April 15, 1952

M. P. ODELL

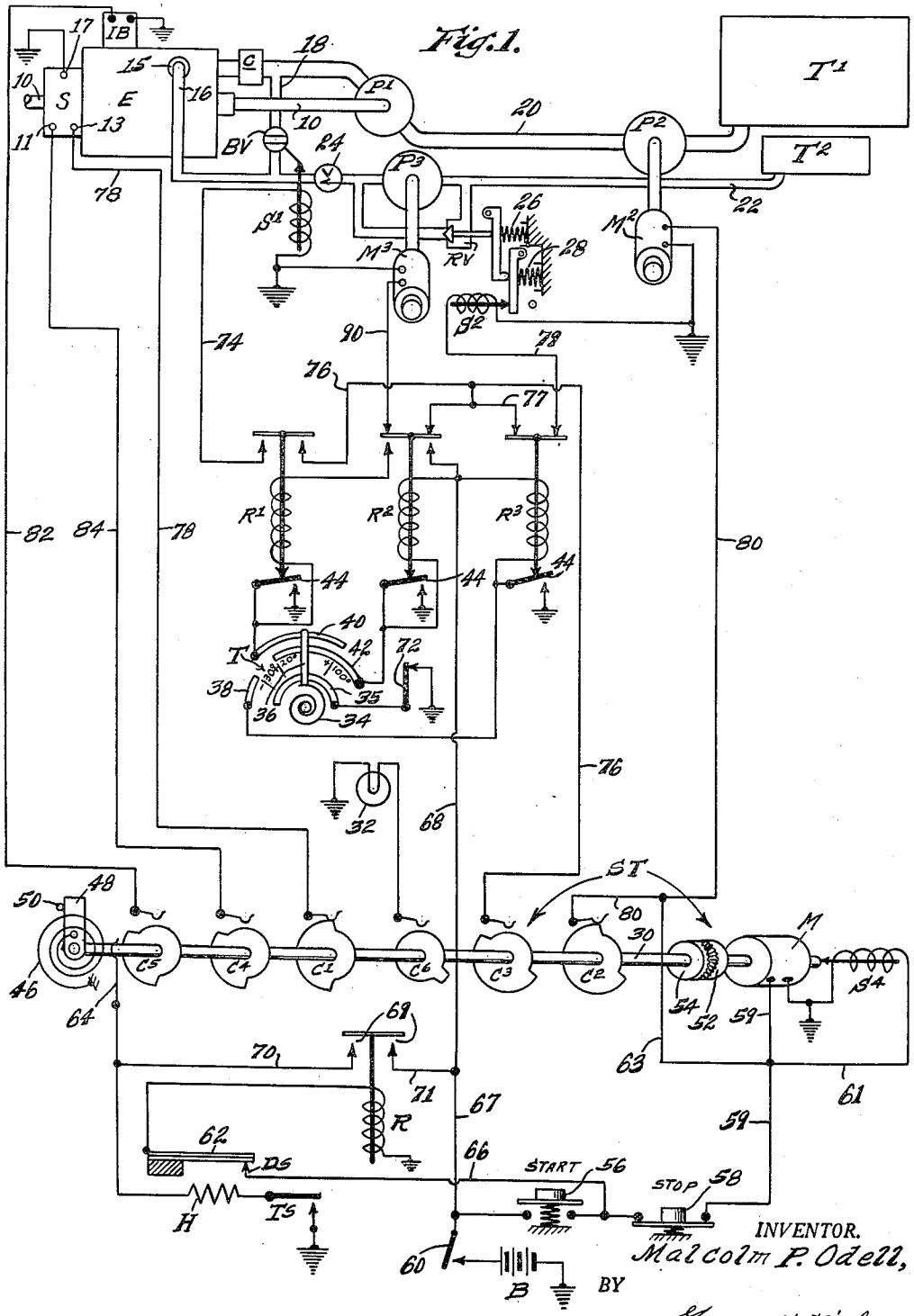
2,592,945

AUTOMATIC STARTING SYSTEM FOR INTERNAL-COMBUSTION ENGINES

Filed Feb. 1, 1945

2 SHEETS—SHEET 1

Fig. 1.



