Feb. 28, 1950 T. O. LILLQUIST 2,499,319

ENGINE PROTECTIVE CONTROL SYSTEM

Filed July 3, 1944

2 Sheets-Sheet 1

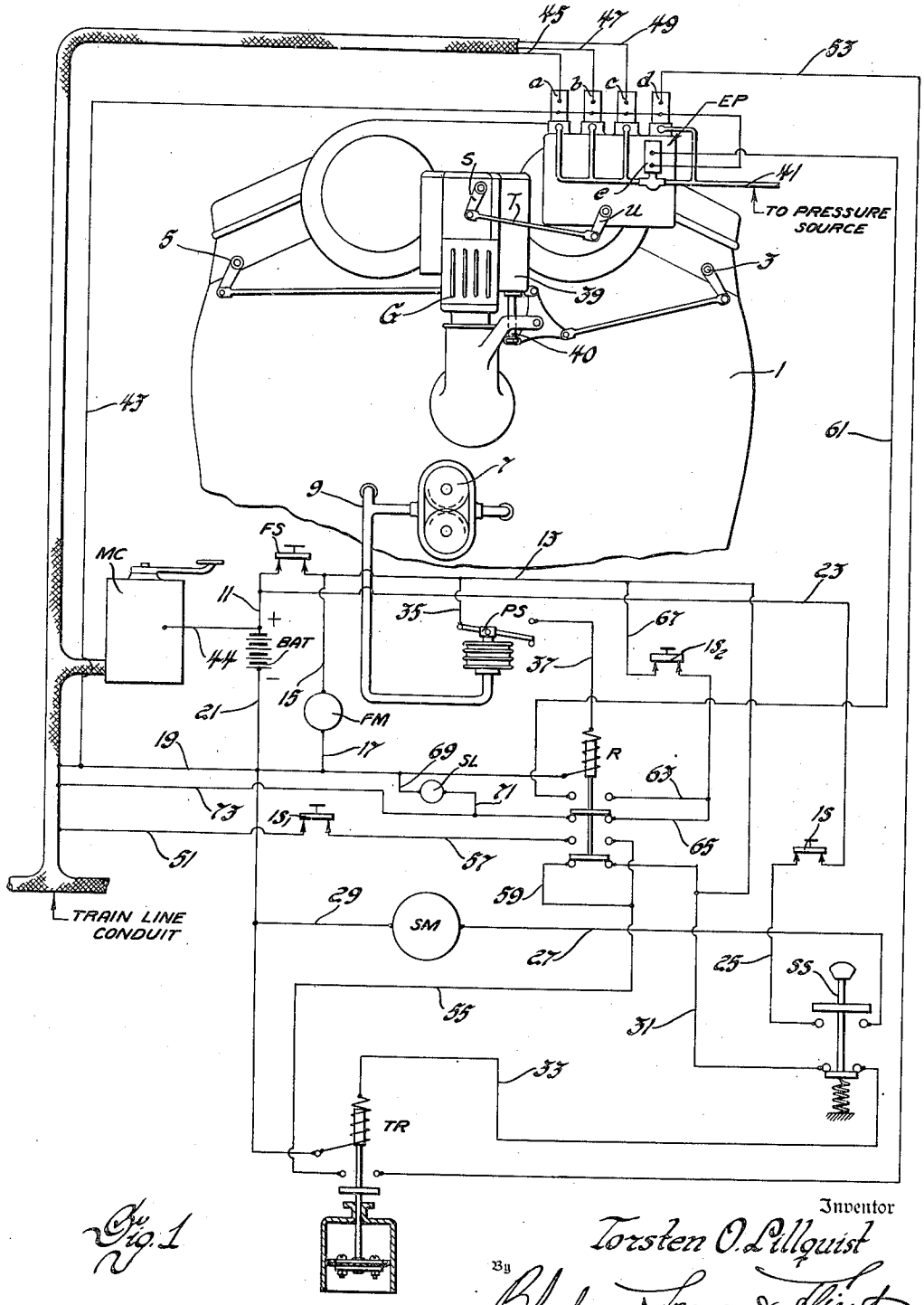


Fig. 1

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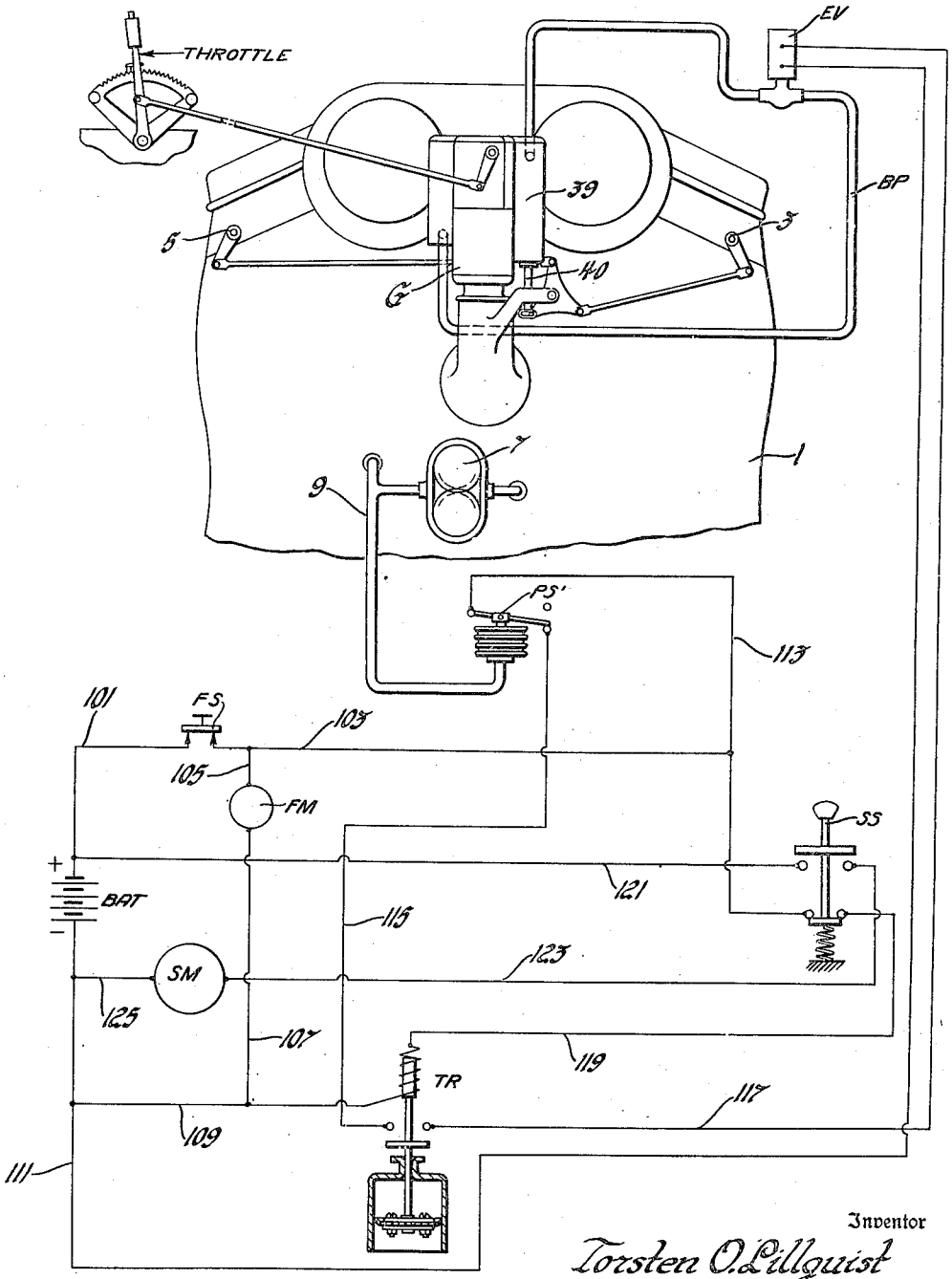


Fig 2

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ENGINE PROTECTIVE CONTROL SYSTEM

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10 Claims. (Cl. 123—179)

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The present invention generally relates to engine protective means and more particularly to protective means for automatically causing shut down of an engine when the engine lubricating oil pressure falls below a predetermined safe operating value.

