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Camp

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[54] **STARTING CIRCUIT FOR ENGINE UTILIZING FUEL INJECTION PUMP**

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[51] **Int. Cl.**[2] **F02N 17/00**

[58] **Field of Search** .... 62/323; 123/179 L, 179 BG, 123/179 A, 179 B, 179 G, 179 H

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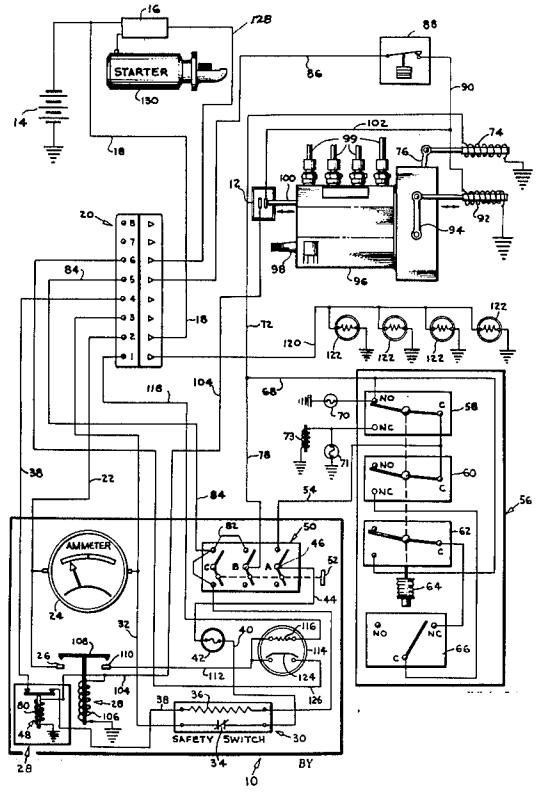
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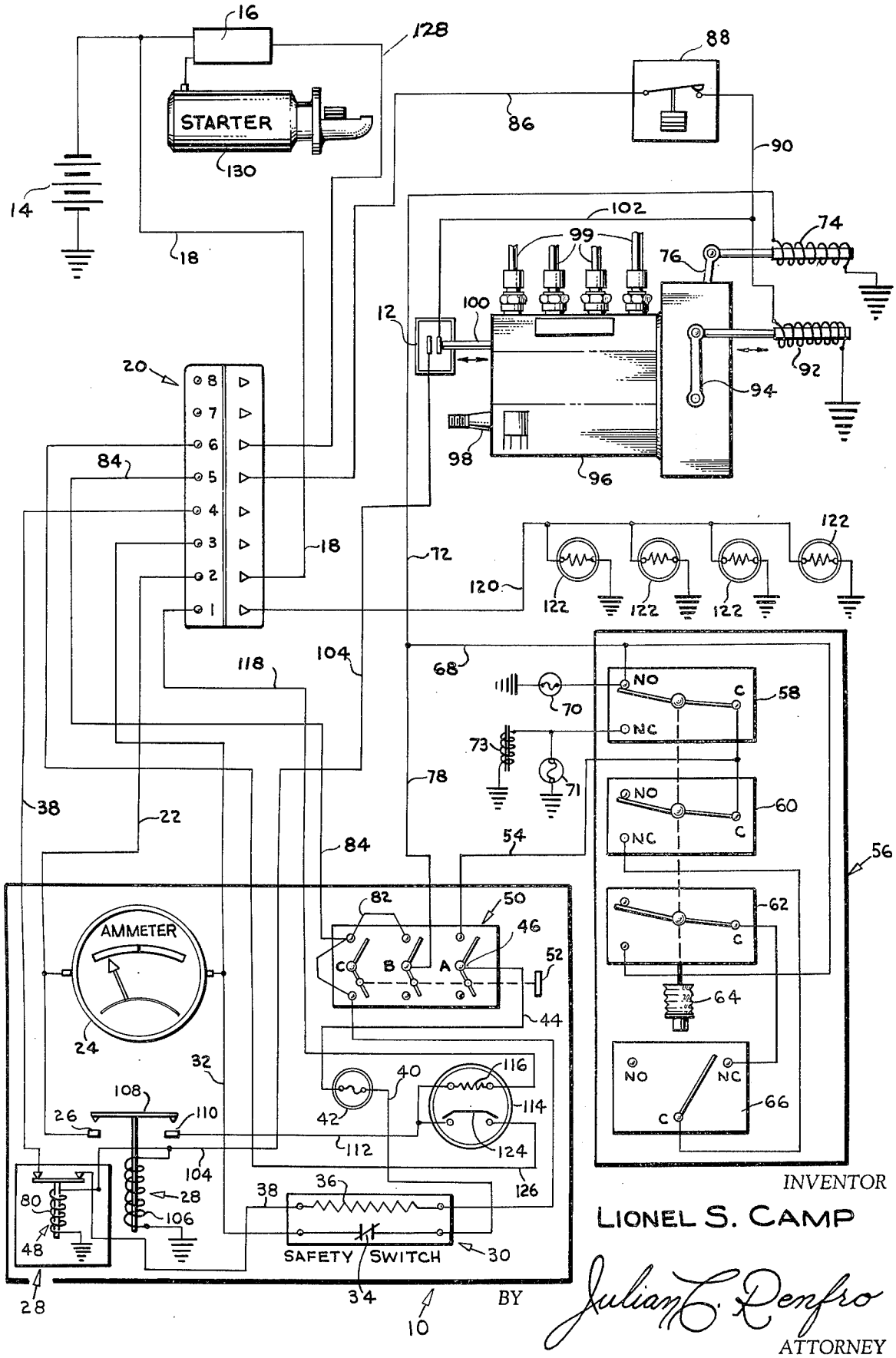
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[57] **ABSTRACT**

