arcing across the contacts is greatly reduced, if not entirely eliminated.

Fig. 2 illustrates a slight modification where battery ignition is used instead of magneto ignition. In this illustration the first relay has its winding 15*a* control three sets of contacts 16*a*, 17*a* and 18*a*. Contacts 18*a* instead of being connected to the ground wire of the magneto are normally open and are connected to battery and to the engine ignition wire 19*a* respectively. Thus in this type of construction closing of switch 14, instead of opening the magneto ground wire, serves to close the circuit from the battery to the ignition system.

It will be understood that in the above described construction that only the essentials to the apparatus that are required to accomplish the desired purpose have been disclosed. In addition to these essentials various other protective devices may also be added such as for example, an automatic choke, an oil cut out that will stop operation of the engine in the event that the oil in the crank case runs low, a water cut out which will also stop operation of the engine in the event that the cooling water runs low or becomes of excessively high temperature. Various other protective devices may also be included and incorporated. These have not been illustrated herein as they are conventional and are auxiliary accessories to the system embodying the present invention.

While the mechanism herein shown for converting the direct current into alternating current is illustrated as comprising a vibrator and a transformer, it will be understood that any other mechanism for converting direct current into alternating current may be employed if it is uninfluenced by variations in ambient temperatures.

Various changes may be made in the details of construction without departing from the spirit or scope of the invention as defined by the appended claims.

I claim:

1. In combination with an internal combustion engine having a battery operated starter, a synchronous motor, means connected to the battery

for converting direct current received from the battery into alternating current supplied to the motor, and means operable by the motor for closing the starter circuit.

2. In combination with an internal combustion engine having a battery operated starter, a synchronous motor, means connected to the battery for converting direct current received from the battery into alternating current supplied to the motor, and means operable by the motor for closing and opening the starter circuit for successive periods of time.

3. In combination with an internal combustion engine having a battery operated starter, a synchronous motor, means connected to the battery for converting direct current received from the battery into alternating current supplied to the motor, and means operable by the motor for closing and opening the starter circuit for successive periods of time and finally leaving the starter circuit open.

4. In combination with an internal combustion engine having a battery operated starter, a synchronous motor, means connected to the battery for converting direct current received from the battery into alternating current supplied to the motor, means operable by the motor for periodically opening and closing the starter circuit and finally leaving the starter circuit open, and means operable by the starting of the engine for discontinuing further operations of the starter, but allowing the mentioned means to restore to initial condition.

5. In combination with an internal combustion engine having a battery operated starter, a synchronous motor, means connected to the battery for converting direct current received from the battery into alternating current supplied to the motor, means operable by the motor for periodically opening and closing the starter circuit and finally leaving the starter circuit open, and means operable by the starting of the engine for discontinuing further operations of the starter, but allowing the mentioned means to restore to initial condition and means for restoring the mentioned means to initial condition after the starter has been successively operated and the starter circuit left in open condition.

6. In combination with an internal combustion engine having a battery operated starting mechanism, an alternating current motor, means for supplying alternating current thereto from the battery, and means operable by the motor for closing the circuit of the starting mechanism.

7. In combination with an internal combustion engine having a battery operated starting mechanism, an alternating current motor, means for supplying alternating current thereto from the battery, and means operable by the motor for periodically closing and opening the circuit of the starting mechanism.

8. In combination with an internal combustion engine having a battery operated starting mechanism, an alternating current motor, means for supplying alternating current thereto from the battery, and means operable by the motor for periodically closing and opening the circuit of the starting mechanism and finally allowing the starting mechanism circuit to remain open in the event that the engine has not started.

9. In combination with an internal combustion engine having a battery operated starting mechanism, an alternating current motor, means for supplying alternating current thereto from the battery, means operable by the motor for periodically closing and opening the circuit of the starting mechanism and finally allowing the starting mechanism circuit to remain open in the event that the engine has not started, and means operable by the starting of the engine for discontinuing further operations of the starter but allowing the mentioned means to restore to initial position.

10. In combination with an internal combustion engine having a battery operated starting mechanism, a synchronous motor, means for supplying alternating current thereto from the battery, and means operable by the motor for closing the circuit of the starting mechanism.

11. In combination with an internal combustion engine having a battery operated starting mechanism, a synchronous motor, means for supplying alternating current thereto from the battery, and means operable by the motor for periodically closing and opening the circuit of the starting mechanism and finally allowing the starting mechanism circuit to remain open in the event that the engine has not started.

12. In combination with an internal combustion engine having a battery operated starting mechanism, a synchronous motor, means for supplying alternating current thereto from the battery, means operable by the motor for periodically closing and opening the circuit of the starting mechanism and finally allowing the starting mechanism circuit to remain open in the event that the engine has not started, and means operated by the starting of the engine for discontinuing further operations of the starting mechanism and allowing the mentioned means to restore to initial position.

13. In combination with an internal combustion engine having a starting mechanism, means including an electric circuit controlling operation of the starting mechanism, a battery for energizing said circuit, an alternating current motor, means for supplying alternating current thereto from the battery, and means operable by the motor for closing said circuit.

14. In combination with an internal combustion engine having a starting mechanism, means including an electric circuit controlling operation of the starting mechanism, a battery for energizing said circuit, an alternating current motor, means for supplying alternating current thereto from the battery, and means operable by the motor for periodically closing and opening said circuit.

15. In combination with an internal combustion engine having a starting mechanism, means including an electric circuit controlling operation of the starting mechanism, a battery for energizing said circuit, an alternating current motor, means for supplying alternating current thereto from the battery, means operable by the motor for periodically closing and opening said circuit and finally allowing said circuit to remain open in the event that the engine has not started.

16. In combination with an internal combustion engine having a starting mechanism, means including an electric circuit for controlling operation of the starting mechanism, a battery for energizing said circuit, a synchronous motor, means for supplying alternating current to the synchronous motor from the battery, and means operable by the motor for periodically closing and opening said circuit.

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