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Fig. 2.

CIRCUITS AND THEIR TIMING

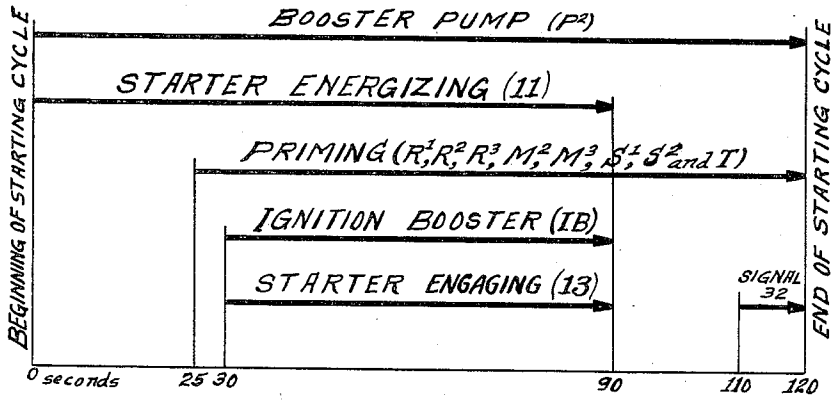
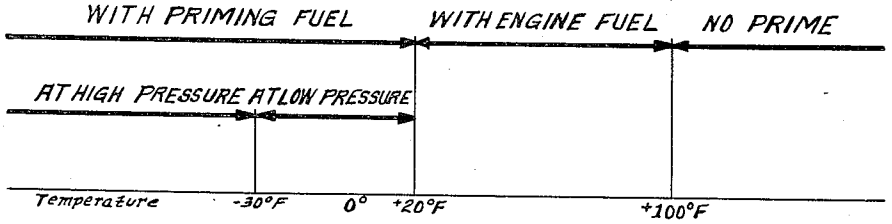


Fig. 3.

PRIMING AT VARIOUS TEMPERATURES



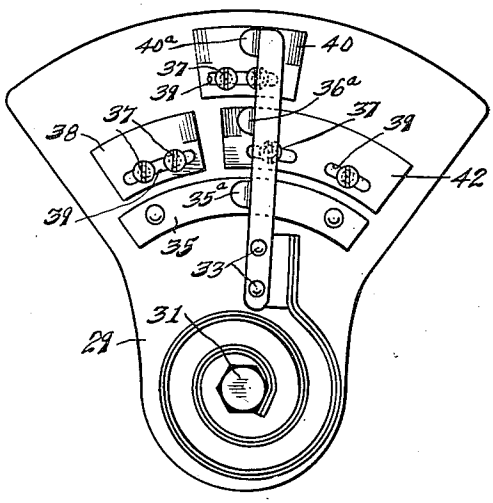


Fig. 4.

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UNITED STATES PATENT OFFICE

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AUTOMATIC STARTING SYSTEM FOR INTERNAL-COMBUSTION ENGINES

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11 Claims. (Cl. 123—187.5)

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This invention relates to a system for starting the engines of an aircraft or other internal combustion engines, requiring no attention from the pilot other than momentary pressure or a starting switch, thus leaving him free to perform other functions preliminary to taking off the craft while the starting cycle of the engine is proceeding automatically.

One object of the invention is to provide a system which is automatic in all respects as far as starting of the engine is concerned and which includes thermostatic means responsive to the temperature ambient to the engine for setting into operation proper priming means for starting the engine in a satisfactory manner, regardless of the prevailing temperature.

Another object is to provide a sequential timer for timing various steps in the starting cycle such as the operation of an auxiliary fuel pump, a starter for the engine, an ignition intensifier, and automatic priming means, as well as means for meshing the starter at the proper time and furnishing a signal to the operator to indicate termination of the starting cycle.

Still another object is to provide an automatic system wherein a thermostat responsive to the temperature ambient to the engine energizes various combinations of relays, depending upon whether the temperature is high enough that no priming is required or low enough that priming is required, certain lower ranges of temperature positioning the thermostat so that a special auxiliary fuel can be used for priming the engine instead of the regular engine fuel.

