Sept. 24, 1935. T. IGARASHI 2,015,309

AUTOMATIC STARTING AND STOPPING APPARATUS FOR A DIESEL ENGINE

Filed Jan. 17, 1935 3 Sheets-Sheet 1

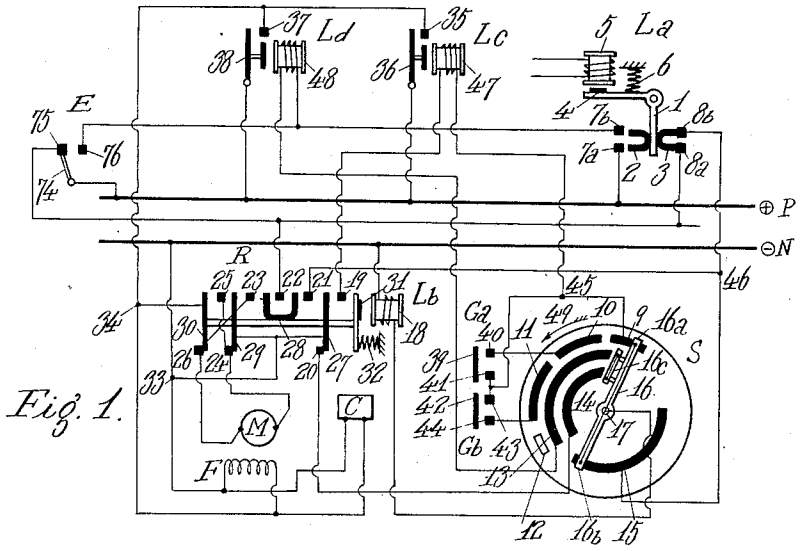

Fig. 1.

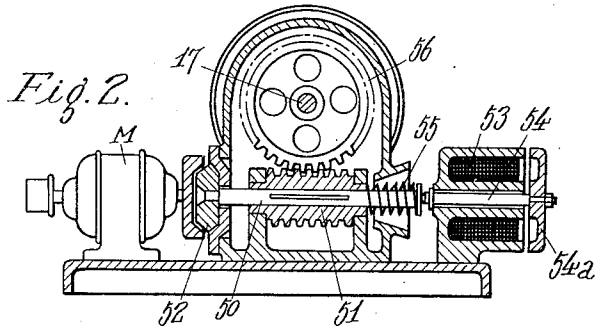

Fig. 2.

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Filed Jan. 17, 1935 3 Sheets-Sheet 2

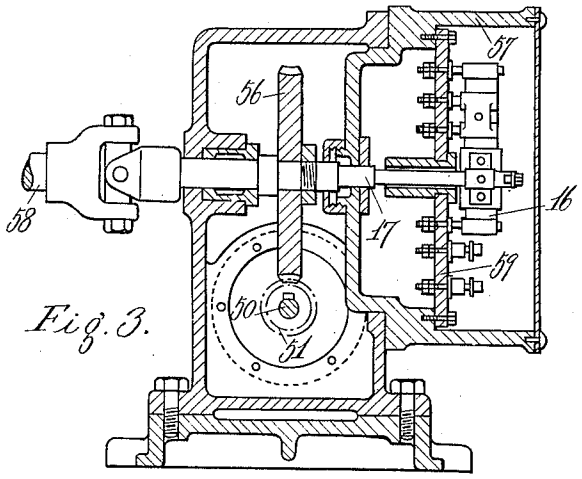

Fig. 3.

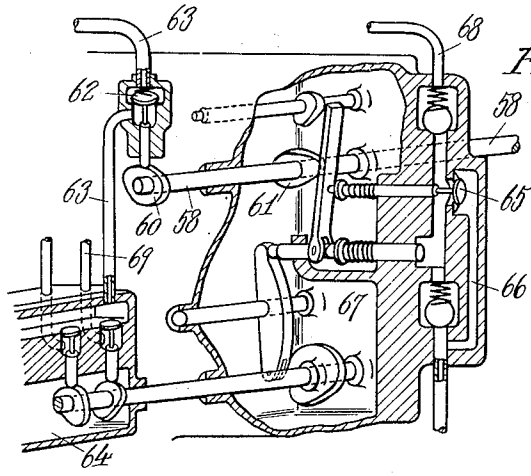

Fig. 4.