An automatic starting device for an engine that utilizes an injection pump for supplying metered quantities of fuel to the engine, with the arrangement being admirably suited for use in conjunction with the refrigeration apparatus of trucks engaged in carrying cargo such as meat or produce over great distances. Advantageously, my device can automatically restart the engine without damage each time a temperature-responsive means calls for the cooling (or the heating) of the cargo. This arrangement obviates the disadvantages of prior art refrigeration arrangements in that it enables the engine to be stopped at such times as the temperature requirements of the cargo have been met, rather than necessitating the engine having to run continuously as was previously necessary because of the difficulties heretofore associated with the restarting of such engines automatically. Significantly, the teachings of my device can be incorporated into existing equipment, with only a comparatively few component and connection changes being required in order to convert from the continuous run to the selective run cooling arrangement.

8 Claims, 1 Drawing Figure




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STARTER
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NO
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AMMETER
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C
B
A
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32
108
26
110
40
116
114
42
112
124
126
104
28
80
106
48
36
38
SAFETY SWITCH
30
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28
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STARTING CIRCUIT FOR ENGINE UTILIZING FUEL INJECTION PUMP

INTRODUCTION

This invention relates to an automatic starting device for an internal combustion engine that utilizes a fuel injection pump, and more particularly to a starting unit admirably suited for Diesel engine installations associated with refrigeration units on trucks and other vehicles, that ordinarily run for long periods of time.

Large interstate refrigeration trucks and the like are of course commonplace on the highways, with these trucks frequently carrying cargoes of meat, produce, flowers and other items that need to be maintained at a controlled temperature for prolonged periods of time in order to prevent spoilage.

These trucks are equipped with thermostatic arrangements such that temperature will be maintained within a range of a few degrees, and this of course includes the refrigeration of such cargoes as mentioned above when the truck is passing through warm zones, as well as the heating of the cargoes when passing through frigid regions.

Most people are not aware, however, that the Diesel engine mounted upon these trucks is ordinarily not shut off during the entire length of the journey, due to the difficulties of restarting same. Therefore, in order to prevent the cargo from being frozen (or overheated), it is necessary through the thermostatic control to arrange the refrigeration apparatus such that after the cargo has reached a suitable temperature, the refrigeration apparatus then works in an opposite manner, or in other words applies some heat to the cargo that is being refrigerated, or applies some chill to the cargo that is basically being heated, thus preventing temperature extremes from being reached in either instance. Thus, over a number of hours, the refrigeration apparatus will have cycled many times between the heating phase and the cooling phase of its operation.