A further object is to provide a pump for the auxiliary priming fuel having a pressure setting arrangement which is controlled by relays for either high or low pressure output, depending upon whether the temperature is below a predetermined point such as —30 degrees, or above that point.

Still a further object is to provide a means to terminate the operation of the various elements of the starting system after a timed period, or prior to that time provided the engine starts properly, so that there is no chance of the engine becoming flooded.

An additional object is to provide a stop control for the starting system which can be manually operated at any time during the starting cycle in case the operator for any reason wishes to terminate the starting cycle.

With these and other objects in view, my invention consists in the elements of a starting system and their arrangement and combination

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whereby the objects contemplated are attained, as hereinafter more fully set forth, pointed out in the claims and illustrated in the accompanying drawings, wherein:

Fig. 1 is an electro-diagrammatic view of an automatic starting system for internal combustion engines embodying my invention;

Fig. 2 is a diagram showing the circuits which come into play during the starting cycle and the timing for the various circuits;

Fig. 3 is a diagram showing the priming of the engine with different fuels at various temperatures and at different pressures for certain temperature ranges; and

Fig. 4 is a detail view of a thermostat used in my system.

On the accompanying drawings I have used the reference character E to indicate an engine of internal combustion type, such as an aircraft engine. The engine E is provided with a starter S, such as one of the usual "inertia" type, having a ground terminal 17 common to two circuits, one of which is energized through terminal 11 and controls the rotation of the starter and the other of which is energized through terminal 13 and controls the engagement of the starter with engine E.

The engine has an ignition intensifier or "booster" IB for the purpose of providing an extra hot spark during the starting period, and this booster is of conventional design. Fuel is supplied to the engine E through a carburetor C from one or more fuel tanks, one of which is illustrated at T^1, and through an engine driven fuel pump P^1 connected with the power shaft 10. During starting of the engine an electrically driven auxiliary pump P^2 is operated, the motor therefor being shown at M^2.

During the starting of the engine it is primed through primer jets 15 from a conduit 16, and when engine fuel from the tank T^1 is used for priming it is supplied from a branch 18 of the main fuel line 20 through a by-pass valve BV. At that time the valve is opened by energization of a solenoid S^1.

At certain low temperatures a special auxiliary priming fuel is supplied from a tank T^2 through a priming fuel conduit 22, and a pump P^3. The pump P^3 is driven by an electric motor M^3. A check valve 24 is provided to prevent reverse flow of fuel from the conduits 16 and 18 into the conduit 22.

The pump P^3 has a pressure regulating means in the form of a relief valve RV, the opening of which is normally opposed by a pair of springs

26 and 28. The pressure at which the pump operates is thus relatively high (60 to 75 pounds per square inch). The pressure of the spring 28 may be relieved from the relief valve RV by energizing a solenoid S^2, whereupon the spring 26 only is operable and reduces the operating pressure of the pump P^3 to 30 or 40 pounds per square inch.

For controlling the solenoid S^1, the motor M^3 and solenond S^2, relays R^1, R^2 and R^3 are provided, and these relays, together with solenoids S^1 and S^2, pump P^3, motor M^3, by-pass valve BV, and relief valve RV, comprise a priming system PS for the engine. The relays are controlled by a thermostat T and a cam C^3 mounted on a timer or cam shaft 30 of a sequence timer ST. For driving the sequence timer, a motor M is provided. The timer shaft 30 also has cams C^1, C^2, C^4, C^5 and C^6 thereon. The cam C^1 controls energization of the starter S, the cam C^2 controls energization of the booster pump motor M^2, solenoid S^4 and motor M, the cam C^4 controls energization of the starter meshing solenoid S^3, the cam C^5 controls energization of the ignition booster IB, and the cam C^6 controls energization of the signal light 32.

These cams have lobes of such length that they perform their various functions over time periods illustrated in Fig. 2. These periods are arbitrary, and may be varied somewhat in relation to each other, but it has been found by experiment at all temperatures that the periods illustrated in Fig. 2 are quite satisfactory, providing special priming fuels are used at low temperatures, such as those indicated in Fig. 3 below 20° F.