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AUTOMATIC STARTING AND STOPPING APPARATUS FOR A DIESEL ENGINE

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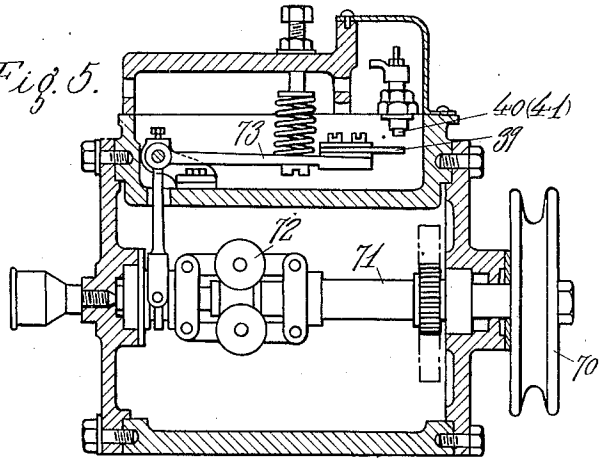
Fig. 5.



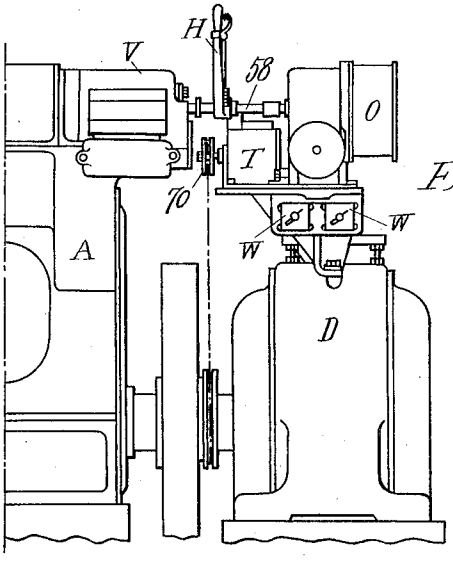


Fig. 6.

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UNITED STATES PATENT OFFICE

2,015,309

AUTOMATIC STARTING AND STOPPING APPARATUS FOR A DIESEL ENGINE

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Application January 17, 1935, Serial No. 2,313
In Japan February 16, 1934

7 Claims. (Cl. 123—179)

This invention relates to improvements in an automatic starting and stopping apparatus for a Diesel engine, especially adaptable for a Diesel engine coupled with a stand-by dynamo which is to start quickly and automatically for generation of electric current when a supply of the current in use is accidentally interrupted.

An object of this invention is to provide an apparatus comprising a motor, a circuit-opening device and a magnetic coupling for engaging and disengaging the motor with both the circuit-opening device and the valve-controlling shaft of a Diesel engine, so that the revolution of the motor controls both the circuits and the shaft, and the control of the circuits manages the revolution of the motor, in turn.

Further object of this invention is to provide a circuit-opening device which, in co-operation with relays and a reversing switch, drives the motor in one direction or another, so that the shaft for operation of the starting device of a Diesel engine is actuated and the engine is automatically started or stopped.

Further object of this invention is to provide a device which, when an external condition changes, opens a compressed air valve for starting a Diesel engine, and when the engine reaches to a predetermined speed, fuel oil is supplied automatically into the engine's cylinder by means of a timing device.

Further objects of this invention are described in the following specification referring to the drawings attached.

Fig. 1 shows a general arrangement of several devices and their electric connections constituting this invention.

Fig. 2 is a part sectional elevation of a motor and a magnetic coupling, illustrating the connection between the motor shaft and the circuit-opening device.

Fig. 3 is a sectional elevation of the circuit-opening device and Fig. 4 is a part sectional perspective view of the starting air valve box, the fuel oil pump and driving mechanisms therefor, of the engine.

Fig. 5 is a sectional elevation of a timing device, and Fig. 6 is an external appearance of an engine equipped with a dynamo and the apparatus of this invention, the latter being placed on the dynamo.

In Fig. 1, La, Lb, Lc, and Ld are relays which control the supply of current, co-operating with a circuit opening device S, to a motor M, its field coil F and a magnetic coupling C. Ga and Gb are timing devices which change the electric connections in the device when the revolution of the engine gets to pre-determined speeds.