It should be quickly apparent that an unnecessary amount of fuel is used during a long journey in order that the Diesel engine can be continuously operated. Additionally, it must be considered that an undesirable amount of dehumidification of the cargo takes place, and as an example, over a long run in which the cargo is beef, the loss of 200 lbs of weight of the beef in a large truck due to such dehumidification is not at all unusual. Therefore, it is quite customary to use ice in the truck to prevent extensive dehumidification of certain cargoes.

As an additional factor, the unnecessary hours the Disel engine runs in which it is applying heat to a cargo basically needing refrigeration or vice versa represents additional and needless wear and tear on the engine and the refrigeration equipment.

Various attempts have been made to design automatic starting devices for Diesel engines, but up into the present time at least, none of such devices has been successful because of the inability of such apparatus to terminate the cranking procedure in a timely manner and without damage to the engine or the starter. Consequently, all known manufacturers of truck refrigeration equipment have taken it for granted that the equipment would run continuously through the duration of the trip, with the refrigeration controls cycling frequently.

In accordance with the present invention, I have provided a novel electrical switch arrangement such that

appropriate electrical contact is broken to terminate the cranking procedure at such time as the diesel engine being started has reached a low operational speed such as 250 to 400 rpm, thus effectively making possible an automatic starting of the engine when the temperature of the cargo necessitates same, with such starting taking place without damage to any component or involving overspeed.

This automatic starting is accomplished by my novel electrical arrangement that advantageously utilizes most of the components and wiring found on conventional control panels. Thus, it is entirely feasible to take advantage of my invention on existing equipment, with the changeover from the continuous run to the selective run of the engine in order to take advantage of the present teachings ordinarily not costing more than $100 to $200.

An important part of my invention involves an electrical switch that is mounted adjacent the injector pump of the diesel engine in such a manner that the switch is electrically closed when the injector pump has been moved to a starting position, with this switch causing current to be delivered to the starter so that it will cause the engine to turn over. Then, when the engine has reached a speed sufficient that the rack of the injector pump moves to prevent overspeed, the electric circuit is broken by this switch to terminate the cranking procedure.

Quite obviously my invention entails an arrangement in which the above mentioned switch is only one functional part, for most Diesel engines used for refrigeration employ a glow plug in each cylinder that is caused by the passage of electric current to reach near incandescence, so that when the engine is subsequently caused to turn over, the glow plugs will cause the engine to commence firing. Accordingly, part of my circuit entails an arrangement such that early in the starting sequence the glow plugs are activated, with the circuit in which the starter is disposed not being closed until such time as the glow plugs have reached a suitably high temperature, thus preventing unnecessary cranking.

Other aspects of my invention entail various safety switches and the like, but with the basic arrangement being such that most of the components of the refrigeration circuits presently in use are carried over and utilized in conjunction with the components peculiar to this invention.

Accordingly, it is a basic object of my invention to provide an automatic starting device for a Diesel engine.

Another object of my invention is to provide a control for a Diesel refrigeration unit such that the engine will be started when a thermostat calls for cooling or heating, and then the engine will be turned off when the temperature requirement has been satisfied.

Yet another object of my invention is to provide a refrigeration unit control such that the running time of the engine will be minimized.

Still another object of my invention is to provide a refrigeration unit for a vehicle or the like that makes it possible to minimize running time, and thus make it possible to avoid excessive dehumidification of the cargo and excessive use of fuel.

Yet still another object of my invention is to provide an automatic starting and stopping of the engine associated with the refrigeration unit, utilizing a control panel that can be exchanged for present day by control pan-

els with only a minimum of installation difficulty, thus making it a simple matter to change over from present-day system to my highly advantageous arrangement.

A still further object of my invention is to provide a refrigeration arrangement for a truck or the like such that at all operating times of the engine, the engine will be operated in the high speed regime, thus eliminating the low-speed operation that is presently employed during certain phases of operation of conventional equipment.

These and other objects, features and advantages will be more apparent from a study of the appended drawing of an exemplary embodiment of my invention.

DETAILED DESCRIPTION

Turning to the FIGURE of drawing, it will be seen in this exemplary embodiment of my invention that the panel **10** contains most of the novel components of my invention, with the rest of the circuit components being in accordance with the prior art except for the switch **12** associated with the rack of the injection pump **96,** and certain wiring associated therewith, as discussed hereinafter.

