

Aug. 1, 1933.

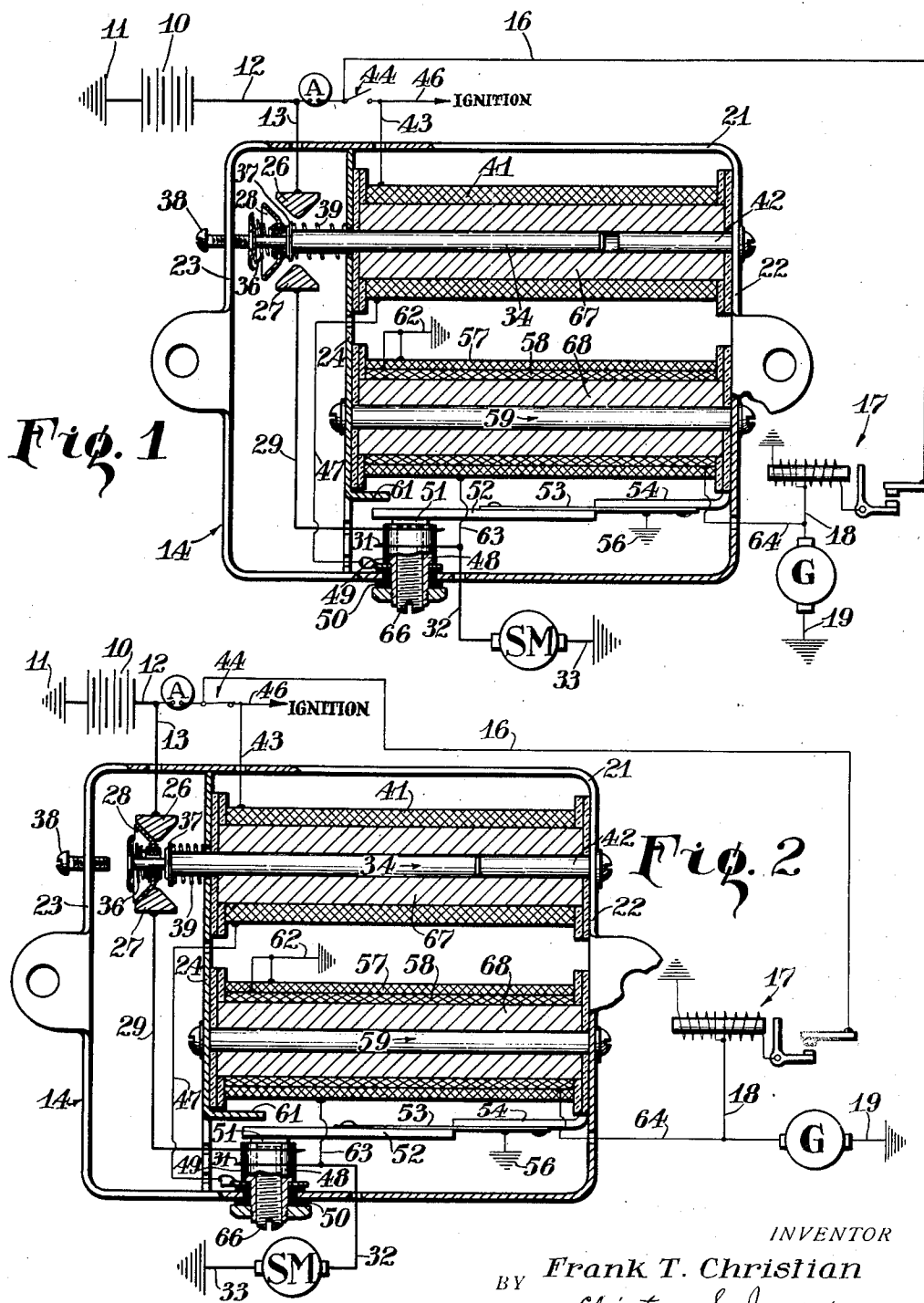
F. T. CHRISTIAN

1,920,782

AUTOMATIC STARTING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 19, 1930

2 Sheets-Sheet 1



Aug. 1, 1933.