According to this invention, when the outer condition changes so that the stand-by or spare dynamo is required to start, for example, when the supply of electric current in use is accidentally interrupted and a spare dynamo is to be driven, or the water level in a dam rises too high by an accident and a sluice for water release which is operated by a Diesel engine is to be opened as quickly as possible, the relay La changes the connection of electric circuits so that a small motor M starts, and at the same time the magnetic coupling C connects the motor with the spindle of the circuit-opening device S, thus an arm mounted on the spindle of the circuit-opening device is rotated at a reduced speed through a worm gearing.

As the spindle of the circuit opening device is mechanically connected with a valve controlling shaft of the engine, when an arm on the spindle reaches to a position, the compressed air valve is opened and the Diesel engine begins to start by means of compressed air, meanwhile the circuit for the motor M is opened and the latter stops its rotation. As soon as the engine gets to a predetermined speed, the timing device Ga changes the connection of a circuit so that the motor again starts, and the arm of the circuit-opening device and the valve-controlling shaft are rotated to such a position that fuel oil is supplied into the cylinder by the fuel pump, when the engine quickly accelerates its speed meanwhile the circuit for the motor is again opened. When the engine reaches its speed to the normal one, another timing device Gb connects the circuit of the motor, and the latter thirdly starts its revolution until the arm of the circuit-opening device and the valve controlling shaft are brought to the running position of the engine where the circuit for the motor is left open and the starting operation is now finished.

When the normal condition is recovered, for example, the current in use is again supplied from the external line, the relay La changes the connection of the electric circuit and the motor M revolves in the reverse direction until the arm of the circuit-opening device resumes its original position.

The above mentioned operations are accomplished by this invention within a few seconds. The detail of the operations shall be described later on.

In Fig. 1, a bell-crank 1 has two connecting pieces 2 and 3 on one arm and an iron piece 4

on another arm which faces to a magnetic coil 5 of the relay L*a*. Through the coil 5 passes electric current supplied from the outer line so as to always attract the iron piece 4 while the normal condition continues.

The bell-crank 1 is controlled by a relay in this example, but its operation can be accomplished by other electrical or mechanical means, if required. For example, if the engine is utilized to control the water-level of a dam, the bell-crank can be operated by a float provided in the dam.

In case the electric current in the outer line is suddenly interrupted by an accident, the magnetic coil 5 is demagnetized, and the bell-crank 1 is swung by the action of a spring 6 so that the connecting piece 2 opens the contact points 7*a* and 7*b* while the connecting piece 3 closes the contact points 8*a* and 8*b* as shown in Fig. 1.

The circuit opening device S consists of a stational disc and a rocking arm 16 mounted on a spindle 17 which is provided at the centre of the disc. This disc is made of an insulating material, and contact pieces 9 to 11 and 13 to 15 made of conductive materials and a piece 12 are distributed on the disc. The pieces 9 to 12 are disposed on a same circle and the pieces 13 and 14 are placed on two concentric circles.

The rocking arm 16 is made of an insulating material, and has two contact pieces 16*a* and 16*b* which are electrically connected with each other. The piece 16*a* is in contact with the pieces 9 to 12 in succession when the arm slides along the disc, but is not in contact with the pieces 13 and 14. The arm has another contact piece 16*c*. This piece is firmly fixed to, but insulated from, the arm and can bridge over the pieces 13 and 14. The piece 16*b* is in contact with the piece 15 while the piece 16*a* is in contact with any of the pieces 9, 10 and 11, but the piece 16*b* leaves the piece 15 when the piece 16*a* leaves the piece 11. The pieces 13 and 14 are electrically connected through the piece 16*c* when the piece 16*a* is in contact with the pieces 10, 11 or 12, but are not connected when the arm 16 is at the extreme position (as shown in Fig. 1) of the piece 9.

The arm 16 is electrically connected with a bus-bar N of a D. C. source through the magnetic coil 18 of the relay L*b*, and the pieces 9, 10, 11, 13, 14 and 15 are electrically connected respectively with a contact point 19 of a reversing switch R through the magnetic coil 47 of the relay L*c*, a contact point 40 of the timing device G*a*, a contact point 44 of another timing device G*b*, the contact point 7*b* through the magnetic coil 48 of the relay L*d*, the contact point 20 of the reversing switch and the contact point 8*b*, as shown in Fig. 1.