Current is supplied from a battery **14,** with typically the negative terminal connected to ground, and the positive terminal connected to supply current to the starter solenoid **16** as well as to the panel **10.** Latter is accomplished by means of a lead or wire **18** that carries current from the battery to a terminal or connector **20.** This latter device for example may be a Jones plug, and may have eight terminals, as shown, or may have more. It will be noted by those skilled in the art that for the sake of simplicity, I have omitted showing certain connections to and through the plug **20** inasmuch as such are of no concern to this invention.

The lead or wire **18** may for example connect to terminal **2** of the plug or connector **20,** and thence through the plug to lead **22,** that in turn connects to the Ammeter **24** and to inlet terminal **26** of preheat relay **28.** It should be noted that control panels in accordance with the prior art contain the Ammeter **24** and the relay **28,** with the Ammeter having a current carrying shunt (not shown) so that current can pass through the device **24** and thence to the safety switch **30** by means of a lead or wire **32.** The Ammeter may for example be a device manufactured by Autolite or Hobbs, with this device of course serving to indicate the charging rate of the battery **14** by the generator or alternator (not shown) associated with the Diesel engine with which this invention may be used.

The safety switch **30** is of conventional construction, manufactured for example by Cutler Hammer, and having a normally closed switch **34** therein to enable current to pass therethrough except in case of a significant malfunction. A filament **36** in switch **30** is connected by means of a lead **38** via relay **48** discussed hereinafter to terminal **4** of plug **20,** and thence to a circuit (not shown) associated with the sensing of any overheating of the water in the engine block and/or any drop in the oil pressure of the engine. Should overheating occur, or oil pressure be lost, the filament **36** will heat and open the switch **34,** shutting off the engine by causing the fuel cutoff solenoid **92** to move to cut off fuel to the engine. However, the switch **30** is disabled during the starting procedure by the relay **48** to prevent undesirable shut-down, as will be made clear as the description proceeds.

Current passing through safety switch **30** then flows via lead **40** to fuze **42,** which device serves in a conventional manner to open the circuit to the fuel cutoff solenoid **92** and thus stop the engine in the event of an overcurrent.

Current passing through the fuze is carried by lead or wire **44** to the input terminal **46** of a control switch **50** provided to the control panel **10** in accordance with this invention. The control switch preferably utilizes three sets of switch contacts A, B, and C ganged together and operated by a common button or lever **52,** which may for example be pushed by the operator to close the contacts of these three switches, and pulled to cause them to open. When the button has been pushed to cause the switch contacts to close, current is carried from the input terminal via contacts A to lead **54,** which in turn carries current to the thermostat assembly **56.** This temperature-sensitive electrical device is provided in accordance with the prior art, and for example may be such types as manufactured by Partlow or Unitrol. It comprises a heat and cool switch **58,** and a pair of switches **60** and **62.** Each of the switches **58, 60** and **62** has a movable contactor portion, moved by operation of bellows **64** located in the compartment to be refrigerated, and these switches are sequentially operated.

When the contactor of the heat-cool switch **58** is in the closed or N.O. position shown, which is the position in which cooling effort is to be brought about, current supplied by lead **54** is carried by this contactor to lead **68,** as well as to a cool light **70** that serves to indicate that cooling is being called for. Lead **68** in turn connects to a lead **72** that carries current to the throttle solenoid **74,** which device is provided in accordance with the prior art in order for either the high speed or the low speed regime to be selectable, but which device is now always in the high speed position when the engine is running. Current also flows from lead **68** to lead **78** and thence through contacts B of the control switch **50** (when in the closed position) to the jumper **82** and thence to lead **84** that connects to terminal **5** of the Jones plug **20.** Current flowing through this terminal then flows into lead **86** and thence through the high pressure cutout **88,** which is a normally-closed switch provided in accordance with the prior art in order to shut down the engine should the pressure of the freon on the high side of the compressor become excessive. current passing through the cutout **88** then flows via lead **90** to the fuel cutoff solenoid **92.** Current flowing through this solenoid causes the fuel lever **94** to be moved in the direction calling for fuel. The fuel controlling device **94** is to be regarded as a part of the injection pump **96,** such as may be made by Bosch. Power for bringing about the operation of the injection pump **96** is supplied from the engine, into the camshaft **98,** the rotation of which causes fuel to be metered from the four pressure lines **99** of the device to the fuel injectors of the engine in a conventional manner. Extending from the injection pump is a control rod **100,** which is a part of the rack of the injection pump. The rack is caused to move in a left-right sense in response to movement of the fuel lever, which movement is to the left, as viewed in this drawing, when more fuel is being called for.

