Aug. 15, 1950 W. G. OVENS 2,518,712

AIRCRAFT ENGINE STARTING DEVICE

Filed June 23, 1943

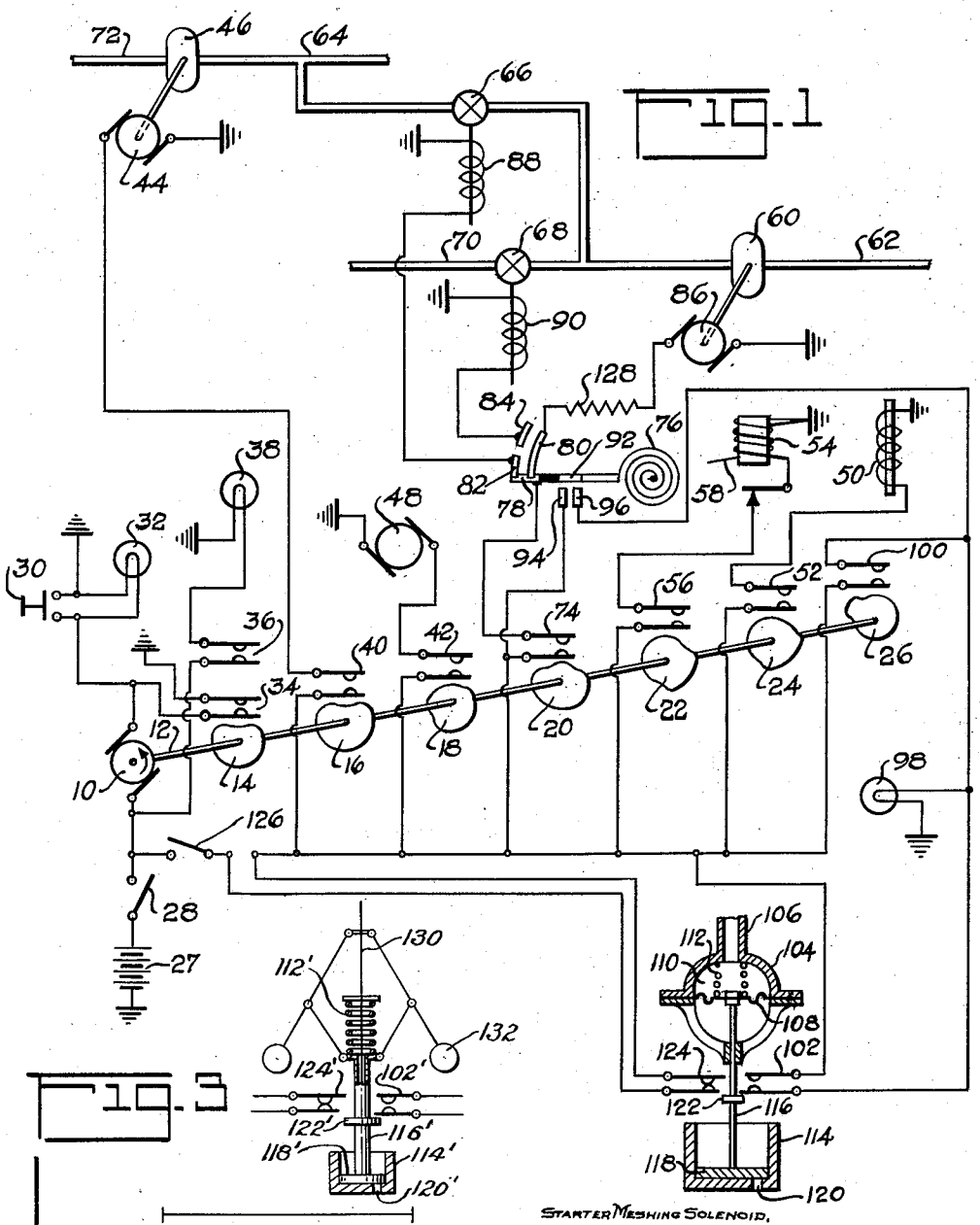


FIG. 1

FIG. 3

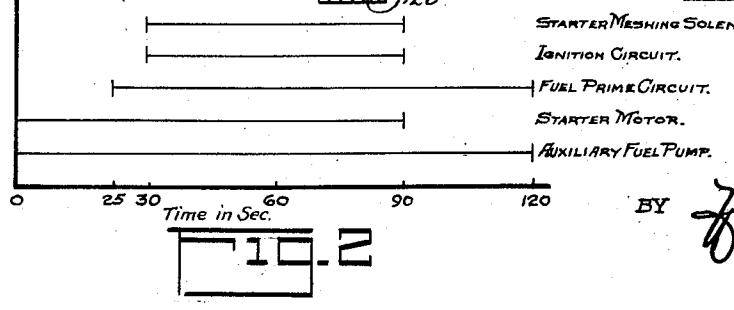


FIG. 2

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Patented Aug. 15, 1950 2,518,712

UNITED STATES PATENT OFFICE

2,518,712

AIRCRAFT ENGINE STARTING DEVICE

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Application June 23, 1943, Serial No. 492,193

13 Claims. (Cl. 123—179)

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This invention relates to a system and apparatus for providing automatic starting of an internal combustion engine and is particularly directed to the starting of an aircraft engine.

The starting of an aircraft engine involves the coordinated operation of numerous engine starting instrumentalities. The procedure is complicated and requires considerable precision and manual effort and may even require the cooperation of two men. It is an object of this invention to provide an apparatus under the control of a push button which, when closed, automatically effects operation of the engine starting instrumentalities in the proper sequence and for the proper duration. In other words, it is an object of this invention to provide an apparatus requiring only a single manual operation in order to start an aircraft engine.

It is a further object of this invention to provide an automatic starting apparatus for an engine, which apparatus requires only a single manual operation and which is automatically capable of effecting different starting programs as determined by existing temperature conditions. For example, the extent and character of the priming operation is determined by the temperature of the surrounding atmosphere.

Specifically, the invention comprises an electric motor which, after it is set in operation, closes a holding circuit for itself to insure operation of the motor through a complete cycle. During the cycle the motor is adapted to close and open a plurality of switches in a predetermined sequence and these switches are adapted to control the various engine starting instrumentalities.

