Sept. 2, 1958 J. H. DAVIDS 2,849,857

CONTROL FOR ENGINE STARTING MEANS

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Fig. 1

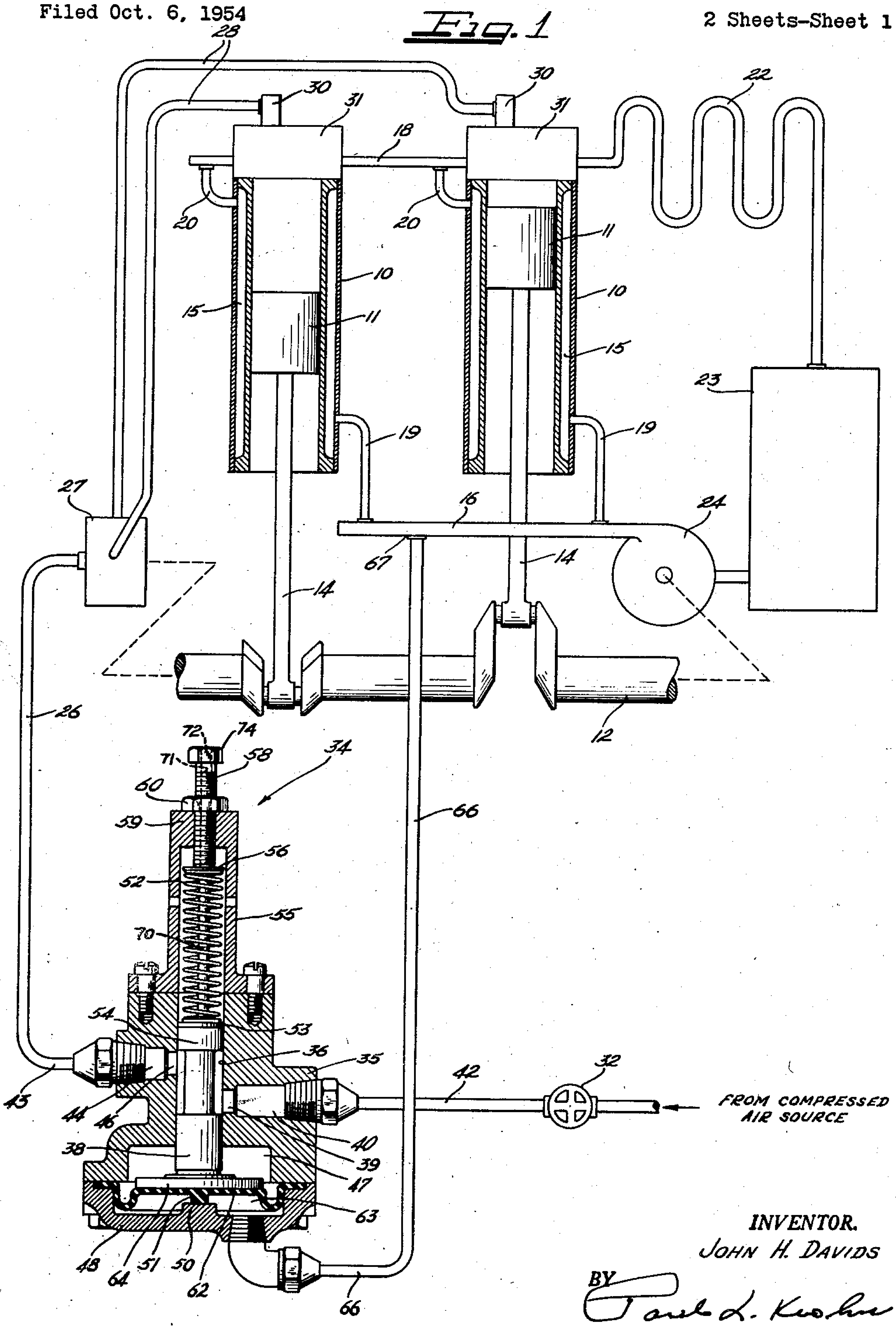