This movement to the left of control rod **100** is such as to close the contacts of switch **12** provided in accordance with this invention, thus completing by means of leads **102** and **104** provided in accordance with this in-

vention, the circuit from lead **90** to the solenoid **106** of normally-open preheat relay **28,** and also to solenoid **80** of relay **48.** Current flowing through the solenoid **106** causes contactor **108** to close, thus interconnecting contact **26,** previously mentioned, with contact **110.** This of course enables current to flow the battery **14** via lead **18,** terminal **2** of the plug **20,** the lead **22,** the preheat relay and the lead **112** to the heat actuated switch **114.** Latter switch is not per se novel, but does represent a modification of the heat actuated switch customarily provided in starter panels of the prior art. This is to say, not only does the heat actuated switch **114** have a heating means in the form of a filament **116** connected via lead **118,** terminal **1** of the plug **20,** and lead **120** to the glow plugs **122,** but also the switch **114** has a heat-sensitive circuit-closing means, such as a klixon device **124** that is positioned so as to be sensitive to and effected by the heat generated by filament **116.** Thus, upon the contactor **108** closing, the filament **116** as well as the glow plugs **122** are caused to heat, for the filament **116** is in series with the plugs, although the plugs are of course in a parallel arrangement with respect to each other. When the filament has put out a certain amount of heat, or in other words, has reached a certain pre-established condition of heating, the heat-sensitive klixon device is caused to actuate and close, and thus connect the lead **112** to lead **126,** that in turn connects via terminal **6** of plug **20** to lead **128** that is attached to the starter solenoid **16.** The starter solenoid, upon being energized, is caused to actuate and thus bring about the cranking of the engine by the starter **130.** Cranking continues until such time as the engine has reached sufficient speed, say 250 to 400 rpm, that the rack of the injection pump moves to open switch **12** and deprive the coil **106** of current necessary to hold contactor **108** closed. At this point, the relay **28** opens, immediately terminating the action of the starter **130.**

It should be noted that at certain times it is desirable to prevent the operation of the safety **30,** which might undesirably serve to shut down the engine during the preheating sequence, due to low engine oil pressure at that time. Accordingly, and as mentioned hereinbefore, I utilize a relay **48** which will serve at those certain times to open the circuit in which lead **38** is involved, thus to deprive the filament **36** of current and in turn preventing contacts **34** from opening. The relay **48** is normally closed, and has a solenoid winding **80** which is energized at such time as the solenoid winding **106** is energized, which of course is as a result of current carried by lead **104** upon the switch contacts **12** closing. This relay is of course different than relay **28,** which is normally open. Therefore, at such time as current is delivered to solenoid winding **28** to close the contactor **108** and cause the heat actuated switch to be energized as part of the starting sequence, the solenoid winding **80** is energized to cause the contactor of relay **48** to open and thus prevent undesirable engine shutdown.

Operation of my device is as follows:

The operator, when he wishes to cause the operation of the unit, presses the button **52** to cause the switches A, B and C to close. These switches remain closed throughout the journey. The closing of the switches causes current to flow via control switch **50,** the fuze **42,** the safety switch **30,** the Ammeter **24,** and the terminal or plug **20** from the battery. Current reaching the control switch is carried through the now-closed contacts A to the thermostat assembly **56,** which, if cooling (or heating) is being called for, causes current to reach the throttle solenoid **74.** Current also reaches the fuel cutoff solenoid **92** at this time via the contacts B of the control switch **50,** which solenoid causes the control rod **100** of the rack of the injection pump to move to the starting position, thus to close the contacts of electric switch **12,** and cause the preheat relay **28** to actuate and supply current from the battery to the heat actuated switch **114.** Only when current is flowing through the solenoid **92** is the fuel shutoff control **94** moved to a position such that the engine can operate.

At this time, the glow plugs **122** in the engine are caused to heat, as is the filament **116** caused to heat. When filament **116** gets hot enough, the klixon device **124** operates to cause the solenoid **16** of the starter **130** to actuate, and thus bring about cranking of the engine.

