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AUTOMATIC STARTING DEVICE FOR INTERNAL COMBUSTION ENGINES

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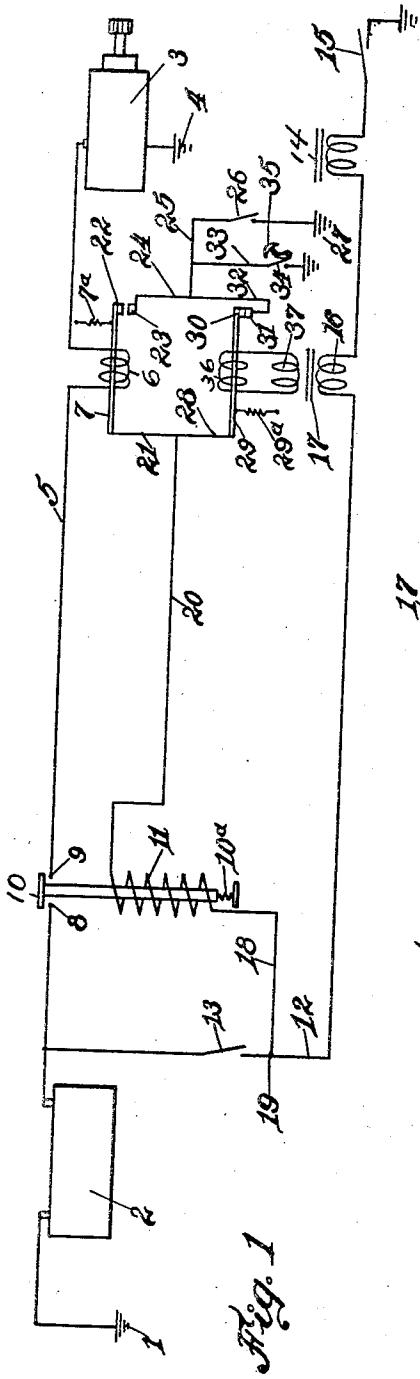


Fig. 1

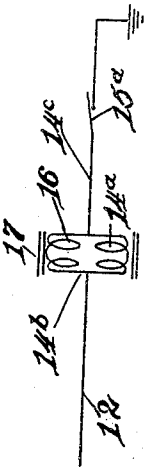


Fig. 2

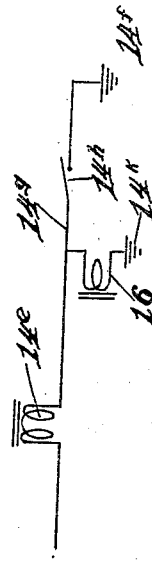


Fig. 3

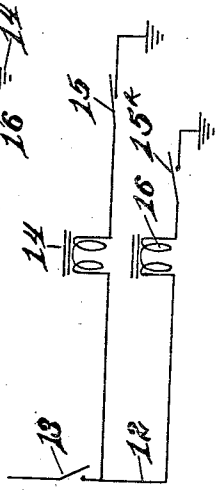


Fig. 4

Inventor
Leonard J. Cuthbertson

By Shepherd Campbell

Attorneys

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AUTOMATIC STARTING DEVICE FOR INTERNAL COMBUSTION ENGINES

Leonard J. Cuthbertson, Girard, Kans.

Application September 7, 1938, Serial No. 228,838

3 Claims. (Cl. 290—38)

The object of this invention is to provide an automatic starting system for internal combustion engines, embodying simple and inexpensive electrical connections and devices, so arranged that when the ignition switch of the engine is closed, the mechanism will function first to connect the battery to the starting motor to crank the engine, disconnect the starting motor from the battery just as soon as the engine becomes self-operative, regardless of the engine speed, and recrank the engine at any time that it stalls or stops, without any annoying and dangerous time lag between the time of stalling or stopping and the time that the engine will again be cranked.

A further and important object of the invention is to introduce an automatically controlled and wholly electrical delay means in the system, which means is engine controlled and in turn controls the time at which the starting motor may again be brought into operative relation to the engine. This is accomplished by so designing a transformer, the primary of which is energized under control of engine rotation, that sufficient self-inductance will be set up in the secondary of said transformer to introduce just the relatively short but highly necessary time lag to insure that the engine will have come to rest before the starting motor reengages with the engine.