It has been found that conventional pressure operated gauges and signal alarm devices for indicating improper lubrication of an engine are frequently overlooked and damage to the engine results, especially where engines are operated in multiple and are located on separate units of a multi-unit locomotive or in different compartments of a ship.

The object of the present invention is to provide simple engine protective control means whereby the engine may be started, shut down or operated at any speed by manually operable control means, as long as the engine is properly lubricated but is shut down automatically when improperly lubricated by the provision of pressure responsive control means which also permits re-starting and operation of the engine for a limited time only, as long as the engine is improperly lubricated.

The protective control means by which the above object is accomplished will become apparent by reference to the following detailed description and drawings illustrating two types of engine protective control means.

Figure 1 of the drawings is a diagrammatic showing of an engine protective control system adapted for use on an engine which is provided with remotely controlled speed setting means whereby the engine may be conveniently controlled and operated in multiple with other engines provided with similar protective control means, and

Figure 2 of the drawings is a diagrammatic showing of an engine protective control system adapted for use on an engine in which the speed setting is operated directly by a hand throttle.

In Figure 1 a Diesel engine 1 is shown provided with rotatable fuel control shafts 3 and 5 for varying the fuel supplied to the engine in order to vary the speed and load thereof and an engine driven lubricating pump 7 for supplying lubricating and cooling oil under pressure to the engine parts through a pressure delivery pipe 9. An oil pressure responsive switch PS having normally opened contacts is connected in the oil supply pipe 9 so that the switch contacts will be moved to a closed position to permit normal manual control of the engine speed or shut down of the engine only when the engine lubricating oil pressure reaches a preselected safe value. The pressure switch contacts are opened upon a reduction in the lubricating oil pressure below the preselected safe value to cause the engine to be shut down automatically and also to permit re-starting and operation thereof for a limited time as long as the lubricating pressure is less than the preselected safe value.

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The engine is supplied with fuel by a suitable fuel pump, not shown, which is driven by a fuel pump motor FM adapted to be connected to a battery BAT by closure of a manually operable fuel pump control switch FS. The fuel pump motor FM and switch FS are connected in series across the battery BAT by conductors 11, 13, 15, 17, 19 and 21.

An engine starting motor SM, a starting switch SS and an isolation switch IS are connected in series across the battery by conductors 11, 23, 25, 27, 29 and 21. The starting switch is shown provided with two sets of stationary contacts and cooperating contacts movable upon depression of an operating handle against the action of a suitable spring to cause the upper pair of stationary contacts to be bridged in order to control energization of the engine starting motor and to cause opening of the lower pair of switch contacts which serve as control contacts. The spring provided on the starting switch SS normally serves to cause closure of the lower control contacts and the opening of the upper starting motor control contacts. The normally closed control contacts of the starting switch SS are connected in series relation with the actuating winding of a time delay relay TR across the battery BAT by conductors 11, 13, 31, 33 and 21.

The time delay relay TR is shown provided with a normally open pair of stationary contacts, an armature contact having a suitable dashpot associated therewith for delaying upward movement of the armature contact into bridging relation with the stationary contacts upon energization of the relay winding but permitting unrestrained downward movement of the armature contact to cause quick opening of the relay contacts.

The normally open contacts of the lubricating oil pressure switch PS are connected in series with the actuating winding of a relay R across the battery by conductors 11, 13, 35, 37, 19 and 21. The relay R is shown provided with four pairs of stationary contacts and an armature having two contacts normally bridging the stationary pair of contacts second from the top and the lower pair, and movable upwardly out of contact with these

stationary contacts and into bridging relation with the stationary upper pair of contacts and the stationary pair of contacts second from the bottom upon energization of the relay winding. The relay R controls engine speed and shut down control means, to be described, and also controls illumination and a signal alarm light SL when the relay winding is deenergized by the opening of the contacts of the pressure switch PS upon a drop in engine lubricating oil pressure below the preselected safe value.