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Fig. 2

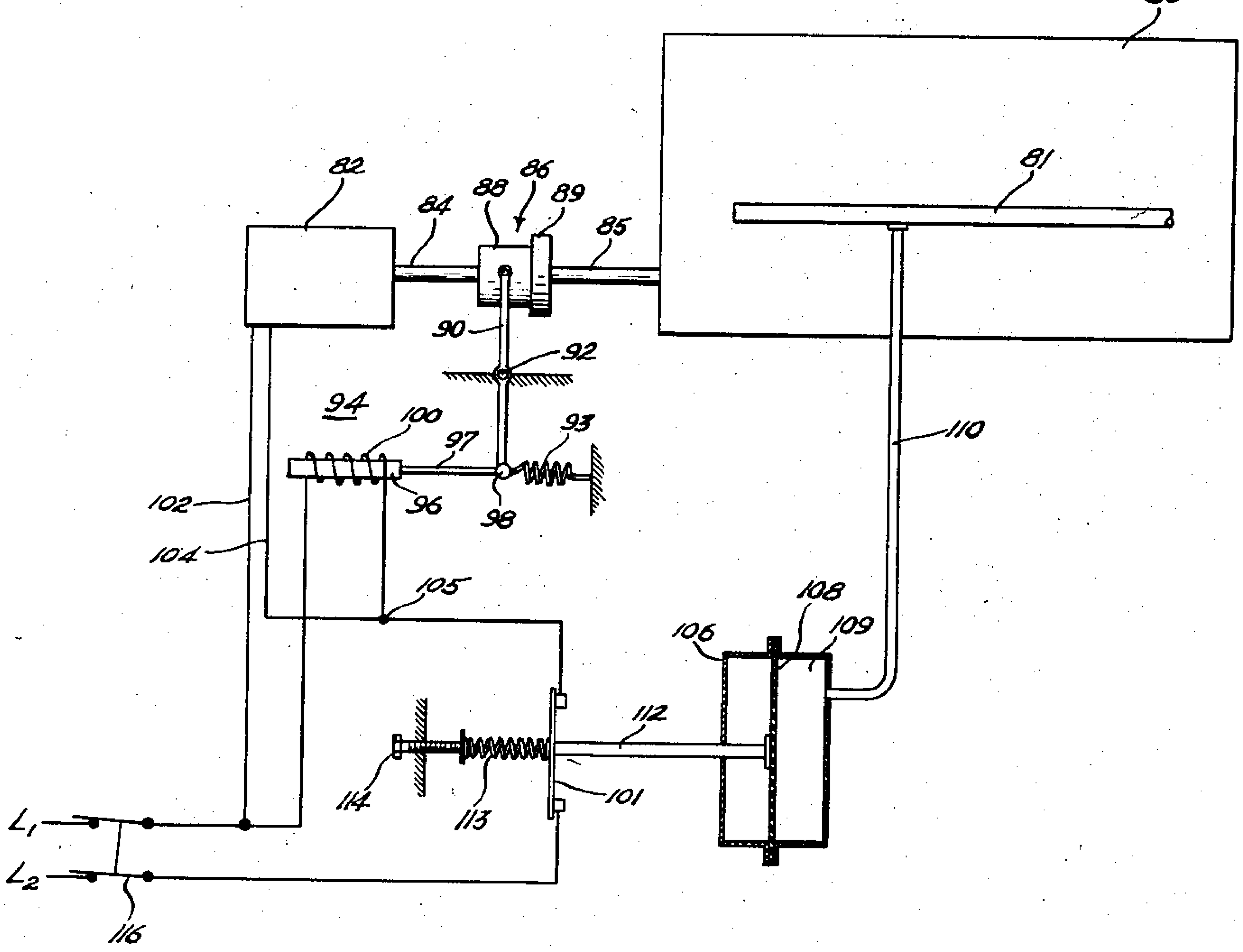
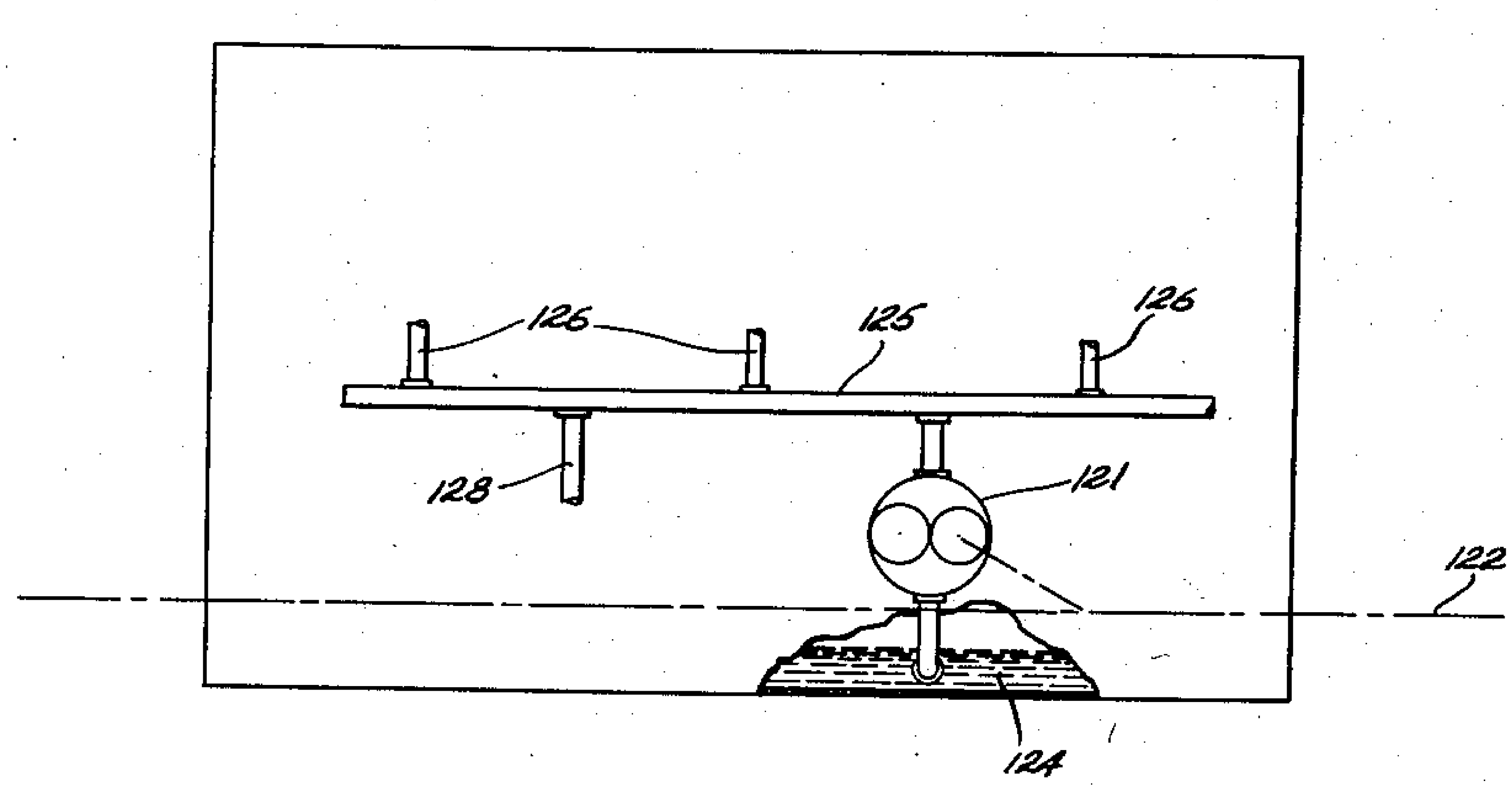