Other objects of this invention will become apparent upon reading the following specification in connection with the drawing in which:

Fig. 1 is a diagrammatic layout of the starting apparatus embodying the invention,

Fig. 2 is a graphical illustration of a typical starting program; and

Figure 3 is a view illustrating a modified portion of Figure 1.

Referring to the drawing, the engine starting apparatus comprises an electric motor 10 drivably connected, either directly or through appropriate gearing, to a cam shaft 12. This cam shaft is provided with a plurality of cams 14, 16, 18, 20, 22, 24, and 26, inclusive. The circuit for the motor includes a battery 27, a master switch 28, and a starting switch 30 biased to open position. A signal lamp 32 is connected in parallel with the starter switch 30 whereby this signal lamp is energized as soon as the master switch 28 is

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closed. When the starter switch 30 is closed the motor 10 is energized and drives the cam shaft 12 and as soon as the cam shaft has rotated a small predetermined amount, the cam 14 simultaneously closes switches 34 and 36. Switch 34 closes a holding circuit for the motor 10 which circuit is held closed by the cam 14 until the shaft 12 completes one revolution. In this way the cam 14 insures rotation of the motor 10 and its cam shaft through a complete cycle. Simultaneously with the closure of switch 34, switch 36 closes a circuit to the signal lamp 38, thereby indicating that the motor holding circuit has been closed and whereupon the operator may release the starter switch 30. The starter switch 30 and the motor holding circuit switch 34, when closed, both short circuit the signal lamp 32 and, therefore, energization of the signal lamp 32 when the master switch 28 is closed, indicates to the operator that the motor 10 is in position for starting a cycle.