The engine speed and shut down control means comprises a governor G of conventional type having the usual governor pilot valve operated by the engine driven governor fly weights, not shown, for controlling the pressure in a hydraulic power cylinder 39 associated with the governor and including a plunger 40 which is shown operatively connected by suitable levers and links to the engine fuel control shafts 3 and 5. The plunger 40 is biased by a suitable spring to normally move the fuel control shafts 3 and 5 to shut off fuel to the engine to cause shut down thereof and the plunger is moved by pressure in the cylinder 39 to cause operation of the engine at any one of a plurality of preselected values of constant speed or shut down of the engine depending upon the governor speed setting adjustment in a well known manner. The governor G is shown provided with a conventional speed setting lever S.

Electropneumatic governor speed setting control means, generally indicated at EP, comprising four electropneumatically actuated elements *a*, *b*, *c* and *d* and connecting linkage, similar to that shown in Figure 3 of United States Patent 1,871,163, Dilworth, are provided to actuate the governor speed setting lever S. The governor speed setting lever S is connected by a link T and a lever U equivalent to the throttle valve lever 3 of the Dilworth patent, so that the governor speed setting lever S may be set to various speed setting positions between idle and maximum and to an engine shut down position to cause operation of the engine 1 in a well known manner at constant values of speed between idle and maximum and to cause shut down of the engine by the action of the governor. This linkage is arranged to cause shut down only when the electropneumatic means *d* is electrically energized to cause pressure application thereto, and to cause operation of the engine at idling speed when all of the electropneumatic means *a*, *b*, *c* and *d* are deenergized and inoperative, and to cause operation of the engine at preselected values of constant speed above the idle value when the means *d* is energized and pressure operated in combination with any of the other electropneumatic means *a*, *b* and *c*. The means *d* is shown connected directly to an air pressure supply pipe 41, and an electromagnetic shutoff valve *e* is shown connected between the pressure pipe and separate supply pipes connected to each of the electropneumatic means *a*, *b* and *c* so that these means are rendered inoperative when the shutoff valve *e* is deenergized and the electropneumatic means *d* is energized to cause shut down of the engine. One terminal of each of the electrical windings of the means *a*, *b*, *c*, *d* and *e* is connected by a conductor 43 to the conductor 19, which serves as a negative control conductor and is shown entering the train line conduit and connected to the conductor 21 which is connected to the negative battery terminal.

A manually operable master controller MC is provided with suitable electrical contacts connected between the positive battery terminal and

each of the other winding terminals of the means *a*, *b*, *c* and *d* by a positive control conductor 44 and positive train line conductors 45, 47, 49 and 51 so that these electropneumatic means may be selectively energized and pressure actuated in the previously described manner to cause operation of the engine at different preselected values of constant speed or to be shut down. The other winding terminals of the electropneumatic means *a*, *b* and *c* are shown connected respectively to positive train line conductors 45, 47 and 49, shown entering the train line conduit. The other winding terminal of the electropneumatic means *d*, causing shut down of the engine, is connected in series relation with the stationary contacts of the time delay relay TR and stationary pair of contacts second from the bottom of the relay R and also with another isolation switch IS1 to the positive train line conductor 51 by conductors 53, 55 and 57. One contact of the lower pair of stationary contacts of the relay R is connected to the conductor 31 and the other is connected by a conductor 59 to the conductor 55. The other winding terminal of the pressure shutoff valve *e* is connected by a conductor 61 to one of the upper pair of stationary contacts of the relay R and the other contact of this pair is connected by a conductor 63 to a conductor 65 which is connected between one of the stationary contacts of the relay R second from the top and one contact of another isolation switch IS2, the other contact of which is connected by a conductor 67 to the conductor 13. The signal alarm light SL, previously mentioned, is connected by conductors 69 and 71 between the negative train line conductor 19 and a signal light train line conductor 73, which is connected to the other stationary contact of the relay R second from the top.