The reversing switch R is controlled by the relay L*b*. This switch consists of eight stational contact points 19 to 26 and four movable pieces 27 to 30. These movable pieces and an iron piece 31 facing to the magnetic coil 18 of the relay L*b* are mounted on an insulating frame, which always takes the position by a spring 32 as shown in Fig. 1 when the coil 18 is not magnetized. At this position the pieces 27, 29 and 30 are in contact with the points 20, 24 and 26 respectively, and the piece 28 does not close the points 21 and 22.

The point 21 is electrically connected at a point 46 with the circuit containing the point 8*b* and the piece 15; the point 22 is connected with a bus-bar P through an emergency switch E; the points 23 and 26 are electrically connected and the points 24 and 25 are also connected. The pieces 27 and 29 are connected at a point 33, and the piece 30 is connected at a point 34, with the circuit for the magnetic coupling C and the field F. This circuit begins from the bus-bar N, and contains the field F of the motor M and the magnetic coupling C in parallel or series and ends at another bus-bar P through the relays L*c* or L*d* so that the circuit is closed when either of the relays is actuated, but the direction of electric current in the circuit for the motor M is reversed as described later on.

The relay L*c* is provided with a contact point 35 and a rocker 36, and the relay L*d* also is provided with a contact point 37 and a rocker 38. The rockers 36 and 38 are connected with the bus-bar P in parallel.

The timing apparatuses G*a* and G*b* are driven by the main engine. When the revolution of the engine reaches to such a speed that fuel oil is just to be charged into the cylinder, the movable piece 39 of the device G*a* connects the contact points 40 and 41.

When the engine gets to the normal speed or near thereof, the device G*b* is actuated and the movable piece 42 connects the contact points 43 and 44. The points 41 and 43 are connected at a point 45 with the circuit which contains the piece 9 and the coil 47.

In the normal condition the arm 16 of the circuit-opening device is at the extreme point of the piece 9. When an accidental condition occurs, the bell-crank 1 takes the position as shown in Fig. 1 and the piece 3 electrically connects the points 8*a* and 8*b*, so that the circuit which contains the bus-bar P, emergency switch E, points 8*a*, 8*b*, connecting piece 15 of the circuit opening device, rocking arm 16, coil 18 of the relay L*b* and bus-bar N is closed, and the coil 18 is magnetized. Then the relay L*b* is actuated and pulls the iron piece 31 together with the frame of the movable pieces. Thus the point 19 and the piece 27, the points 21, 22 and the piece 28, the point 23 and the piece 29, and the point 25 and the piece 30 are respectively connected. Now a circuit containing bus-bar P, emergency switch E, points 8*a*, 8*b*, 15, 16, 9, 45, coil 47, contact point 19 of the reversing switch, 27, 33 and bus-bar N is closed and the relay L*c* is actuated.

The rocker 36 of the relay L*c* is now attracted by the magnetized coil 47 so as to contact with the point 35, and a circuit containing bus-bar P, 36, 35, magnetic coupling C (and field F in parallel) and bus-bar N is closed.

At the same time other two circuits are closed, one being bus-bar P, 36, 35, 34, connecting piece 30 of the reversing switch, 25, 24, motor M, contact points 26 and 23, piece 29, 33 and bus-bar N, and another being bus-bar P, emergency switch E, contacting points 22, 28, 21, 46, connecting piece 15 of the circuit-opening device, arm 16, coil 18 of the relay L*b* and bus-bar N. The first two circuits are for the motor M, field F and the coupling C, while the third one is to supplementally magnetize the coil 18 of the relay L*b*.

The motor M now starts and drives the spindle 17 in the direction as indicated with the arrow 49, at a reduced speed, until the piece 16*a* of the arm 16 mounted on the spindle touches the piece 10 leaving the piece 9. Thus the circuit containing the bus-bar P, switch E, 8*a*, 8*b*, the piece 15, arm 16, piece 9, coil 47, piece 27, point 33 and bus-bar N is opened, therefore the

circuit containing the rocker 36 and contact point 35 of the relay Lc is opened so that the coupling is disconnected and the motor stops.

When the spindle 17 has been rotated until the piece 16a touches the piece 10, a valve controlling shaft of the engine connected with the spindle 17 opens the valve of compressed air for starting the engine, and the latter starts by means of compressed air as an ordinary Diesel engine does.