The thermostat T, shown in detail in Fig. 4, comprises a bimetal coil 34 or some equivalent temperature sensing element which is located preferably adjacent the engine so as to be responsive to the temperature ambient to the engine. Location in the carburetor air induction system is probably best. The bimetal coil 34 has a contact arm 36 engageable with contact sectors 35, 38, 40 and 42 at the approximate temperatures indicated on Figs. 1 and 4. The contact sectors 38, 40, and 42 are connected with relays R^3, R^1 and R^2, respectively, which relays each include a holding switch 44 for retaining the relay energized after its energization is initiated by the thermostat and until such time as the circuit to the coils of the relays is broken by a starting relay R. A thermostat cut-out switch 72 is connected between the sector 35 of the thermostat T and ground and is adapted to be manually actuated.

With respect to the construction of the thermostat T the segments 42, 38 and 40 are preferably adjustable as by mounting them by means of screws 37 through slots 39. With such an arrangement the segment 38 can extend counter-clockwise as far as necessary since when the thermostat arm 36 goes below —30° it stays on this contact. However, the clockwise end of the segment 38 must be accurately positioned to correspond to the position of the arm 36 at —30°. Similarly, the clockwise end of segment 42 may be located anywhere, and the position of its counter-clockwise end must be accurately located. Thus there are two points which must be set with considerable accuracy in the construction of the thermostat in order to have it operate at the two specified temperatures, namely, —30° and 20°. It is also important that the clockwise end of segment 40 be accurately located. This counter-clockwise end, however, may overlap the segment 42 to any extent, as there can be no circuit through the relay coil R^1 unless there is also one through the relay coil R^2. In other words, after the arm 36 leaves the segment 42 it can still remain in contact with the segment 40 without effecting energization of the relay coil R^1. This permits of a comparatively simple arrangement of thermostat segments which may be adjusted at three critical points, namely, —30°, 20° and 100°, without having to adjust the length of the segment 40, and this is made possible by the particular relay arrangement used. It is only when the arm 36 engages both segment 40 and segment 42 that a circuit for the energization of relay R^1 becomes set up, and the counter-clockwise projection of segment 40 beyond the counter-clockwise end of segment 42 is a matter of indifference. Segment 40 can accordingly be made any convenient length, and an accurate machining job is dispensed with.

The arm 36 may be provided with contact fingers 35^a, 36^a and 40^a for proper engagement with the various segments 35, 38 and 42, and 40. The bimetal element 34 may have one of its ends anchored to the arm 36 as by rivets 33, and its other end anchored to a stationary post 31. This post, as well as the contact segments, are mounted on a suitable base 29 of insulating material.

The cam shaft 30 of the sequential timer is normally rotated counter-clockwise, as by a spring 46, so that a stop arm 48 carried by the shaft engages a stationary stop pin 50. The shaft is rotated in the opposite direction by the timer motor M through driving and driven clutch discs 52 and 54. The discs are meshed by energization of a solenoid S^4, the solenoid being energized whenever the motor M is energized and deenergized when the motor is deenergized.

A starting push-button 56 is provided as an initiating control for the sequence timer, and for energizing a starting relay R, shown in its normal or unenergized position. The connections to the relay include a holding circuit which will hereafter be more fully described when describing the operation of the starting system. The timing period can be terminated at any time by a stop push button at 58 which breaks the circuit to the motor M and declutches the disc 52 from the disc 54 so that the cam shaft 30 may return to the initial position shown in Fig. 1. The current may be supplied from any suitable source, such as a battery B through a master switch 60.

For automatically breaking the circuit of the relay R a tachometer switch TS is provided. This switch closes at about 800 R. P. M. of the engine and effects deenergization of the coil of the relay R by opening the delay switch DS. The delay switch includes a temperature responsive element such as a bimetal bar 62 thereof which warps upwardly by heat from a heater H. The heater is adjusted so that the delay switch operates about ten seconds after closure of the tachometer switch. The current from the battery B through the contacts of the relay R is supplied to the various circuits of the cams on the cam shaft 30 by a brush 64 contacting the cam shaft to transmit current to the shaft and through the shaft to each cam. The various circuits are believed clearly illustrated in Fig. 1 so that they will need no further description except as referred to in the operation of the system which follows:

From the above it will be evident that the starting system for engine E includes as major components starter S, ignition booster IB, auxiliary

pump P^2, and priming system PS, controlled jointly by sequence timer ST and thermostat T.