With the fuel pump switch FS and isolation switches IS, IS1 and IS2 closed and the engine shut down the following control means are energized. The fuel pump motor FM is energized through the conductors 11, 13, 15, 17 and 19 and fuel is supplied to the engine so that it may be started. As there is no lubricating oil pressure supplied by the engine pump 7 when the engine is shut down the oil signal train line conductor 73 will be energized through the normally closed contacts of the relay R second from the top and conductors 11, 13, 67 and 65 and the signal light will accordingly be illuminated as it is connected by the conductors 69 and 71 connected between the signal train line and negative train line conductor 19. It will be evident that the signal lights provided for other engines connected to these train line conductors will likewise be illuminated when any engine is shut down. The winding of the time delay relay TR is also energized through the normally closed lower control contacts of the engine starting switch SS and conductors 11, 13, 31, 33 and 21 to cause closure of the contacts of the time delay relay thereby causing energization of the winding of the electropneumatic means *d* through these contacts and conductors 11, 13, 31, 59, 55, 53, return conductor 43, negative train line conductor 19 and negative battery conductor 21. Energization of the electropneumatic means *d* causes application of pressure thereto through the pressure pipe 41 and operation thereof and therefore movement of the governor speed setting means to the engine shut down position.

Normally the engine is started by opening the isolation switch IS2 and movement of the master controller handle to the idle speed controlling

position after which the handle of the starting switch SS is depressed. Opening the isolation switch IS2 deenergizes the oil signal train line conductor 73 to prevent illumination of the signal lights SL connected thereto and also opens the energizing circuit to the pressure shutoff valve *e* through the upper contacts of the relay R to prevent energization of the valve and application of pressure and operation of the electropneumatic means *a*, *b* and *c* upon closure of these relay contacts thereby to prevent operation of the engine above the idle speed value when it is started.

Depression of the handle of the starting switch SS causes closure of the upper pair of switch contacts and the opening of the lower pair of control contacts. Closure of the upper contacts causes energization of the starting motor SM through the conductors 11, 23, 25, 27, 29 and 21 to cause starting and operation of the engine at idle speed.

Upon starting of the engine the handle of the starting switch is released and the switch spring causes opening of the upper contacts to deenergize the starting motor and closure of the lower control contacts which cause reenergization of the winding of the time delay relay and upward movement of the armature thereof resisted by the action of the relay dashpot. This delaying action of the dashpot prevents closure of the time delay relay contacts until the engine lubricating oil pressure reaches the preselected safe value necessary to cause closure of the pressure switch contacts which causes energization of the winding of the relay R and closure of the upper pair and pair of contacts second from the bottom of this relay. If the oil pressure does not reach this preselected safe value prior to the delayed closure of the contacts of the time delay relay TR the pressure switch PS and relay R contacts will remain in the normal position shown and the winding of the electropneumatic means *d* will be reenergized through the normally closed lower contacts of the relay R, the closed contacts of the time delay relay and conductors 11, 13, 31, 59, 55, 53, 43, train line conductor 19 and negative battery conductor 21 to again cause shut down of the engine by delayed closure of the contacts of the time delay relay TR. The engine after starting accordingly operates at idling speed during the interval between closure of the control contacts of the starting switch SS and subsequent closure of the time delay relay contacts if the engine lubricating oil pressure does not build up to the preselected safe value prior to delayed closure of the contacts of the time delay relay. If, however, the engine oil pressure does build up normally to this preselected safe value, closure of the pressure switch contacts occurs before closure of the contacts of the time delay relay. This closure of the pressure switch PS before closure of the contacts of the time delay relay TR causes energization of the winding of the relay R through conductors 11, 13, 35, 37, 19 and 21 and the opening of the lower contacts of the relay R. As the lower contacts of the relay R are connected by conductors 59, 55 and 53 in series circuit relation with the time delay relay contacts and electropneumatic engine shut down means *d*, this means is not energized and consequently remains inoperative upon subsequent closure of the time delay contacts thereby preventing shut down of the engine. As mentioned above, energization of the winding of the relay R also causes closure of the upper relay contacts and