As soon as the engine gets to a predetermined speed, adequate to begin the supply of fuel oil into the engine's cylinder, the timing device Ga is effected and the contact points 40 and 41 are connected, whereby the open circuit containing the coil 47 of the relay Lc is again closed through the arm 16, piece 10, contact points 40 and 41. This results in the starting of the motor M, and the spindle 17 is again rotated until the piece 16a touches the contact piece 11 leaving the piece 10. This means that the circuit for the motor is opened at the point between the contact piece 10 and the arm 16, and the motor again stops. Now the fuel pump continues the fuel injection and the starting air valve has been closed.

When the engine's speed has accelerated and gets nearly to the normal one, the timing device Gb closes the contact points 43 and 44, so that the above circuit is again closed, and the motor M drives the spindle 17 until the pieces 16a and 16b leave the contacts 11 and 15, respectively. When the piece 16a is placed on the point 12, the circuit for the relay Lc is left open whereby the circuits for the motor, its field coil and the magnetic coupling are opened. The circuit is also opened at the point between the piece 15 and the arm 16, so that the reversing switch takes the original position as shown in Fig. 1. The engine is then running at the normal speed.

When the normal condition is recovered, for example, the current in use is again supplied from the outer line, the bell-crank 1 is rocked by the attraction of the coil 5, and the piece 2 closes the points 7a and 7b, then the circuit which contains the bus-bar P, contact points 7a and 7b, coil 48 of the relay Ld, contact pieces 13, 16c and 14 of the circuit opening device, point 20 and piece 27 of the reversing switch, 33 and bus-bar N is closed. By this means the rocker 30 gets in contact with the point 37 and closes the circuits for the motor, its field and the coupling just as the relay Lc does. In this case, however, the reversing switch is not operated so that the direction of current for the motor M is reversed comparing the case wherein the relay Lc is actuated.

On account of this ground, the motor M rotates in the opposite direction, and the spindle 17 also rotates the piece 16a until the latter gets to the extreme point on the piece 9 and the above circuit containing the relay Ld is opened at the point between the pieces 13 and 14, so that fuel-oil injection is stopped and the valve controlling mechanism passes over the position for operating the compressed air valve of the Diesel engine in succession and the engine stops.

As the supplementary circuit for the relay Lb before mentioned is closed when the piece 16b is in contact with the piece 15, the reversing switch R does not return to its normal position even if the bell-crank 1 closes the contact points 7a and 7b while the arm 16 is being rocked along the pieces 9, 10 and 11 during a starting operation of the engine.

This means that the engine starts up to its normal speed when the contact points 7a and 7b are once opened closing the points 8a and 8b, as otherwise, the engine would repeat starting and stopping several times if the current in use is repeatedly interrupted before the engine accelerates its speed to the normal one, and the compressed air reserved for starting the engine would be exhausted.

In Fig. 2, M is the small motor above mentioned. The shaft of this motor is coupled with the spindle 50 of a worm 51 through a friction coupling 52. Another end of the spindle 50 touches a spindle 54, which extends through a magnetic coil 53 and is provided with an iron plate 54a fixed thereto. The spindle 50 is slidably fitted to the boss of the worm by means of a feather key, and is always pushed towards the right end so as to brake the friction disc of the coupling on the surface of the frame by means of a spring 55, which is inserted between the frame and a flange fixed on the spindle. By this means the friction coupling is not engaged and the iron plate 54a is a little apart from the outer end of the magnetic coil 53 when the coil is not magnetized.

A worm gear 56 is engaged with the worm 51. This worm gear is fixed on the spindle 17 of the circuit-opening device S as before mentioned, and the spindle 17 is connected with the valve controlling shaft 58 of the engine.

In Fig. 3, 59 is a disc made of an insulating material and is fixed to a shoulder of the casing 57 for the circuit opening device, and the spindle 17 extends through the centre of the disc. On the disc are distributed the contact pieces 9 to 15 and the arm 16 is fixed at the end of the spindle in the manner as before mentioned.

The valve controlling shaft 58 extends into the valve casing of the engine as shown in Fig. 4, and an air controlling cam 60 and an oil controlling cam 61 are mounted thereon.

The cam 60 controls a valve 62 provided in the air pipe 63 extending between the air valve box 64 of the engine and a tank of compressed air, not shown. 69 is a pipe for supplying air from the air valve box to the engine's cylinder, not shown. The cam 61 provided on the shaft 58 operates the valve 65 which controls the opening of a by-pass 66. If the by-pass is opened, the fuel oil discharged by an oil pump 67 returns to the suction side of the pump, so that fuel oil is not supplied to the cylinder through the pipe 68.