Simultaneously with the closing of the holding circuit, the cams 16 and 18 operate to close switches 40 and 42 respectively. Switch 40, when closed, completes a circuit to the motor 44 which is drivably connected to an auxiliary fuel pump 46. This fuel pump 46 replaces the hand operated and so-called "wobble" pump which is generally used to build up fuel pressure before the engine driven fuel pump is operating. Cam 16 is designed to hold switch 40 closed until just prior to the end of the cycle whereby the auxiliary fuel pump 46 operates practically throughout the cycle which for a particular model engine may be for 120 seconds, as graphically illustrated in Fig. 2. The switch 42, when closed by the cam 18, completes a circuit to the engine starter motor 48 and this circuit is held closed for a period of 90 seconds from the start of the cycle.

The starter motor 48 is part of a conventional so-called "inertia starter" in which an electric motor or manually operable means are used to energize an inertia wheel, and after the inertia wheel is up to speed a clutch is engaged to drivably connect the inertia wheel with the engine to be cranked. Patent 1,679,602 to R. Chilton illustrates such an inertia starter although, obviously, any conventional inertia starter may be used. This starter is also provided with a solenoid 50 which when energized drivably clutches or meshes the inertia wheel (not shown) driven by the motor 48, with the engine to be started. The circuit of the meshing solenoid 50 is opened and closed by switch 52 which in turn is controlled by the cam 24. This cam is designed to close

the circuit to the meshing solenoid 30 seconds after the beginning of the starting cycle and to open the circuit of the solenoid 90 seconds from the start of the cycle. That is, the meshing solenoid automatically effects engagement of the starter inertia wheel with the engine after the starter motor 48 has operated for 30 seconds and presumaby has driven the inertia wheel to the desired speed.

In an aircraft engine the electric energy required by the ignition circuit is normally supplied by a magneto. Accordingly, auxiliary ignition apparatus is required during the starting operation and for this purpose it is common practice to provide a conventional vibrator-type ignition coil. Thus, in Fig. 1 a vibrator-type ignition coil 54 is connected to the switch 56 controlled by the cam 22. The switch 56 energizes the ignition coil during the same portion of the starting cycle as the meshing solenoid 50 is energized by the switch 52, as graphically illustrated in Fig. 2. The secondary winding 58 of the ignition coil is connected to the usual ignition distributor (not shown).

In addition to the above apparatus, in general it is necessary to prime the engine in order to start it. With a particular engine model it has been found that with an atmospheric temperature in excess of 100° F. no priming is necessary, with a temperature between 20° and 100° F. the standard aircraft fuel is satisfactory for priming, but with a temperature below 20° F. a special priming fuel is required. To meet these requirements a primer pump 60 has its outlet connected to the conventional priming nozzles in the induction system of the engine through a conduit 62. The intake of this pump 60 is connected through a solenoid valve 68 and a conduit 70 to a supply tank containing a special priming fuel, or this pump is connected through the solenoid valve 66 to the conduit 64 which is supplied with standard engine fuel by the pump 46. The pump 46 has its intake side connected to the standard fuel supply tank of the aircraft through a conduit 72. This priming system is controlled by the cam 20 through a cam controlled switch 74 and a thermostatic element 76. Fuel priming control switch 74 is adapted to be closed 25 seconds after the start of the cycle, and remains closed until the end of the cycle, as graphically illustrated in Fig. 2. The switch 74 is connected to a contact portion 78 carried by the thermostatic element 76 and which contact portion is adapted to wipe over the cooperating contacts 80, 82, and 84 with change in temperature. Contacts 78 and 80, when engaged, complete a circuit from the cam switch 74 to the electric motor 86 for driving the priming pump 60. Contacts 82 and 84 are connected to solenoids 88 and 90, respectively. Contact portion 78 of the thermostatic element 76 is arranged to engage the contact 82 between 20° and 100° F. and to engage the contact 84 below 20° F., and at the same time to engage the contact 80 throughout these temperature ranges. Above 100° F. all circuits through the thermostat contact portion 78 are broken and a signal lamp circuit is completed by contact portion 92 of the thermostatic element, bridging the spaced contacts 94 and 96 to energize the signal lamp 98. With this construction when the cam 20 closes switch 74 if the temperature is below 20° F. solenoid valve 68 is opened and the priming pump 60 supplies priming fuel to the priming nozzles from the special priming fuel supply through the line 70. If the temperature is between 20° and 100° F. then when the cam switch 74 is closed the solenoid valve 66 is opened instead of the valve 68, whereupon the priming pump 60 operates to supply standard engine fuel to the priming nozzles. If the temperature rises above 100° F. the priming pump 60 will not be energized and the signal lamp 98 will indicate this fact to the operator.