By this simple and very economical expedient, I am able to secure absolutely reliable operation and to avoid the use of bellows, vibrators, etc., heretofore resorted to in an effort to secure this result in a reliable way. The manner of securing this result will be more particularly described in the following description. This application is a continuation in part of my copending application Serial No. 177,153, filed November 29, 1937.

Further objects and advantages of the invention will be set forth in the detailed description which follows.

In the accompanying drawing:

Figure 1 is a diagrammatic view;

Figs. 2 and 3 are views illustrating modified ways of connecting the primary winding of the transformer into the ignition circuit, and

Fig. 4 is a view illustrating a means of connecting the primary winding of the transformer to any circuit capable of producing a pulsating current flow through the transformer primary.

Like numerals designate corresponding parts throughout the several figures of the drawing.

In the drawing, 1 designates the ground connection of the conventional storage battery 2 of an automobile engine. The starting motor 3, of the conventional well-known type which is automatically disconnected from the fly wheel of the automobile engine when said engine reaches a pre-determined speed, is grounded upon one side at 4.

The other side of this motor is connected to the storage battery by a conductor 5, which includes within its length the coil 6 of a relay, the armature of which is indicated at 7. Contacts 8 and 9, disposed in the connection between the starting motor and the battery, are adapted to be bridged by a relay armature 10 when current flows in a coil 11 and attracts said armature.

A second circuit is formed by a conductor 12, which has the main ignition switch 13 included in its length. This conductor 12 leads from the conductor 5 and to the ignition devices of the engine, the spark coil being indicated at 14 and the distributor breaker points being indicated at 15. The conductor 12 includes in its length the primary coil 16 of a specially designed transformer 17, hereinafter described.

The coil 11 is connected by a conductor 18 with the conductor 12 at a point 19, and current passes from the coil 11 through a conductor 20. At this point, the third circuit, constituted by the conductor 18 and associated parts, is split into two branches, one of which includes the relay armature 7 in its length, said armature being connected to the conductor 20 by a conductor 21.

The armature 7 controls the two contact points 22 and 23. These contacts are normally separated or open, being held so by a spring 7a. The contact 23 is connected, through conductors 24, 25 and manually controlled switch 26, with a ground 27. The other branch circuit from the wire or conductor 20 includes a conductor 28, relay armature 29, constituting a control circuit relay, contact points 30 and 31, conductors 32 and 25 and switch 26 to ground 27.

I may, if desired, employ a shunt circuit including a conductor 33 and a clutch-pedal actuated switch 34. I have indicated the switch 34 as being so disposed with relation to the automobile clutch pedal 35 that when this pedal is moved to clutch releasing position, the switch will be closed. When the circuits are controlled by the clutch pedal, the switch 26 will be open, and will have no function, and conversely, when the switch 26 is employed and closed, the clutch controlled switch will be shunted by switch 26, and the operation of the clutch controlled switch will have no effect on the circuits.

The armature 29 of the control circuit relay

is moved under the influence of the winding 36 of the magnet of said relay, this winding being in series with the secondary winding 37 of the transformer 17. The contacts 30 and 31 are normally closed, by a spring 29a, and they are opened by the movement of the armature 29 when current flows in the winding 36.

The operation of the device is as follows: When ignition switch 13 is closed, current flows from storage battery 2 through 12 and coil 16 of transformer 17, to the ignition devices of the engine, such as the coil 14 and distributor 15. Current will also flow through wire or conductor 18, coil 11, wire 20, wire 28, contacts 30 and 31 of relay 29, which are normally closed, wire 32, wire 25, switch 26, which is closed (as will be explained), to 27.

When current flows through coil 11, relay 10 is energized and closed, connecting battery 2, relay head 10, conductor 5, coil 6 of relay 7, to starting motor 3 and to ground 4. This starts the starting motor 3 to rotating, which in turn starts cranking the engine. This increased load causes an increased current to flow in relay coil 6, which causes relay 7 to close contacts 22 and 23, which are normally open, under the action of spring 7a.