Practical operation

Assuming that the temperature ambient to the engine E is in the range of 20° to 100°, the thermostat T will be in the position illustrated in Fig. 1. The engine may now be started by closing the master switch 60 and then pressing on the starting button 56 to initiate operation of the sequential timer. The current from the battery B reaches the starter switch and from there passes through the normally closed stop switch 58 to the motor M by way of wire 59 and to the solenoid S^4 by way of branch wire 61 and returns to ground as in all circuits of the system. This results in the motor M rotating and the solenoid S^4 engaging the clutch 52—54 so that the cam shaft 30 starts rotating clockwise.

Current through the starter switch 56 also passes through wire 66, delay switch DS, bimetal element 62 and relay R, returning by way of the ground. This closes the starting relay R so that current from the master switch 60 is supplied through wires 67 and 71 and the contacts 69 of the relay R to the timer switch brush 64 by way of wire 70. Current is supplied from the master switch 60 to the coils of the relays R^2 and R^3 by wires 67 and 68. The circuit for the coil of relay R^3 is open at contact 38 of the thermostat, but the circuit for the coil of relay R^2 is closed at contact 42, from which the current flows through contact arm 36, contact 35, and to ground through thermostat cut-out switch 72 which is normally closed.

Energization of the relay R^2 depresses the bridging contact thereof from the position shown in Fig. 1 so that current from wire 68 is supplied to relay R^1 and returns through the elements 40, 36, 35 and 72 to ground. This operation of relay R^2 prevents energization of the motor M^3 for the auxiliary fuel pump P^3 and sets up a circuit for the priming solenoid S^1 through wires 74 and 76. The wire 76 is connected with the contact wiper for the cam C^3 so that the solenoid S^1 is energized only when the cam C^3 reaches the proper position (illustrated in Fig. 2 as twenty-five seconds after the beginning of the starting cycle).

The cams C^1 and C^2, it will be noted, are in position to contact their wipers at the beginning of the starting cycle. Accordingly, the current through the relay R and the brush 64 passes through wires 78 and 80 to the starter S and the booster pump motor M^2, respectively, for energizing them. Current also flows through wires 80 and 63 to energize motor M and solenoid S^4. This results in initiation of rotation of cam shaft 30, moving arm 48 away from stop 50. Thus in the temperature range of 20° to 100°, the starting cycle involves the following steps:

The booster pump P^2 and the starter S are energized at the beginning of the starting cycle. Priming is accomplished by energizing the booster pump and the solenoid S^1 for opening the by-pass valve BV so that as the engine is rotating it will be primed with engine fuel from the tank T^1 through the conduit 16 to the priming jets 15. The priming starts twenty-five seconds after the beginning of the starting cycle. Five seconds later the ignition booster IB is energized through a wire 82 from cam C^5, and the starter is meshed with the engine by energization of wire 84 from the cam C^4. At the end of ninety seconds the ignition booster IB, the starter S and the starter meshing wire 84 are deenergized by the cam lobes of the cams C^5, C^1 and C^4, respectively, passing their cam wipers.

It should here be mentioned that the "start" button 56 need not be held in all during the starting cycle. Instead, a holding circuit for the relay R is set up when the relay is in the operated position. This holding circuit may be traced from the master switch 60 through wires 67 and 71, the contact 69 of the relay, the wire 70, the brush 64, the sequence motor shaft 30, the cam C^2, the wires 80, 63 and 59, the stop switch 58, the wire 66, and the delay switch DS, together with its bimetal bar 62, to one side of the coil of the relay R, the other side being grounded. Thus the holding circuit is through the stop switch 58 so that whenever it is opened the holding circuit is broken.