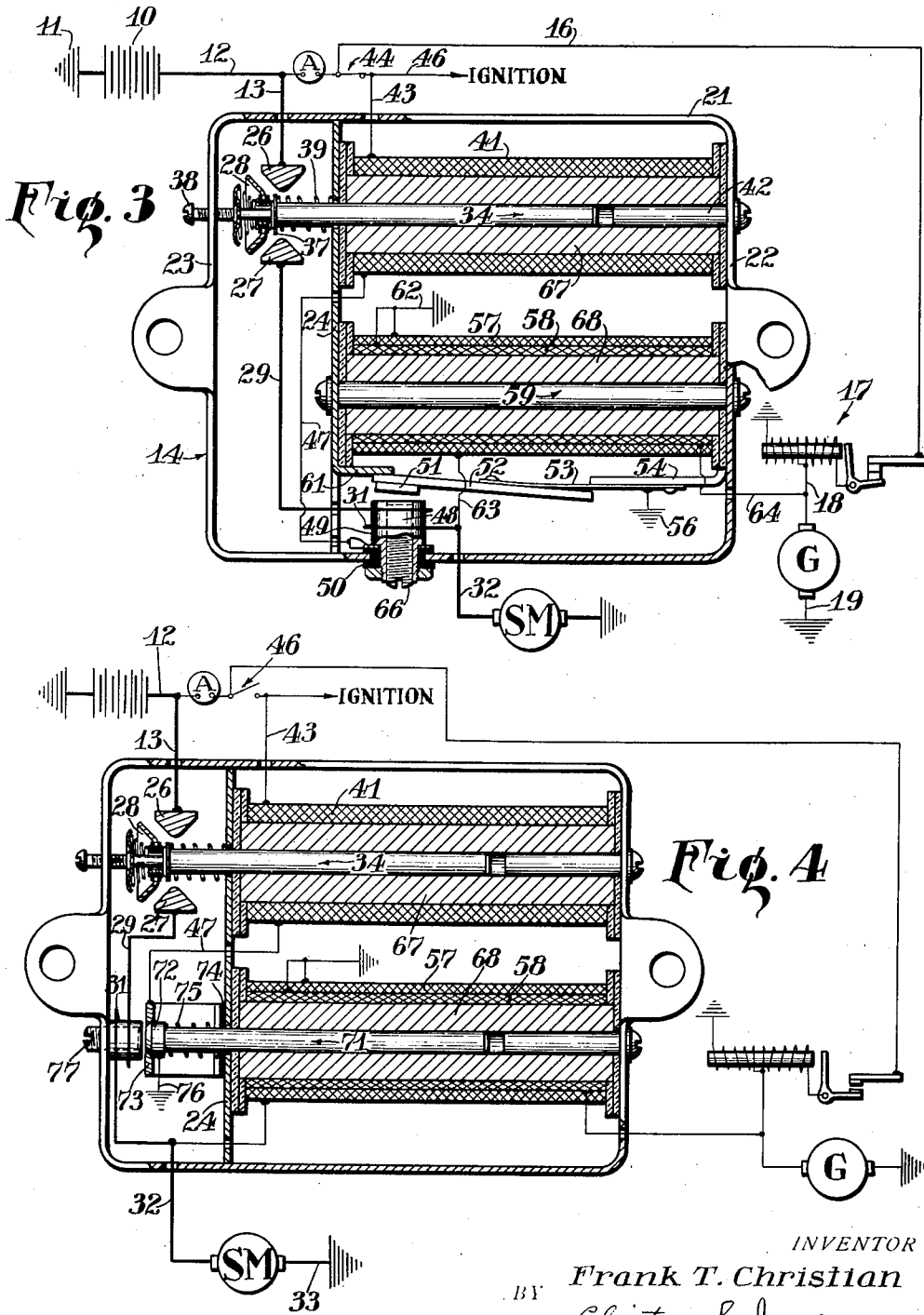
F. T. CHRISTIAN

1,920,782

AUTOMATIC STARTING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 19, 1930

2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

1,920,782

AUTOMATIC STARTING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Frank T. Christian, Elmira, N. Y., assignor to
Eclipse Machine Company, Elmira, N. Y., a
Corporation of New York

Application December 19, 1930. Serial No. 503,432

1 Claim. (Cl. 290—38)

This invention relates to automatic starting systems for internal combustion engines and more particularly to an automatic time delay for such systems for delaying the action of the starter for a predetermined time after the engine has come substantially to rest.

When an internal combustion engine stops, particularly if the engine be limber and comprise a comparatively small number of cylinders, the flywheel will usually rock back and forth once or twice before coming to rest. In starting systems which are adapted to automatically come into action when the engine stalls for any reason, it is desirable that the start be delayed until the engine is completely stationary, since otherwise the starting engagement may take place during a back rock of the engine flywheel, thus causing undesirable stresses to be imposed on the starting mechanism.