if, after starting of the engine, the isolation switch IS2 is closed, the electromagnetic shutoff valve *e* will then be energized through conductors 11, 13, 67, 65, 63, 61, 43, negative train line conductor 19 and negative battery conductor 21 to cause the opening of the shutoff valve *e*. This causes the electropneumatic means, *a*, *b* and *c* to be connected to the pressure pipe 41 so that upon energization of the windings thereof in combination with winding of the means *d* by movement of the master controller, the means *a*, *b*, *c* and *d* operate to cause operation of the engine at speeds above the idle value. It will be evident that similar electropneumatic means on the other eninge governors connected to the train line conductors 43, 45, 47, 49 and 51 will be controlled in like manner by operation of the master controller and all the engines will accordingly be caused to operate at the same speed.

Upon a reduction in lubricating oil pressure in any engine below the preselected safe value the contacts of the engine pressure switch PS will open to cause deenergization of the winding of the relay R and thereby cause the relay armature to fall to the normal position, as shown. This causes deenergization and closure of the electromagnetic valve *e* to render inoperative the electropneumatic means *a*, *b* and *c*, and also causes energization of the electropneumatic means *d*, thereby causing automatic shut down of the engine and likewise causes energization of the signal alarm lights to indicate shut down of the engine.

The control system illustrated in Figure 2 of the drawings, with the exception of the following modifications, is similar to the system illustrated in Figure 1. The governor G on the engine 1 is similar to that shown in Figure 1 with exception of the means comprising a hand throttle connected by linkage to the governor speed setting means for operation thereof and a hydraulic by-pass connection BP including an electrically opened shutoff valve EV for causing relief of pressure on the plunger 40 in the governor power cylinder 39 to normally cause movement of the engine fuel control shafts to the engine shut down position.

The pressure switch PS' connected to the engine oil pump delivery pipe 9 is similar to the switch PS shown in Figure 1 except that the contacts thereon are normally closed when the engine oil pressure is less than the preselected safe value and are opened when the pressure reaches the safe value by reason of the following connections with the switch contacts. A battery BAT, fuel pump switch FS, fuel pump motor FM, starting switch SS, starting motor SM and time delay relay TR are identical to that previously described and are interconnected in the following manner with the pressure switch PS'.

The engine fuel pump switch FS and fuel pump motor FM are connected in series across the battery BAT by conductors 101, 103, 105, 107, 109 and 111. The normally closed contacts of the pressure switch PS' are connected in series with the contacts of the time delay relay TR and winding of the electromagnetic valve EV between conductors 103 and 111 by conductors 113, 115 and 117. The normally closed lower control contacts of the starting switch SS are connected in series with the winding of the time delay relay TR between the conductor 103 and 109 by conductors 113 and 119 and the upper contacts of the starting switch SS are connected in series with the

starting motor M between conductors 101 and 111 by conductors 121, 123 and 125.

With the above described connections when the fuel pump switch FS is closed the fuel pump motor FM will be energized through conductors 101, 103, 107, 109 and 111, the winding of the time delay relay TR will be energized through the normally closed control contacts of the starting switch SS and conductors 103, 113, 119, 109 and 111, which causes delayed closure of the contacts of the time delay relay and the electromagnetic valve EV will be opened by energization of its winding through the closed contacts of the time delay relay, the normally closed contacts of the pressure switch PS' and conductors 113, 115, 117 and 111. Energization of the valve EV causes the valve to open thereby causing by-pass of oil from the governor power cylinder which causes the power plunger 40 to move the engine fuel control shafts 3 and 5 to a position to cause shut down of the engine.