Fig. 3



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CONTROL FOR ENGINE STARTING MEANS

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This invention relates to improvements in the control of starting provisions for internal combustion engines, and more particularly to an improved method of, and control means for, controlling the operation of the engine starting means such as to terminate starting operation thereof automatically in response to starting acceleration of the engine to and above a given or selected engine speed.

Engine starting provisions of heretofore known and prevailing types, as compressed air starters and the like, usually include either a manually operated control or an automatic control mechanically operated generally in accordance with engine speed, as effected through the engine speed controlling governor or other mechanical device actuated in accordance with engine speed. Such controls generally embody gearing, linkage mechanisms or other mechanical connections from the manual lever, engine governor or other speed operated device, which connections present certain disadvantages in respect to manufacturing and maintenance costs, and the overall complexity of the control equipment.

The principal objective of the present invention, therefore, is to afford in connection with engine starting means, a greatly simplified yet highly effective control provision for interrupting operation of the starting means automatically upon engine starting acceleration to and above a given speed, wherein the control provision while operatively dependent upon engine speed, does not embody or utilize gearing, linkages or other mechanical connections of the character above mentioned.

More particularly, the present invention is concerned with internal combustion engines having fluid pressure systems, as pressure lubricating oil and/or cooling water circulating systems, wherein the pressure of the fluid is proportional to engine speed. Given such an engine including suitable starting means therefor, it is an object of the invention to afford simplified control of the starting means in a manner to effect termination of engine starting operation of the starting means in response to the pressure obtaining in a fluid pressure system of the engine upon engine starting acceleration to a predetermined or selected engine speed. In one form of the invention as herein disclosed in connection with an engine of the character indicated, having an air pressure starting system, there is provided a starting air supply control valve normally biased to an open condition permitting starting air delivery to the engine, wherein the valve embodies pressure-actuated means in connection to the fluid pressure system of the engine, operative to close the valve and hence terminate starting air supply to the engine, upon and in response to pressure rise in the engine fluid pressure system to an extent determined by engine starting acceleration to a selected speed, as to a speed below normal engine operating speed. The present invention is applicable also, to other types of engine starting means, as electric motor starters and the like, an example of which is illustrated herein.