Cranking will continue until such time as the injection pump comes up to a certain speed, this device of course being driven by the engine. When the engine reaches a speed of approximately 250 to 400 rpm, indicating of course that it has been started by the efforts of the starter, the governor portion (not shown) of the injection pump will be caused to operate, and to move the rack and control rod **100** in the speed-decreasing direction. This of course allows the contacts of switch **12** to open, and thus immediately terminate the starter operation by depriving the coil **106** of current and thus allowing the opening of the preheat relay **28.** Relay **28** opening serves to cut off the current to the glow plugs **122** and to the starting circuit, which of course deprives the starter solenoid of current.

The engine now runs to cool (or heat) the produce, until such time as the thermostat assembly indicates that the temperature requirements have been satisfied. At this time, the circuit is broken by the contactor of relay **58,** which cuts off current to the solenoid **92** to deprive the engine of fuel. However, the control switch **50** remains in the closed or operative position.

The engine can now remain shut off, thus conserving fuel, until the bulb **64** of the thermostat assembly again calls for effort by the cooling system. At such time as the contactor of switch **58** again closes, the starting procedure described above can again commence.

It should be noted that my starting device is operative to bring about selective heating of the cargo, such as when the truck so equipped is passed through a frigid zone. When upper switch **58** of the thermostat assembly **56** is in the position shown, cooling is brought about, whereas when it moves to the lower or NC position, this means that the cooling requirements have been met. The bulb **71** is caused to light to indicate such fact, and more importantly, pilot solenoid **73** is energized by the switch **58** moving to the NC position. Latter solenoid is associated with the heat valve (not shown), which brings about the heating cycle.

Warming of the cargo will not cause the switch **58** to return to the N.O. position for resumption of the cooling cycle, whereas if sub cooling instead should occur, due for example to the truck passing through a frigid zone, switch **60** will move to its lower or NC position, and direct current to switch **66,** which is a heat lockout switch that is closed above 10°F. Presuming it being closed, current is fed to the common connection of switch **62.** Should yet more cooling take place, switch **62** moves to the lower position, in which current is supplied to lead **68.** From this point, the starting sequence commences in the previously-described manner.

With regard to the electric switch **12** provided in accordance with this invention, the body of this switch may be mounted in the "thimble-like" member (not shown) threadedly attached to the injection pump housing at the location of the control rod **100.** I prefer for the switch to be of a magnetic closing type in order to prevent loading of the control rod as it moves to the position corresponding to the engine-starting position.

I claim:

1. In combination with an engine, a starting device that automatically accomplishes a starting cycle for said engine and utilizes a battery driven electric starter, and a fuel injection pump for supplying metered quantities of fuel to the injectors associated with the cylinders of the engine, said device comprising an electric switch mounted in operative relation with said injection pump, said injection pump having a control rod, said electric switch being moved to a circuit-closing position upon said control rod being moved to a position corresponding to an engine-starting position, and being opened by said control rod being automatically caused to move away from the latter position, and electrical circuit means interconnecting said electric switch with the battery and starter of the engine, whereby upon said electric switch being closed, the cranking of the engine by the starter is caused to commence, and upon the engine reaching a certain speed, said electric switch is caused by the inherent operating characteristics of the injection pump to be opened and thus cause an immediate cessation of the engine cranking effort.

2. The starting device as defined in claim **1** in which glow plugs are utilized in the cylinders of the engine for assisting in the starting of the engine, said starting device additionally including a heat actuated switch for controlling the heating of the glow plugs, latter switch containing heating means arranged to heat with the heating of the glow plugs, as well as having heat-sensitive circuit-closing means adjacent said heating means and disposed in said circuit interconnecting the battery and the starter, said circuit between battery and starter being closed by said circuit-closing means to bring about engine cranking effort at such time as the glow plugs and heating means have reached preestablished conditions of heating.

3. The starting device of claim **2** in which a control panel containing a preheat relay is utilized, said preheat relay, when in the electrically closed position, completing the circuit to said heat-actuated switch, said preheated relay being closed by the closing of said electric switch, and thereafter being opened upon the engine attaining speed, to deprive to heat-actuated switch of current, thus to cause a cessation of cranking effort.