Another function of the time delay is to prevent the operation of the starting mechanism until the starting motor comes substantially to rest after a previous start, even though the engine should make a false start sufficient to disconnect the starting drive and then immediately stop before the generator has time to build up and control the automatic starting mechanism. This is desirable in order to secure a sufficient acceleration of the motor shaft on the next start to insure the automatic meshing of the starting gear.

It is an object of the present invention to provide an automatic starting system for internal combustion engines embodying a novel and improved time delay which is efficient and reliable in its action and which is substantially unaffected by external physical conditions.

Another object is to provide such a device which is not liable to get out of order or lose its adjustment during long periods of use.

A further object is to provide such a device in which the operation of the time delay is dependent on the electrical constants of the component parts of the automatic starting switch whereby no moving parts are added, and the device is adapted to operate uniformly over long periods of time without being subject to wear or deterioration.

Further objects and advantages will be apparent to those skilled in this art from the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a schematic showing of a preferred form of an automatic starting mechanism embodying the present invention, illustrated in con-

junction with a conventional electrical system for internal combustion engines, the automatic starting mechanism being shown substantially in medial section;

Fig. 2 is a similar view of the device showing the position of the parts of the automatic starting mechanism during the starting operation;

Fig. 3 is a similar view showing the position of the parts of the automatic starting mechanism while the engine is running under its own power;

Fig. 4 is a view similar to Fig. 1 showing a modified form of control relay for the automatic starting mechanism.

In Fig. 1 there is illustrated an electrical starting system for an internal combustion engine, not shown, including a battery 10 one terminal of which is grounded as indicated at 11 and the other terminal of which is connected through leads 12 and 13 to an automatic starting device indicated generally by numeral 14. The battery 10 is also connected through ammeter A, lead 16, automatic cut-out 17 and lead 18 to one terminal of generator G, the other terminal of which is grounded as indicated at 19. It will be understood that the generator G is adapted to be mechanically connected in any suitable way to the engine whereby when the engine is running the generator serves to charge the battery 10 in the usual manner.

The automatic starting mechanism 14 is preferably mounted in a casing such as indicated at 21 comprising end portions 22 and 23 and partition member 24. Said mechanism comprises means for energizing and deenergizing the starting motor in the form of an electromagnetic starting switch having fixed contacts 26 and 27 and a bridging contact member 28 suitably formed to cooperate therewith. Contact 26 is connected to the battery 10 through leads 13 and 12, and contact 27 is connected to a starting motor SM through lead 29, single turn coil 31, and lead 32, the opposite end of the starting motor being grounded as indicated at 33.

The starting switch member 28 is mounted on a slidable plunger 34 of suitable magnetic material with provision for yielding longitudinal movement thereon in one direction against the pressure of a spring 36 which normally retains said switch member against an abutment 37 on said plunger. The plunger is normally retained in the position shown in Fig. 1 with the end thereof against an adjustable stop 38 and the switch member 28 out of contact with the fixed switch members 26 and 27, by a spring 39 located on the plunger 34 and compressed between said

abutment 37 on the plunger and the partition member 24 of casing 21.

A magnetic operating means for the starting switch in the form of a solenoid coil 41 is fixedly mounted within casing 21 surrounding the plunger 34 and arranged when energized to draw said plunger downward into contact with a magnetic pole piece 42 rigidly mounted on the end member 22 of the casing, such movement of the plunger being arranged to bring the switch member 28 into contact with switch members 26 and 27 as indicated in Fig. 2. One terminal of solenoid 41 is connected by means of a lead 43 to a manually operated switch 44 which is connected to the battery 10 through ammeter A and lead 12. The switch 44 preferably serves as the ignition switch of the engine, in which case a lead 46 extending from said switch is connected to the ignition mechanism, not shown.

The opposite terminal of solenoid 41 is connected through a lead 47 to a sleeve 48 of non-magnetic conducting material fixedly mounted in the side of casing 21 within the single turn coil 31 and insulated therefrom and from said casing as indicated at 49 and 50. The outer end of sleeve 48 serves as a fixed electrical contact member of a controlling means for the starting switch in the form of an electromagnetic relay. A movable contact 51 adapted to cooperate therewith is mounted on a bar 52 of suitable magnetic material such as pure, soft iron which is yieldably mounted as by means of a spring strip 53 on a bracket 54 of similar magnetic material fixed to the end member 22 of casing 21. The bracket 54 is grounded to the casing as indicated at 56 whereby, when the contact 51 is in engagement with contact sleeve 48, solenoid 41 will be energized whenever the manual switch 44 is closed.