The engine should now be started, but if it has not, or if, for any reason, the operator wishes to stop the starting cycle, the stop button 58 may be momentarily depressed, which breaks the holding circuit for relay R, thus permitting the cam shaft 30 to return to its initial position for another start.

If the engine does not start, the motor M continues to rotate, and at 110 seconds the cam C^6 engages its cam wiper for energizing the signal 32 to warn the pilot that the starting cycle is about completed and it is time for him to change his carburetor mixture control from "auto rich" to "auto lean." At the end of 120 seconds, the priming circuit is broken at the cam C^3 so that current is no longer supplied to the solenoid S^1. At the same time the circuit to signal light 32 is broken by cam C^6, while circuits are broken by cam C^2 which deenergize booster pump motor M^2, motor M, and solenoid S^4. The energization of solenoid S^4 is effective to release cam shaft 30 from motor M so that it can return to its initial position, with arm 48 against stop 50, under the influence of spring 46.

If the engine does start and reach a speed of 800 R. P. M., heater H is energized by tachometer switch TS, and if the engine speed is maintained for 10 seconds, the circuit to relay R is interrupted by operation of delay switch DS, putting the entire system out of operation. In this case light 32 is never energized.

After the starting cycle is initiated by depression of the starting button 56 it may be desirable to deenergize the circuit through the thermostat T to prevent a shift in the thermostat to a different range causing a lock-in of another relay in addition to those initially energized. They, of course, are held by their holding switches 44 so that current is no longer needed from the thermostat. This is accomplished by manually opening the thermostat cut-out switch 72. This also prevents any vibration caused by the starting of one engine on a multi-engine aircraft from affecting the thermostat of another engine when its contact arm 36 is adjacent the position of change from one temperature range to another. This switch operates independently of the starting switch. If the pilot or operator of the system does not want to cut off the thermostat T he does not open the switch 72, and the thermostat remains operative in the circuit so as to respond to any change in temperature conditions which might occur, for instance, between a false or attempted start and a second start. The false start may have raised the temperature of the engine somewhat so as to position the thermostat in a different temperature range.

In the event that the temperature is at or above

100°, the priming of the engine during starting is unnecessary. This is taken care of by the contact sector 42 only being in electrical engagement with the contactor arm 36 so that only the relay R^2 is energized. The relay R^2, when energized, cannot then energize the relay R^1 because there is no circuit from the lower end of the coil of relay R^1 through the contact sector 40. Accordingly, the only element of the priming mechanism which is energized is the booster pump motor M^2 through the cam C^2 so that a fuel supply is provided during the starting period and until the engine has attained sufficient speed for the main fuel pump P^1 to efficiently supply the requirements of the engine.

If the temperature range is between −30° and 20° the contactor arm 36 is free of all sectors of the thermostat, with the possible exception of sector 40. However, the relay R^1 can be energized only when the switch of the relay R^2 is closed against the lower contacts thereof in addition to the circuit established across the arm 36 and the sector 40. Therefore, none of the relays R^1, R^2 and R^3 is energized, and this results in the priming circuit from the wire 76 passing through the bridging contact of the relay R^2 in its upper position, and a wire 90 to the motor M^3 which drives the auxiliary primary fuel pump P^3. The pump will accordingly pump priming fuel from the tank T^2 through the conduits 22 and 16 and the check valve 24 to the priming jets of the engine, thus providing a more volatile fuel for easier starting at this temperature.

The solenoid S^2 will also be energized at this time because the bridging contact of the relay R^3 remains in its raised position and, therefore, current from the wire 76 can flow to the solenoid S^2 by way of wires 77 and 79. This compresses the spring 28 so that only the spring 26 opposes opening of the relief valve, and the spring 26 may have an effective pressure of 30 to 40 pounds, which is indicated as "Low Pressure" in Fig. 3. In other respects the timing cycle is the same, that is, the booster pump P^2 is operated its usual length of time, the ignition booster and the starter meshing circuits are energized their usual length of time, and priming is had over the usual time period. The signal 32 also lights during its usual last ten seconds of the starting cycle.