Current now flows through storage battery 2, switch 13, wire 18, coil 11, wire 20, wire 21, relay contacts 22 and 23, wire 24, wire 25, switch 26, to ground 27. This means that after leaving wire 20, current flows through both sets of contacts 22 and 23 and 30 and 31.

When starting motor 3 starts the engine to rotating, alternating pulsations set up in primary coil 16 of transformer 17, due to the ignition mechanism, induces an alternating current in coil 37, which energizes coil 36 of relay 29. This opens contacts 30 and 31, which are held open against the action of spring 29a as long as the ignition mechanism operates.

Current now flows from wire 20, wire 21 and contacts 22 and 23, wire 24, wire 25, to switch 26 and ground 27. When engine becomes self-operative, the decrease in starting motor current from storage battery 2, through relay 10, wire 5, coil 6 and starting motor 3, is such that relay contacts 22 and 23 open. This interrupts the current from the battery 2, through coil 11, which deenergizes relay 10, opening the starting motor circuit at contacts 8 and 9, stopping the starting motor 3.

Should the ignition mechanism become inoperative at any time, as by the stalling of the engine, relay 29 is no longer energized by transformer 17, and hence relay points 30 and 31 close to normal state, and this again starts the cranking operation.

The transformer 17 is so designed that during the time that the engine is in operation, such self-inductance will be built up in the secondary winding 37 of said transformer that when the engine ceases to operate, there will be enough residual electro-motive force in said secondary winding to introduce just the necessary time lag to permit the engine to actually come to rest before the starter will again be connected to the engine.

One of the most important requisites in a device of this sort is to provide a construction and control that will not connect the starting motor to the engine until both the starting motor and the engine have become stationary. This condition is absolutely necessary for obvious reasons. Since the starting motor and the engine are the two elements around which all operations must revolve, it is clear that these two elements should control all operations, and not some other extraneous control member.

No device of the prior art of which I have knowledge so adjusts the electrical connections that they themselves, without the use of extraneous mechanical devices, automatically prevent the actuation of the starter until the engine has stopped rotating, but which at the same time insure that such action of the starter may begin at the very earliest moment that it is safe for it to do so. To obtain this result, my transformer is so designed that the current induced in the secondary and connected to the relay is such that all of the energy is not immediately dissipated in the relay but holds the relay open for a given length of time, depending upon the circuit constants.

This time period is constant for all operating conditions, regardless of engine speed; that is, the inductive voltage built up in the secondary of the transformer has a certain value for a certain time after the last time the breaker points in the primary circuit function by rotation of the engine. This gives a time delay that is reliable under all conditions, because it is controlled directly by the engine rotation, and thus starts the cranking operation at the first instant that the engine is ready to be cranked. By using this inductive voltage designedly built up in the secondary, I am able to avoid added artificial time delay devices, such as bellows, vibrators, etc., sometimes employed for this purpose.

The steps necessary to get any desired time lag are well known to the electrical engineer. However, in securing the desired result, calculations may be based on the following formulas, where:

E—the induced average E. M. F. in volts;

I—change in current in amperes during the time T in seconds;

T—time in seconds;

H—inductance of the circuit in henrys;

U—absolute permeability of the material of the magnetic circuit in perms per inch cube;

L—length of the magnetic circuit;

A—cross-sectional area of the core in square inches;

N—number of turns in the coil;

$$T=\frac{H\times I}{E} \text{ and } H=\frac{N^2\times U\times A}{100{,}000{,}000\times L}$$

The first formula shows that the larger the current and inductance and the lower the voltage, the longer the time T. Hence to keep the power used low, both E and I are kept small. For experimental work on this device E was worked at 6 volts and I at 0.5 ampere. In the second formula, a large number of turns, a high value for the absolute permeability of the magnetic circuit, a large core cross-section, and a short coil length, would tend to give a larger self-inductance.

Now, the voltage induced by this transformer will vary with the speed of the engine, or that is, the voltage induced in the secondary will be controlled by the rate at which the breaker points interrupt the current flow through the primary of the transformer. (Since it is the minimum idling speed or below that determines this operation of the relay, the transformer was designed to produce 6 volts in the secondary, and thereby control the relay and produce the required time delay on one operation of the breaker points.