Movable contact 51 is adapted to be controlled by means of a pair of coils 57 and 58 which are concentrically wound on a core 59 of suitable magnetic material mounted on the end 22 and partition 24 of casing 21. The casing 21 and partition 24 are formed of suitable magnetic material and the partition 24 is provided with a tongue 61 bent into parallel relationship with the core 59 and arranged in proximity to the swinging bar 52. It will thus be seen that the core 59, partition 24, tongue 61, bar 52 and bracket 54 form a magnetic circuit which is closed except for the gap between the tongue 61 and bar 52 and that the energization of either of the coils 57 or 58 will tend to swing said bar 52 in a direction to close said gap, thereby opening relay contacts 51, 48.

Both coils 57 and 58 have one terminal grounded as indicated at 62 while the other terminal of coil 57 is connected by means of lead 63 to the starting motor lead 32 and the other terminal of coil 58 is connected by means of lead 64 to the generator lead 18.

Adjustably mounted within the non-magnetic contact sleeve 48 is a core 66 of suitable magnetic material which cooperates with the single turn coil 31 to hold the contact 51 against the contact sleeve 48 during the cranking operation by virtue of the heavy current then passing through the single turn coil 31. The core 66 is adjustably mounted within the contact sleeve 48 in order to provide a variable air gap between the core and the magnetizable bar 52 to control the effect of single turn coil 31. This gap is so adjusted that coil 57 opens the contacts 51 and 48 when the current through the single turn coil 31 is reduced

by the relief of the load on the starting motor when the engine becomes self-operative.

The operation of the device as so far described is as follows: Starting with the parts in the positions shown in Fig. 1, closure of the ignition switch 44 will complete a circuit from the battery 10 through leads 12 and 43 to solenoid 41, through lead 47, contacts 48, 51 and bracket 54 to the ground at 56. The consequent energization of the solenoid 41 draws the plunger 34 inward closing the starting switch 26, 27, 28 and thus completing the starting circuit from battery 10 through leads 12 and 13, switch 26, 27, 28, lead 29, single turn coil 31, and lead 32 through the starting motor to the ground at 33. At this time, the coil 57 is also energized from the starting circuit through lead 63 and ground connection 62, but the armature member 52 is retained in its original position by the heavy current traversing the single turn coil 31 in spite of the magnetization of coil 57, the position of the parts being as shown in Fig. 2.

When the engine starts, the load on the starting motor is relieved, thus greatly reducing the current through the starting circuit which weakens the magnetic effect of single turn coil 31 and also strengthens the magnetic effect of coil 57 by reason of the rise in voltage applied to the lead 63. The armature 52 is therefore attracted into contact with the tongue 61, opening contacts 51, 48 which causes the deenergization of solenoid 41 and the consequent opening of starting switch 26, 27, 28 by the action of spring 39. The coil 57 is not completely deenergized, however, since it is still traversed by a small amount of current generated by the armature of the starting motor spinning by momentum in its residual field. This current is sufficient to maintain the armature 52 in contact with the tongue 61 until the starting motor has nearly stopped spinning. Meanwhile the generator G being driven from the engine, builds up sufficient voltage to energize coil 58 through lead 64 and thereupon retain the armature 52 in retracted position as long as the engine is self-operative.

In case the engine stops for any reason while the ignition switch 44 remains closed, coils 57 and 58 then being deenergized, the armature 52 will move to close contacts 51, 48 whereby solenoid 41 is again energized and the starting operation will be repeated.

As previously pointed out, if this restarting operation should take place before the flywheel of the engine had come completely to rest, engagement of the starting mechanism with the flywheel might take place during a back rock of the flywheel thus causing unnecessary stresses on the starting mechanism. In order to delay the action of the starting mechanism sufficiently to avoid such an occurrence, according to the present invention, the electrical characteristics of the magnets formed by coils 57 and 58 or solenoid 41 or both are made such that changes of flux therein are retarded sufficiently to secure the desired delay in the actuation of the starting switch.