The signal lamp 98 may also be energized by closure of the cam switch 100 by cam 26. This cam is adapted to close switch 100 approximately 10 seconds prior to the completion of the starting cycle and to hold this switch closed for the remainder of the cycle. In addition, signal lamp 98 may be energized by the closure of switch 102 by engine manifold pressure responsive means 104. This pressure responsive means is connected to the engine intake manifold through a conduit connection 106. A flexible diaphragm 108 is disposed across the housing of this pressure responsive means to form a chamber 110 and is subjected to the engine manifold pressure on one side while the opposite side of this diaphragm is exposed to atmospheric pressure. The diaphragm 108 is connected to the dashpot 114 by a rod 116 having a piston head 118 slidably received within the dashpot housing which is provided with a restricted vent 120. The dashpot thereby operates to retard any upward movement of the rod 116 and the connected diaphragm 108. Therefore, as soon as the engine is operating smoothly the resulting drop in engine manifold pressure results in continued upward movement of the diaphragm 108 against the bias of spring 112. The rod 116 is provided with a projecting collar 122 which is arranged to close the switch 102 as soon as the engine is operating smoothly and, in addition, a normally closed switch 124 is disposed relative to the collar 122 and switch 102 so as to be opened approximately 10 seconds after the closure of the switch 102.

In this way the switch 124 is arranged to open the battery connection to the switches controlled by the cams 16, 18, 20, 22, 24, and 26 after the engine has maintained a predetermined intake manifold pressure for approximately 10 seconds, that is, after the engine is running smoothly. Thus, if the engine starts before the end of the starting cycle the various starting instrumentalities are de-energized within 10 seconds by the opening of the switch 124. However, the holding switch 34 insures continued operation of the motor 10 to the end of its cycle in order that the motor 10 be at the proper initial position for the next starting operation. Also at this point it should be noted that, although the means for interrupting the starting program after the engine is operating has been disclosed as being responsive to the engine intake manifold pressure, other means indicative of engine operation may be used as, for example, means responsive to the speed of the engine as hereinafter described in connection with Figure 3.

A normally closed safety switch 126 is provided to permit the operator to shut down the starting apparatus in case some emergency should arise. This switch 126, like the switch 124, when open disconnects the battery from the various switches controlled by the cams 16, 18, 20, 22, 24, and 26. Although the various starting functions may be interrupted by the opening of switch 124 or 126, the motor circuit holding switch 34 insures continued operation of the motor 10 to the end of the cycle in order to insure return of this motor to its proper initial position.