While at higher engine speeds, the voltage will be about twice this value and this does not interfere with operations.

In experimenting with the variables that would produce the required inductance or time delay, little difference in results could be seen, other than that it appeared that the cross-section of the core from an economical standpoint made the greatest change in inductance. Hence it appears that the time element would hinge around the core. No reason is seen why it would be necessary to change this time delay after the transformer was designed for a particular make of car. However, an air gap introduced into the core will vary the time element.

The relay operated by this transformer is designed to operate at a voltage slightly less than idling speed voltage, i. e., about 4 volts. The main reason for this is to take advantage of the E. M. F. of self-inductance as long as possible and secure a more economical design of the transformer. One transformer which I have found to be satisfactory has 50 turns on the primary and 450 turns on the secondary. The core outside dimensions are 3" x 3" and the cross-section ½".

The specific construction of the transformer is not of the essence of the invention. Any transformer which will produce the desired result will serve. The foregoing discussion of transformer construction is included to insure that a full disclosure of operative means is made in this application. However, I consider that the capability of the relay to operate on only one operation of the breaker points is an important one.

The desired results may be secured with either parallel or series connection of the transformer and the ignition coil. Further, the invention contemplates the setting up of an intermittent current in the primary of the transformer through any desired means as long as such means are engine-controlled. In other words, it is not essential that the spark coil 14 be included in the connection between the transformer and the vibrator 15.

Switch 34 is operated by the clutch pedal as stated, so that when the clutch is disengaged, the switch 34 is closed. If the use of switch 34 is desired, switch 26 is opened, which permits switch 34 to control the circuit instead of switch 26. If switch 26 is closed, the operation of switch 34 will have no effect upon the circuit.

I am aware of the fact that devices have heretofore been proposed for effecting the automatic recranking or restarting of an automobile engine if the same should stall. However, all devices of this sort with which I am familiar have had seriously objectionable features. It is apparent that any undue delay in effecting the recranking of the engine may have serious and even fatal results.

If, for example, the driver of an automobile should, in attempting to avoid an accident, stall his automobile in a position of danger, such as upon a railroad crossing, any delay in effecting the recranking of the engine might easily cause his death. Some of the devices heretofore proposed for effecting the automatic recranking of automobile engines have been actually installed at great expense and have then been discarded at a considerable loss, due to the objectionable features which developed in use.

Under my proposed arrangement, these objectionable features are avoided. When the starting switch initiates the cranking operation, the operation of the breaker points of the ignition mechanism causes pulsations of current through the primary of the transformer, energizing the alternating current coil of the relay and then holding open the contacts 30 and 31 as long as the engine is rotating, regardless of the engine speed and regardless of whether the engine is being cranked or is self-operating. Should the engine stall, the relay will again start the cranking operation, at the first moment that the engine is ready for cranking.

This is possible due to the fact that the starting relay opens the second the gear of the starting motor leaves the fly wheel and hence prevents the starting motor from developing any greater speed than that when cranking the engine. Hence, the starting motor comes to a stop immediately without aid from any device or circuit and can make this stop before the engine stops rotating and can control the relay to operate and again crank the engine in case of a stall.

Thus, it will be seen that the starting motor does not have an opportunity to pick up a high speed of rotation. The excessive time lag or delay in some of the systems heretofore proposed has been occasiond by the fact that it has been necessary to wait for the starting motor either to cease spinning or else materially slow down. Under my method, the starting motor comes to a stop immediately and without aid from any other device or circuit, and it can make this stop before the engine stops rotating. Thus it is in readiness to crank the engine immediately in case of a stall.

This improved starting system can be controlled by the main ignition switch only if switch 26 be closed or by both the ignition switch and the clutch pedal switch 34 if the switch 26 be left open. When the clutch controlled switch is used, the engine will not start upon the accidental turning on of the ignition switch. Since clutch operation is required for all movements of the automobile, a clutch controlled switch provides the advantage of manual operation and still places this starter system in the automatic class, since no further operation is required to start the engine as long as the ignition is turned on.