According to the present invention, this retardation is accompanied by introducing a cylindrical spool or tube of highly conductive non-magnetic material such as copper within the coils and surrounding the cores of such magnets whereby said tube forms in effect a single turn secondary winding of extremely low resistance and having a consequent high damping effect on the changes of flux in the magnets induced by the energization or deenergization of the magnet

coils. As indicated in the drawings, this damping means takes the form of a heavy cylindrical tube 67 of suitable material such as copper within the solenoid 41 and surrounding the plunger 34, and a second similar cylindrical mass of copper 68 within the coils 57 and 58 and surrounding the core 59. The sluggish action of the relay and the actuating solenoid may also be increased still further if desired by so designing the coils thereof as to have a large self-inductance whereby the damping effects of the masses of copper are augmented.

It will be seen that with the device as constructed according to the present invention, if the engine should stall for any reason, the decay of the magnetic flux through the core 59 and armature 52 of the relay will be comparatively gradual, so that the closure of contacts 51 and 48 will not take place immediately but will be delayed for a predetermined period depending upon the electrical characteristics of the relay structure. Moreover, after the closure of contacts 51, 48, the building up of flux by the energization of solenoid 41 is also retarded so that the plunger 34 is not immediately moved to close the starting switch 28 but the closure of said switch will be further delayed by an interval depending on the electrical characteristics of the solenoid structure. It will be understood that either the relay or the starting switch solenoid may be modified to secure the desired delay, but it has been found preferable in practice to modify the magnetic characteristics of both these structures in order to secure the desired delay while preserving a structure of desired small dimensions.

Referring to Fig. 4 of the drawings, a second embodiment of the invention is illustrated which includes a modified form of control relay. As there illustrated, the core 71 of the relay, which is of suitable magnetic material such as pure iron, is slidably mounted within the coils 57 and 58 and is provided with a head 72 of suitable conducting material normally pressed against a stop formed by a bracket 73 mounted on the partition 24 of the casing and insulated therefrom as indicated at 74. The lead 47 from the solenoid 41 is connected to the bracket 73 whereby the latter forms one contact of the relay, the other contact of which is the head 72 of plunger 71 which is normally maintained in engagement with bracket 73 by suitable means such as a spring 75 and which is grounded as indicated at 76.

In this arrangement the single turn coil 31 is arranged in alignment with the plunger 71 and in proximity to the head 72 thereof and a magnetizable core 77 is adjustably mounted within said single turn coil in suitably spaced relation to the head of said plunger. The solenoid 41 and/or the relay 57, 58 etc. are provided with means for retarding the action thereof in the form of cylindrical masses of copper 67 and 68 as above described.

The remaining parts of this embodiment of the invention are the same as in the embodiment previously described and a separate description thereof is therefore deemed unnecessary.

In the operation of this form of the device, closure of the ignition switch 44 completes a circuit through leads 12 and 43, solenoid 41, lead 47, bracket 73 and head 72 of plunger 71, and to the ground at 76. The consequent energization of solenoid 41 causes plunger 34 to close the starting switch 26, 27, 28, thus completing the starting circuit through the lead 13, switch 26, 27, 28, lead 29, single turn coil 31 and lead 32 through the starting motor to the ground at 33.

During the cranking operation the single turn coil 31, cooperating with its adjustable core 77, holds the contact head 72 of plunger 71 against the bracket 73, but when the engine starts the weakening of single turn coil 31 and the strengthening of coil 57 causes the coil 57 to overcome the attraction of single turn coil 31 and withdraw the plunger 71, thus breaking the circuit of solenoid 41. The plunger 71 is maintained in withdrawn position, first by the current generated by the spinning of the starting motor and then by the current supplied to the coil 58 by the generator, as above described in connection with the armature 52.

In case of engine stall, coils 57 and 58 being de-energized, the plunger 71 is released and allowed to close the solenoid circuit, and the solenoid 41 is thereupon energized to close the starting circuit, but as in the first embodiment of the invention, the action of the relay or of the solenoid or both are retarded by the masses of copper 68 and 67 therewithin and by the electrical characteristics thereof as above set forth.

Although certain embodiments of the invention have been shown and described in detail, it is to be understood that changes may be made in the precise construction shown and equivalent means used to perform the desired functions without departing from the spirit of the invention as defined in the claim appended hereto.

What is claimed is:

In an automatic starting system for internal combustion engines, a starting motor, a switch for controlling said motor, electromagnetic means for operating said switch, and means including an electromagnetic relay for controlling said operating means to open the switch when the engine starts and to close the switch in case the engine stalls, the electrical characteristics of the operating means and of said relay being so designed as to cause retardation of the action thereof, said retardations being cumulative with respect to the closure of the starting switch when the engine stalls.

FRANK T. CHRISTIAN.