The engine is started by depression of the starting switch handle which causes energization and rotation of the starting motor SM and engine and deenergization of the winding of the time delay relay TR and the opening of the relay contacts. Opening of the relay contacts causes deenergization and closure of the valve EV to cause pressure application in the governor power plunger 40 and movement thereof to cause the engine fuel control shafts 3 and 5 to be moved to a position corresponding to the governor speed setting determined by the position of the engine hand throttle and this causes starting and operation of the engine at a preselected constant value of speed, preferably idling speed.

Release of the handle of the starting switch SS when the engine starts permits the starting switch spring to cause opening of the upper switch contacts and closure of the lower control contacts. This causes deenergization of the starting motor M and reenergization of the winding of the time delay relay TR which causes delayed reclosure of the contacts thereof and reenergization of the winding of the valve EV and therefore operation of the engine for a limited time only and subsequent shut down of the engine unless the contacts of the pressure switch PS' are not opened by a normal increase in the engine oil pressure to the preselected safe value before the contacts of the time delay relay close. Opening of the contacts of the pressure switch PS' before closure of the contacts of the time delay relay prevents energization and opening of the valve EV thereby permitting normal control of the engine speed and also shut down of the engine by movement of the governor speed setting means by the hand throttle.

Decrease of the engine lubricating oil pressure below the preselected safe value for any operating speed of the engine causes closure of the contacts of the pressure switch PS', thereby causing energization and the opening of the valve EV and this causes automatic shut down of the engine independently of the hand throttle.

I claim:

1. An engine protective control system including an engine having, a lubricating pump, fuel varying means, combined starting and control means, engine shut down means for rendering said fuel varying means inoperative in order to cause shut down of said engine, control means acting only in response to a preselected safe value of pressure delivered to said engine by said lubricating pump for rendering said engine shut down

means inoperative, and time delay means connected with said starting control means and said shut down means to delay operation of said shut down means upon movement of said starting control means to the inoperative control position until said pressure of said pump builds up to said preselected safe value.

2. An engine protective system including an engine having starting control means, a lubricating pump and pressure operated engine shut down means, means for rendering said pressure operated shut down means effective in order to cause shut down of the engine, time delay means controlled by said starting control means for causing delayed operation of said engine shut down means, and means acting only upon normal rise in pressure of said lubricating pump to a safe value to render said shut down means ineffective prior to operation of said time delay means.

3. An engine protective control system including an engine having starting and starting control means, a lubricating pump and pressure operated means for varying the engine speed, a plurality of means for controlling said pressure operated means to cause operation, or shut down of said engine, means for rendering certain of said controlling means ineffective to cause a reduction in the engine speed, means controlled by said starting control means for delaying operation of another of said controlling means to cause delayed shut down of said engine, and means acting in response to normal pressure rise to a safe value of pressure delivery by said lubricating pump to prevent shut down of said engine by delayed operation of said other controlling means and to directly control said other controlling means to cause immediate shut down of said engine upon a reduction in pressure below said safe value delivered by said lubricating pump.

4. An engine protective system including an engine having fuel varying means, a speed responsive governor including pressure operated means controlled thereby for operating said fuel varying means, manual means for varying the governor speed response to cause a variation in the engine speed between zero and maximum values, an engine starting motor, starting motor control means, a lubricating pump, protective means for rendering said pressure operated fuel varying means inoperative to cause shut down of said engine and control means for said protective means comprising time delay means controlled by movement of said starting control means to the non-controlling position, and means acting in response to a normal rate of pressure rise of said lubricating pump to a safe value to prevent control of said protective means by said time delay means but acting in combination therewith upon a reduction in pressure below said safe value to cause immediate shut down of said engine independently of said manual means for varying the governor speed response.