In Figs. 2 and 3, I have illustrated modified methods of connecting the transformer coil 16 into the ignition system. In Fig. 2, the coil 16 is in opposition to the coil 14*a* of the ignition coil and in a loop, to one side of which loop the conductor 12 is attached at 14^b and to the other side of which loop a conductor 14^c is attached, this latter conductor leading to the breaker points 15^a of the distributor.

In Fig. 3, the winding 14^e of the ignition coil is connected to the ground 14^f by a conductor 14^g, that is in series with the breaker points 14^h. In this case, the winding 16 is in a shunt circuit leading from the conductor 14^g to a ground 14^k and at a point between the ignition coil and the breaker points.

In Fig. 4, I have illustrated an arrangement wherein, instead of relying upon the breaker points 15 of the distributor to set up a pulsating current in the primary winding of the transformer, I have disposed this primary winding 16 in a separate circuit and have included in that circuit a separate means 15^k for setting up a pulsating current in the coil 16.

This could be any make and break device driven from any rotating part of the engine, such as the pump shaft, crank shaft, cam shaft, fan shaft, or otherwise. It is clear that as far as the result

is concerned, it makes no difference whether the circuit interrupting means be the conventional breaker points of the distributor or some other equivalent mechanism which would cease to function when the engine stopped. It is therefore to be understood that the element 15[k] is, in function, like the conventional element 15 of Fig. 1.

It is to be understood that the invention is not limited to the precise arrangements shown, but that it includes within its purview whatever changes fairly come within either the terms or the spirit of the appended claims.

Having described my invention, what I claim is:

1. The combination with an internal combustion engine having an electric motor-operated starter, of a battery, a pulsating current producing medium operated from and in unison with the engine, a circuit which receives said pulsating current, a starting motor circuit leading from the battery to the starting motor, a magnetically controlled switch for closing the starting motor circuit, a control circuit including an energizing coil for the said magnetically controlled switch of the starting circuit, a transformer, the primary winding of which is included in the circuit which receives the pulsating current, a secondary coil for the transformer, a control circuit relay coil energized from the secondary of the transformer, a starting circuit relay comprising a winding that is included in the starting motor circuit, means for connecting the armatures of both the starting motor circuit relay and the control circuit relay with the energizing coil of the magnetically controlled switch of the starting motor circuit, a pair of normally open contact points controlled by the starting circuit relay, a pair of normally closed contact points controlled by the control circuit relay, and means for completing the circuit from one each of the contacts of a pair back to the battery, the said transformer being so designed that the interruption of the primary current by any engine rotation will cause the secondary winding to have induced a voltage of self-induction sufficient to hold open and delay the closing of the control circuit relay and consequently to delay the starting of the starter until the engine has come wholly to rest.

2. The combination with an engine and an electrically controlled starter for the same, of an electric circuit including the primary winding of a transformer, an interrupter, engine-driven and included in said circuit and functioning to set up an intermittent current in said circuit as long as the engine is in normal operation, a second circuit in which is included the secondary winding of said transformer and electrical connections between the second circuit and the starter, through which the supply of current to the starter is controlled, said transformer being so designed that during any engine rotation, sufficient voltage of self-inductance is created in its secondary winding as to introduce enough delay in the functioning of the electrical elements which control the starter as to prevent the starter from being set in operation until the engine has come to rest.

3. The combination with an internal combustion engine having a starter and a motor for said starter, of a battery, a first circuit leading from the battery to the starting motor, an electrically operated switch for closing said first circuit, electrical means for moving said switch, a second circuit in which said electrical means is included, contact means included in said second circuit for maintaining a normally open gap in said second circuit, means for controlling said contact means to close said gap under the influence of the increased current in the first-named circuit, present when the starting motor is operating under load, and to open said gap instantly when the load upon the starting motor is relieved by the starting of the engine, a third circuit connected to the electrical means which operates the said switch and including a movable control member, a transformer and electrical means to which current is supplied from the secondary of said transformer for moving said movable member of the third circuit, a circuit including the primary winding of said transformer, engine-driven means in the last-named circuit for creating an intermittent electric current in said circuit, said transformer being so designed that under any engine rotation, sufficient voltage of self inductance is built up in said secondary as to insure that the engine will have come to rest before said movable member of the third circuit is moved under the influence of the transformer.

LEONARD J. CUTHBERTSON.