The time of operation of the valves 62 and 65 is controlled by the cams 60 and 61 so as to correspond with the proper positions of the arm 16 relative to the contact pieces of the circuit opening device S.

An example of the timing devices Ga and Gb is shown in Fig. 5. The rotation of the engine is transferred to a spindle 71 of the device through a rope pulley 70. On the spindle is provided a centrifugal device 72 which raises a piece 39 of electrically conductive material in order to bridge over the contact pieces 40 and 41 by means of a bell crank 73 when the spindle 71 is accelerated up to a predetermined speed.

An emergency switch E, see Fig. 1, consists of a connecting lever 74 and two contact points 75 and 76, and is placed in a circuit in series with the contact points 8a and 8b when the lever is in contact with the points 75. This switch is also in series with the contact points 21 and 22 of the reversing switch. In case of emergency, the lever 74 is rocked to contact with the point 76 and the circuit for the coil 48 is closed, and at the same time the circuit containing the points

8a and 8b and another circuit containing the points 21 and 22 are opened independent of the position of the bell-crank l and reversing switch R.

On account of this ground, if a mechanical governor is arranged to rock the lever 14 from the point 15 to 16 when the engine rotates beyond the normal speed, the relay Ld is magnetized and the engine stops.

Referring to Fig. 6, A is a Diesel engine directly connected with a dynamo D. O is the case for the circuit opening device; T is the case for the timing device; V is the valve box of the engine A; and W is a switch box. These devices are placed on a bed plate fixed on the dynamo.

Fig. 1 is merely a skeleton of the device for illustration of the principle of the apparatus. In actual practice, a dash-pot is advisable to be provided with the bell-crank l in order to avoid sensitive fluctuation of the bell-crank when the outer current winks.

It is also advisable that the relays Lc and Ld should be so constructed that the circuits for the field F and the motor M are closed a little earlier than that for the coupling C in order to actuate the coupling when the motor has been accelerated.

The circuit-opening device can be made of a number of cams mounted on the spindle 17, each cam operating opening of respective contact between terminals of the several circuits. According to this modification, the opening time of each circuit can be easily regulated by adjusting the position of each cam on the spindle.

Other attachments such as pilot lamps, test switches, meters and so on should be provided on a switch board for watching.

If a switch is provided in the circuit for the coil 5, the device can be tested at any time if it would reliably start or not. If a switch inserted in the line connecting the point 7a and the bus-bar P is opened while the engine is running, the latter continues its motion even when the coil 5 is magnetized so that the points 7a and 7b are connected by the piece 2. If a switch inserted in the circuit containing the emergency switch is opened when the engine is running, the engine can be stopped at any time.

If a handle H, see Fig. 6, is fixed to the shaft 88, and a clutch is provided with the shaft so that the shaft can be disconnected from the spindle 17, the engine can be started by means of hand operation.

What I claim is:

1. An automatic starting and stopping apparatus for a Diesel engine comprising a motor, a magnetic coupling, a circuit-opening device which is mechanically connected with the motor and is driven by the latter through intermediation of the magnetic coupling for selectively opening the circuits which control rotation of the motor and magnetization of the coupling, a valve-controlling shaft mechanically connected with the circuit-opening device for operation of the compressed air and fuel-oil pump of the engine, a timing device which closes a circuit of the motor when the engine's speed gets to a pre-determined one, and a means for actuating the motor and magnetizing the coupling by co-operation of the circuit-opening device.

2. An automatic starting and stopping apparatus for a Diesel engine comprising a motor, a magnetic coupling, a circuit-opening device which is mechanically connected with the motor and is driven by the latter through intermediation of the magnetic coupling for selectively opening the circuits which control rotation of the motor and magnetization of the coupling, a valve-controlling shaft mechanically connected with the circuit-opening device for operation of the compressed air and fuel-oil pump of the engine, a timing device which closes a circuit of the motor when the engine's speed gets to a pre-determined one, and a reversing switch inserted in the circuits so as to reverse the connection of the circuits for the motor when the switch is actuated by a magnetic coil so that the direction of rotation of the motor is reversed by magnetizing or de-magnetizing the coil.