4. The starting device as defined in claim **1,** that is utilized in conjunction with a refrigeration unit, a temperature-sensitive electrical device disposed to bring about operation of said starting device in the presence of a requirement for heating or cooling, said fuel injection pump having solenoid means that must be energized in order for the engine to run, said temperature-sensitive electrical device being arranged to cause said solenoid means to be energized at such time as a temperature requirement is to be met.

5. An autocmatic starting device for automatically accomplishing a starting cycle for an engine that utilizes a fuel pump for supplying metered quantities of fuel and which pump has a control rod that is in an extended position when the engine is not operating, and in a retracted position when the engine is operating at a selected speed, said engine also having a battery, an electric starter, and electrically heated glow plugs for preheating the engine prior to energizing the starter, said starting device comprising:

a. normally open starter switch means, said switch means in operative electrical connection with the starter and the battery;

b. electrical heating means disposed closely adjacent said starter switch means, said starter switch means being actuated to a closed position by the heat generated by said electric heating means at a predetermined temperature thereof, said electric heating means being connected in series with the glow plugs and arranged to reach such predetermined temperature coincident in time with such glow plugs achieving a selected engine preheat temperature;

c. starting cycle switch means, said starting cycle switch means being connected functionally in series with said electric heating means, and arranged to be in a closed position when the pump control rod is in an extended position, and to be in an open position when the control rod is in a retracted position; and

d. temperature-responsive switch means, said temperature-responsive switch means being connected in series with said starting cycle switch means and electrically connected to the battery.

6. An automatic starting device for automatically accomplishing a starting cycle for a Diesel engine at a selected temperature, the engine having a battery, an electric starter, a fuel injection pump, the pump having a control rod that is in an extended position when the engine is non-operating and in a retracted position when the engine is operating at a selected speed, and electrically heated glow plugs for preheating the engine prior to energizing the starting motor, said starting device comprising:

a. starter switch means, said starter switch means, when in a closed condition, being arranged to connect the starter to the battery;

b. electric heat means, said electric heat means connected cooperatively to the glow plugs and arranged to close said starter switch means at the time such glow plugs achieve a predetermined engine preheat temperature;

c. starting cycle switch means, said starting cycle switch means in operative electrical connection with said electric heat means and controlled by the control rod; and

d. temperature-responsive switch means in operative electrical connection with said starting cycle switch means and the battery.

7. A starting device for an engine that utilizes an electric starter, electrically heated glow plugs for preheating the engine prior to energizing the starter, and a fuel injection pump for supplying metered quantities of fuel, which pump has a control rod that is in an extended position when the engine is not operating, and in a retracted position when the engine is operating at a selected speed, said starting device comprising: an electric switch mounted in operative relation with the control rod of the injection pump, said electric switch being moved to a circuit-closing position when the control rod is in the extended position, and being opened when the control rod is in the retracted position, a preheat relay electrically connected with said electric switch, said preheat relay being energized to move to a

circuit closing position by the closing of said electric switch and to a circuit opening position by the opening of said switch, a heat actuated switch connected in the circuit closed by said preheat relay, said heat actuated switch containing heating means arranged to heat and reach an elevated temperature essentially coincidentally with the heating of the glow plugs and also having heat-sensitive circuit closing means adjacent latter means, latter circuit closing means being disposed in the circuit interconnecting the starter with its power source, latter circuit being closed by said heat sensitive circuit-closing means to cause cranking efforts by the starter at such time as the glow plugs and heat sensitive means have reached a pre-established condition of heating, said preheat relay being caused to open and thus bring about the cessation of such cranking efforts by the starter as a result of the subsequent opening of said electric switch.

8. The starting device as defined in claim **7** in which a temperature-sensitive electrical device is utilized for bringing about the operation of said starting device in the presence of a requirement for heating or cooling, said fuel injection pump having solenoid means whose energization is responsible for placing said control rod in the position corresponding to an engine-starting position, said temperature-sensitive electrical device being arranged to cause said solenoid means to be energized at such time as a temperature requirement is to be met, and correspondingly causing the de-energization of said solenoid means at such time as the temperature requirement has been met, thus causing the engine to be shut down until such time as another temperature requirement has become mainfest.

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