From the above description it is apparent that the signal lamp 98 may be energized by the closure of any one of three switches, namely: switch 92, switch 100, or switch 102. If the engine does not start until near the very end of the cycle lamp 98 is closed by switch 100, 10 seconds before the end of the cycle to apprise the operator of the approach of the end of the starting cycle. The operator thereupon adjusts the carburetor to supply the normal fuel mixture to insure a continued supply of fuel after the fuel priming operation ceases. During the starting cycle the engine throttle is only opened sufficiently to insure an air supply sufficient for the combustion of the priming fuel while the fuel mixture control is in its cut-off position. If the engine starts to run considerably before the end of the cycle the lamp 98 is energized by the closure of switch 102 and, since the switch 124 opens 10 seconds later to interrupt the various starting functions, this energization of the lamp 98 also indicates to the operator that the starting operation will end in 10 seconds and, therefore, that it is necessary to properly adjust the engine fuel mixture control. If the atmospheric temperature happens to be above 100° F. at the start of the cycle, the signal lamp 98 will immediately be energized through contacts 94 and 96 upon closure of the master switch 128. This will inform the operator that fuel priming is not necessary and will not be provided by the starting apparatus. Thereupon the operator will properly adjust the carburetor fuel mixture control. In other words, the energization of lamp 98 will always inform the operator of the need for adjusting the fuel mixture control.

It is also desirable to control the operation of the fuel priming pump 60 in accordance with the atmospheric temperature conditions. Thus, when the temperature is quite cold only a small percentage of the fuel volatilizes so that a greater supply of priming fuel is required. To meet this requirement the speed of the pump 60 is controlled by a temperature responsive resistance 128 properly connected into the circuit of the electric motor 86. In this way the speed of the pump 60 is less at higher temperatures because of the increase in the magnitude of the resistance 128.

In the above description the specific temperature limits and the specific duration and sequence of the various phases of the starting cycle are only typical of a particular engine model. Obviously, the invention is not limited to these specific details since the starting procedure naturally varies with different engines. In addition, some of the starting functions may be manually controlled, or, if desired, additional starting functions may be included.

As previously mentioned, Figure 3 illustrates a modification in which engine speed, instead of engine manifold pressure, is used for interrupting the engine starting program. In Figure 3, a shaft, diagrammatically indicated at 130, is drivably connected to the engine to be started and is provided with flyweights 132 pivotally mounted thereon. The flyweights 132 are connected to a sleeve 116' having at its lower end a piston 118' slidably received within a dash pot housing 114' which, in turn, is provided with a restricted vent 120'. With this construction, as the engine approaches a predetermined speed, the flyweights 132 move outwardly thereby raising the sleeve 116' and its piston 118' against a spring 112'. The sleeve 116' has a collar 122' arranged to

control switches 102' and 124' for interrupting the engine starting program. The primed reference numerals of Figure 3 designate parts substantially identical to the parts designated by the similar, but unprimed, reference numerals of Figure 1 so that the operation of Figure 3 should be clear without further description.

Therefore, while I have described my invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding my invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. I aim in the appended claims to cover all such modifications and changes.

I claim as my invention:

1. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine, said mechanism comprising motor means, a plurality of means each operable to effect a particular starting function by controlling the activation of one of said instrumentalities, means responsive to operation of said motor means to effect a predetermined program of operation of said plurality of means, and means responsive to the engine manifold pressure for interrupting said program.

2. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine, said mechanism comprising motor means, a plurality of means each operable to effect a particular starting function by controlling the activation of one of said instrumentalities, one of said plurality of means being operable to effect priming of the engine as its starting function, means responsive to operation of said motor means to effect a predetermined program of operation of said plurality of means, means responsive to the temperature of the surrounding air, and means controlled by said responsive means for controlling said priming operation.

3. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine, said mechanism comprising a cyclically operable motor, a plurality of means each operable to effect a particular starting function by controlling the activation of one of said instrumentalities, means responsive to operation of said motor to effect a predetermined program of operation of said plurality of means, means responsive to engine starting to interrupt said program, means to insure completion of the motor cycle even though the starting program is interrupted, and means to indicate completion of the motor cycle.