5. An engine protective system including an engine having starting and starting control means, a lubricating pump, fuel varying means, and a speed responsive governor having pressure operated means controlled for actuating said fuel varying means, and a plurality of pressure operated means for varying the governor speed response, a controller for controlling said pressure operated governor speed response varying means and means for rendering certain of said pressure operated governor speed response varying means ineffective to cause a reduction in said

engine speed, said other pressure operated governor speed response varying means causing shut down of said engine, time delay means connected to said other pressure operated governor speed response varying means to cause delayed operation thereof, said time delay means being connected to and controlled by said starting control means upon movement thereof to the non-controlling position to cause delayed shut down of said engine after starting thereof, and automatic means acting automatically in response to normal build-up in pressure of said lubricating pump to a safe value to render said time delay means ineffective to cause shut down of said engine, and to permit normal control of said pressure operated governor speed response varying means by said controller, said automatic means being connected to said time delay means and acting in combination therewith to cause immediate shut down of said engine independently of said controller by direct control of said means rendering certain of said pressure operated governor response varying means ineffective and to said other speed response varying means.

6. An engine protective system including an engine provided with starting means, starting control means, a lubricating pump, fuel varying means and a speed responsive governor including pressure operated means controlled by said governor for actuating said fuel varying means, a plurality of pressure operated governor speed response varying means for varying the engine fuel and speed between idle and maximum values, and means for rendering certain of said speed response varying means inoperative to cause shut off of fuel supplied to said engine and shut down thereof, a master controller connected to said governor response varying means and adapted to be connected in multiple with similar response varying means for multiple control thereof, alarm signal means, time delay control means and lubricating pressure responsive control means operable upon starting of said engine and connected to said master controller, said alarm signal means, said means for rendering certain of said speed response varying means inoperative in order to cause delayed shut down of said engine, said time delay means being connected to said starting control means for control thereby and said lubricating pressure responsive control means being connected with said lubricating pump and operable only upon normal build-up of pump pressure to prevent shut down of said engine except when the pump pressure fails to build up to or falls below said safe value, said alarm signal being connected to said pressure responsive means and controlled thereby for values of lubricating pressure below said safe value.

7. An engine protective control system including an engine provided with starting and starting control means, a lubricating pump, fuel varying means, pressure operated means for operating said fuel varying means, manual means for normally controlling said fuel varying means, means for rendering said pressure responsive means inoperative, and time delay control means and control means acting in response to the pressure of said fuel pump connected to said means rendering said pressure operated means inoperative, said time delay means being connected to and controlled by said starting control means, said pump pressure responsive means acting upon normal build-up in pump pressure to a safe value

in order to prevent delayed shut down of said engine except upon a decrease in pump pressure below the normal value with the time delay control means operative and thereby to cause immediate shut down of said engine.

8. In combination an engine having a lubricating pump and regulating means for controlling the fuel supplied to said engine for causing normal operation or shut down thereof, time delay means for modifying operation of said fuel regulating means to cause delayed shut down of said engine, lubricating pump pressure responsive means associated with said time delay means to cause undelayed shut down of said engine only if insufficient lubricating pressure is supplied thereto, engine starting means, combined control means for said starting means and time delay means to delay shut down of said engine by operation of said time delay means only until sufficient lubricating pressure is supplied by said pump to said engine upon starting thereof.

9. In combination an engine having a lubricating pump, regulating means for controlling the fuel supplied to said engine, modifying means for modifying operation of said regulating means to cause operation of said engine at different output values or shut down of said engine, time delay means for controlling delayed operation of said regulating means to cause delayed shut down of said engine, means associated with said time delay means and acting in response to insufficient pressure delivered by said engine lubricating pump to render inoperative the delaying action of said time delay means to cause undelayed shut down of said engine, an engine starter and combined control means for said starter and said time delay means to cause operation of said starter and delayed operation of said time delay means only until sufficient pump pressure is developed during starting of said engine.

10. In combination an engine having a lubricating pump and fuel regulating means, engine speed responsive control means for said fuel regulating means to control the engine power output, modifying means for said speed responsive control means to vary the engine output and to cause shut down of said engine, time delay means for controlling said modifying means to cause delayed shut down of said engine pressure operated means associated with said time delay means and acting in response to insufficient lubricating pressure of said pump to cause undelayed shut down of said engine, engine starting and starting control means, said starting control means when inoperative controlling said time delay means to delay shut down of said engine only until sufficient starting lubricating pressure is developed by said pump.

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