In the event that temperature is below −30°, it is desirable to avoid energizing the solenoid S^2 so that both springs 26 and 28 can be imposed on the relief valve RV to cause the pump P^3 to operate at high pressure, as indicated in Fig. 3 (60 to 75 pounds per square inch). This is accomplished by the contact segment 38 being engaged by the contactor arm 36 of the thermostat T so that the relay R^3 is energized to open the circuit for the solenoid S^2. In respects other than high pressure for the priming fuel from the tank T^2 rather than low pressure, the starting cycle in this case is the same as when the temperature range is between −30° and 20°.

After the starting cycle has been completed, and during which time any one of the starting sequences may have been performed, depending upon the position of the thermostat T, the master switch 60 can be manually opened and left in the open position until such time as the starting system is to again be used.

From the foregoing specification it will be obvious that I have provided an automatic starting system for internal combustion engines wherein the basic control unit is a sequence switch controlled as to initiation by a starting switch. The starting cycle can be stopped immediately at any desired time, and the sequence switch will be automatically reset to the starting position for the cycle. Ten seconds after the engine is firing regularly the relay R is deenergized to shut down the starting mechanism and return the sequence switch to proper position for another starting cycle.

If the temperature ambient to the engine has been raised due to an incomplete start, the thermostat T may be in a position for another range of temperature. No release of any of the relays R^1, R^2, and R^3 can take place, however, until the entire starting system is returned to its inoperative condition, due to the effect of holding contacts 44.

Each starting cycle is initiated in a very simple manner by a momentary depression of the starting button 56 to close the starting circuit. The switch 72 can thereafter be opened if desired to prevent vibration from causing improper operation of the relays R^1, R^2 and R^3 after they are initially operated in accordance with the position of the thermostat at the time of starting. The operated relays are thereafter held in by their own holding switches to the exclusion of the remaining relay or relays, as the case may be.

Some changes may be made in the construction and arrangement of the parts of my starting system without departing from the real spirit and purpose of my invention, and it is my intention to cover by my claims any modified forms of structure or use of mechanical equivalents which may be reasonably included within their scope.

I claim as my invention:

1. A starting system, for an internal combustion engine having priming means and fuel supply means, comprising temperature responsive control means, means for causing variations in characteristics of the fuel supplied to said priming means, means connecting said second named means in controlled relation to said temperature responsive means for initial actuation in accordance with the response thereof, and means preventing subsequent change in the response of said control means from further affecting said second named means.

2. A starting system, for an internal combustion engine having priming means, comprising temperature responsive control means, means for preventing operation of said priming means, means connecting said second named means in controlled relation to said temperature responsive means for initial actuation during periods when the temperature exceeds a selected value, and means preventing subsequent change in the response of said control means from altering the condition of actuation of said second named means.

3. A starting system for an internal combustion engine having priming means, a source of priming fuel, and means for maintaining at a selected upper value the pressure at which said fuel is supplied from said source, said system comprising temperature responsive control means; means for disabling said pressure maintaining means; and means connecting said disabling means in controlled relation to said temperature responsive means for actuation when the temperature is above a selected value.

4. A starting system for an internal combustion engine having priming means, a source of priming fuel at a first selected pressure, and means for reducing to a second selected value the pressure at which said fuel is supplied from

said source, said system comprising for operating said pressure reducing means, temperature responsive control means, and means connecting said operating means in controlled relation to said temperature responsive means so that said priming means is supplied with said fuel at said high pressure when the temperature is below a certain value and at said reduced pressure when the temperature is above said value.

5. A starting system, for an internal combustion engine having priming means and fuel supply means, comprising temperature responsive control means, means for determining characteristics of the fuel supplied to said priming means, means connecting said second named means to said temperature responsive means for actuation in accordance with the response thereof, and means for preventing subsequent change in said response for causing change in the previously determined characteristics of fuel.