4. Starting control mechanism for an engine having a plurality of starting instrumentalities including an auxiliary fuel pump, auxiliary ignition circuit and an inertia starter, said mechanism comprising motor means, means automatically responsive to energization of said motor means to effect operation of the auxiliary fuel pump and the starter motor of said inertia starter and to subsequently effect energization of said auxiliary ignition circuit and to drivably connect the inertia wheel of said starter with said engine, and means responsive to engine starting for terminating the operation of said inertia starter, auxiliary fuel pump and auxiliary ignition circuit.

5. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine, said mechanism comprising motor means, a plurality of means operable to effect a plurality of starting functions including engine fuel prim-

ing by each controlling the activation of one of said instrumentalities, means responsive to operation of said motor means to effect a predetermined program of operation of said plurality of means, means responsive to a condition of the surrounding air, and means controlled by said condition responsive means for automatically controlling the quality of the priming fuel.

6. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine, said mechanism comprising a cyclically operable motor, a plurality of means each operable to effect a particular starting function by controlling the activation of one of said instrumentalities, means responsive to operation of said motor to effect a predetermined program of operation of said plurality of means, means responsive to engine starting or to completion of a motor cycle for terminating said program, and indicating means operative a predetermined interval prior to said termination.

7. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine, said mechanism comprising a motor, a plurality of means each operable to effect a particular starting function by controlling the activation of one of said instrumentalities, means responsive to energization of said motor to effect operation of said plurality of means in a predetermined sequence, and means operable to interrupt the operation of said plurality of means at any time, said motor automatically returning to its initial position for a subsequent starting operation upon said interruption of the operation of said plurality of means.

8. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine, said mechanism comprising motor means, a plurality of means each operable to effect a particular starting function by controlling the activation of one of said instrumentalities, means responsive to operation of said motor means to effect a predetermined program of operation of said plurality of means, means responsive to the attainment of an engine condition indicative of engine starting for interrupting said program, and indicating means operative a predetermined interval prior to said program interruption.

9. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine, said engine being operable thereafter independently of said instrumentalities which include a fuel pump, fuel priming means, and a starter unit for providing said engine with starting torque; said mechanism comprising means to effect a predetermined program of operation of said instrumentalities such that operation of said fuel pump and fuel priming means are initiated before said starter unit is rendered effective to provide said engine with starting torque and both said operations continue for a time after said starter unit is rendered ineffective.

10. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine, said engine being operable thereafter independently of said instrumentalities which include a fuel pump, an ignition circuit, fuel priming means, and a starter unit for providing said engine with starting torque; said mechanism comprising means to effect a predetermined program of operation of said instrumentalities such that the operation of said fuel pump and said fuel priming means are initiated before said ignition circuit is energized and before said starter unit is rendered effective to provide said engine with starting torque and both said operations continue for a time after said ignition circuit is de-energized and said starter unit is rendered ineffective.

11. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine; said mechanism comprising motor means; a plurality of means each operable to effect a particular starting function, by controlling the activation of one of said instrumentalities, one of said plurality of means being operable to effect the supplying of fuel to said engine as its starting function; means responsive to operation of said motor means to effect a predetermined program of operation of said plurality of means; means responsive to the surrounding air temperature; and means controlled by said temperature responsive means for regulating the fuel supplied to said engine during said program.

12. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine; said mechanism comprising motor means; a plurality of means each operable to effect a particular starting function by controlling the activation of one of said instrumentalities; means responsive to energization of said motor means to effect operation of said plurality means in a predetermined sequence; and means operable to interrupt the operation of said plurality of means at any time, said motor means automatically returning to its initial condition for a subsequent starting operation upon said interruption of the operation of said plurality of means.

13. Mechanism for controlling the activation of a plurality of instrumentalities for starting an engine; said mechanism comprising motor means; a plurality of means each operable to effect a particular starting function by controlling the activation of one of said instrumentalities, one of said plurality of means being operable to effect priming of the engine as its starting function; means responsive to operation of said motor means to effect a predetermined program of operation of said plurality of means; means responsive to a condition of the surrounding air; and means controlled by said condition responsive means for controlling said priming operation.

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