3. An automatic starting and stopping apparatus for a Diesel engine comprising a motor, a magnetic coupling, a circuit-opening device which is mechanically connected with the motor and is driven by the latter through intermediation of the magnetic coupling for selectively opening the circuits which control rotation of the motor and magnetization of the coupling, a valve-controlling shaft mechanically connected with the circuit-opening device for operation of the compressed air and fuel-oil pump of the engine, a timing device which closes a circuit of the motor when the engine's speed gets to a pre-determined one, and a reversing switch inserted in the circuits so as to reverse the connection of the circuits for the motor when the switch is actuated by a magnetic coil so that the direction of rotation of the motor is reversed by magnetizing or de-magnetizing the coil, said reversing switch being provided with connecting members for a supplementary circuit for the magnetic coil of the reversing switch so as to have the switch keep its position even if the main circuit of the magnetic coil is opened.

4. An automatic starting and stopping apparatus for a Diesel engine comprising a motor, a magnetic coupling, a circuit-opening device which is mechanically connected with the motor and is driven by the latter through intermediation of the magnetic coupling for selectively opening the circuits which control rotation of the motor and magnetization of the coupling, a valve-controlling shaft mechanically connected with the circuit-opening device for operation of the compressed air and fuel-oil pump of the engine, a timing device which closes a circuit of the motor when the engine's speed gets to a pre-determined one, a reversing switch inserted in the circuits so as to reverse the connection of the circuits for the motor when the switch is actuated by the magnetic coil so that the rotation of the motor is reversed, and magnetic relays inserted in the circuits, which, co-operating with the circuit opening device, open or close the circuits of the motor, its field and the magnetic coupling.

5. An automatic starting and stopping apparatus for a Diesel engine comprising a motor, a magnetic coupling, a circuit-opening device which is mechanically connected with the motor and is driven by the latter through intermediation of the magnetic coupling for selectively opening the circuits which control rotation of the motor and magnetization of the coupling, a valve-controlling shaft mechanically connected with the circuit-opening device for operation of the compressed air and fuel-oil pump of the engine, a timing device which closes a circuit of the motor when the engine's speed gets to a pre-determined one, and a reversing switch inserted in the circuits so as to reverse the connection of the circuits for the motor when the switch is actu-

ated by a magnetic coil so that the direction of rotation of the motor is reversed by magnetizing or de-magnetizing the coil, and two magnetic relays inserted in the circuits in such a manner that when the first relay is actuated, it controls the reversing switch so as to magnetize the coil of the second relay, which closes the circuit of the motor for rotation in one direction.

6. An automatic starting and stopping apparatus for a Diesel engine comprising a motor, a magnetic coupling, a circuit-opening device which is mechanically connected with the motor and is driven by the latter through intermediation of the magnetic coupling for selectively opening the circuits which control rotation of the motor and magnetization of the coupling, a valve-controlling shaft mechanically connected with the circuit-opening device for operation of the compressed air and fuel-oil pump of the engine, a timing device which closes a circuit of the motor when the engine's speed gets to a predetermined one, a reversing switch inserted in the circuits so as to reverse the connection of the circuits for the motor when the switch is actuated by a magnetic coil so that the direction of rotation of the motor is reversed by magnetizing or de-magnetizing the coil, and three relays inserted in the circuits in such a manner that when the first relay is actuated it controls the reversing switch so as to magnetize the coil of the second relay, which closes the circuit of the motor for rotation in one direction, and the third relay is actuated when a normal condition is recovered so as to close the circuit of the motor for rotation in the reverse direction.

7. An automatic starting and stopping apparatus for a Diesel engine comprising a motor, a magnetic coupling, a circuit-opening device which is mechanically connected with the motor and is driven by the latter through intermediation of the magnetic coupling for selectively opening the circuits which control rotation of the motor and magnetization of the coupling, a valve-controlling shaft mechanically connected with the circuit-opening device for operation of the compressed air and fuel-oil pump of the engine, a timing device which closes a circuit of the motor when the engine's speed gets to a predetermined one, and a means for actuating the motor and magnetizing the coupling by co-operation of the circuit-opening device when the condition requires a starting of the engine, the circuit-opening device consisting of movable bridging members operated by a spindle driven by the motor and of stationary terminals of the circuits, the bridging members being so arranged that required terminals are selectively bridged over or opened by the rotation of the spindle.

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