6. A starting system for an internal combustion engine having priming means, a source of priming fuel at high pressure, and means for reducing the pressure at which said fuel is supplied from said source, said system comprising means for operating said pressure reducing means, temperature responsive control means, means connecting said further means in controlled relation to said temperature responsive means so that said priming means is supplied with said fuel at said high pressure when the temperature is below a first selected value, and at said reduced pressure when the temperature is within a selected range; means for preventing operation of said priming means; and means connecting said last named means in controlled relation to said temperature responsive means for actuation during periods when the temperature is above a second selected value.

7. A starting system for an internal combustion engine having priming means, sources of engine fuel and priming fuel at selected pressures, selective means for supplying fuel to said priming means from either of said sources, and means for reducing the pressure at which said priming fuel is supplied from the source thereof, said system comprising selective means for operating said pressure reducing means, temperature responsive control means, and means connecting said selective means in controlled relation to said temperature responsive means so that said priming means is supplied with said engine fuel during periods when the temperature is within a first selected range, with said priming fuel at reduced pressure during periods when the temperature is within a second selected range, and with said priming fuel at said selected pressure during periods when the temperature is below a selected value.

8. A starting system for an internal combustion engine having priming means, sources of engine fuel and priming fuel at selected pressures; selective means for supplying fuel to said priming means from either of said sources, means for preventing operation of said priming means, and means for reducing the pressure at which said priming fuel is supplied from the source thereof, said system comprising means for operating pressure reducing means, temperature responsive control means, and means connecting said operating means and said third named means in controlled relation to said temperature responsive means, so that said priming means is prevented from operating during periods when the temperature is above a first selected value, and is supplied with said engine fuel during periods when the temperature is within a first selected range, with said priming fuel at reduced pressure during periods when the temperature is within a second selected range, and with said priming fuel at said selected pressure during periods when the temperature is below a second selected value.

9. A starting system for an internal combustion engine having priming means, means maintaining a supply of engine fuel at a selected pressure, a source of priming fuel, pump means for supplying priming fuel from said source at a selected pressure, first motor means operable to actuate said pump means, means for conducting said engine fuel and said priming fuel to said priming means, normally closed valve means for preventing said engine fuel from reaching said priming means, and second motor means operable to open said valve means, said system comprising first and second relay means for causing and interrupting operation of said first and second motor means respectively, temperature responsive relay control means, means connecting said relay means in controlled relation to said temperature responsive means so that said first motor means is operated during periods when the temperature is below a selected value and said second motor means is operating during periods when the temperature is within a selected range, and means interconnecting said relay means so that said second motor means can open said valve only when actuation of said pump means by operation of said first motor means is interrupted.

10. A starting system for an internal combustion engine having priming means, a source of priming fuel, pump means for supplying said priming fuel to said priming means at a first selected pressure, first motor means operable to actuate said pump means, relief valve means for reducing to a second selected value the pressure at which said priming fuel is supplied by said pump means, and second motor means operable to disable said relief valve means, said system comprising relay means for causing and interrupting operation of said motor means, temperature responsive relay control means, and means connecting said relay means in controlled relation to said temperature responsive means so that said first motor means actuates said pump during periods when the temperature is below a selected value; and said second motor means disables said relief valve during periods when said temperature is within a selected range.

11. A starting system for an internal combustion engine having priming means, means maintaining a supply of engine fuel at a selected pressure, a source of priming fuel, pump means for supplying priming fuel at a selected normal pressure, first motor means operable to actuate said pump means, relief valve means for reducing to a second selected value the pressure at which said priming fuel is supplied by said pump means, second motor means operable to actuate relief valve means, means for conducting said priming fuel and said engine fuel to said priming means, normally closed valve means for preventing said engine fuel from reaching said priming means, and third, motor means operable to open said normally closed valve means, said system comprising: first, second and third relay means for causing and interrupting operation of said first, second and third motor means; temperature responsive relay control means; and means con-

necting said relay means in controlled relation to said temperature responsive means so that no fuel passes to said priming means during periods when the temperature exceeds a first selected value, so that engine fuel passes to said priming means during periods when the temperature is in a first selected range, so that priming fuel at said reduced pressure passes to said priming means during periods when the temperature is in a second selected range, and so that priming fuel at said normal pressure passes to said priming means when said temperature is below a second selected value.

MALCOLM P. ODELL.

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