The foregoing as well as other objects and advantages of the invention will appear from the following description considered in connection with the accompanying drawing, wherein:

Fig. 1 illustrates diagrammatically, an internal combustion engine including an air start system and a cooling fluid circulating system (shown only in part), together with a starting air supply control valve shown in vertical section, the valve including a fluid pressure operating means in pressure-responsive connection to the engine cooling fluid system;

Fig. 2 illustrates diagrammatically, application of the invention to control of an electric motor and clutch type engine starter means, and

Fig. 3 shows diagrammatically, an engine having a pressure lubricating fluid system with which the present invention may be employed.

Referring first to the embodiment according to Fig. 1, an internal combustion engine is illustrated diagrammatically and in part only, as including cylinder assemblies **10**, and pistons **11** operatively associated with the crankshaft **12** through connecting rods **14**. The engine is of jacketed, water-cooled type providing cylinder jacket spaces **15** in a cooling water circulating system including water delivery and return headers **16** and **18** respectively. Branch connections **19** from delivery header **16**, supply cooling water to the cylinder jacket spaces **15**, while connections **20** connect the cylinder jacket spaces to the return header **18**, the latter extending to a suitable cooler **22** from which the cooled water is returned to the source indicated by the tank **23**. From the source such as tank **23**, water is delivered to supply header **16** by a suitable pump, as a centrifugal pump **24**, which is driven from the engine crankshaft **12**. With the pump engine driven as indicated, the speed of the pump will vary correspondingly with variations in engine speed, and thus the pump-established pressure of the cooling fluid or water circulating in the engine jacket system, will vary with and be in proportion to engine speed. Hence the water pressure in the system directly reflects engine speed, and this pressure as it increases with engine acceleration in starting, is utilized as the controlling medium in effecting termination of operaton of engine starting means.

In the embodiment of the present invention according to Fig. 1 the engine is provided with a compressed air starting system which in the example shown, includes an air supply conduit **26** extending from a suitable source of compressed air (not shown) to an air distributor generally indicated at **27**. The distributor is operated from the engine crankshaft **12** for proper timing of air delivery to the several engine cylinders, air delivery being effected through conduits **28** to air valves **30** in the cylinder heads **31**, as in the usual or well known air start systems. A manually controlled or otherwise suitably operated main shut-off valve **32** may be included in conduit **26**. Interposed in the supply conduit **26** in the portion thereof between the shut-off valve **32** and the distributor, is a control valve device **34** shown in vertical sectional detail, providing a starting air cut-off control in the present exemplary embodiment of the invention.

As appears in Fig. 1, the valve device **34** comprises a valve body **35** having a central vertical bore **36** in which slides a piston type valve element **38** in controlling relation to a compressed air inlet port **39** at the inner end of inlet passage **40**. Connected to inlet passage **40** is the end portion **42** of that part of supply conduit **26** leading from the compressed air source (not shown). The end **43** of that part of conduit **26** between the valve and the distributor **27**, is connected to the valve outlet passage **44**, the latter having the outlet port **46** associated with the piston valve element **38** as shown.

The valve body has an open bottom recess **47** which in valve assembly, is closed by a cup-shape cover or closure member **48** having an internal boss or land **50** in alignment with the valve bore **36**. The cover boss or land **50** provides a stop for abutment by a projection **51** at the lower end of the piston valve **38**, to limit valve movement in the downward or valve-opening direction. Projection **51** may be provided as a part of a movable fluid motor element secured to the valve, as hereinafter described. The piston valve is biased toward the stop and to the full-open position shown, by a suitable compression spring **52** bearing against the upper end **54** of the piston valve, as through a washer **53**. Spring **52** extends upwardly in a vertically elongate cap member **55** removably attached to the valve body, and engages at its upper end a disc or washer **56** carried by a spring adjusting element or screw **58** threaded through the top wall **59** of cap **55** and provided with a lock nut **60**. Thus by threading the screw in one or the other direction, the biasing force of the spring on the piston valve may be correspondingly determined, as for a particular purpose presently to be indicated.

Marginally secured or clamped between the cover **48** and the lower end of the valve body is a flexible member or diaphragm **62** which cooperates with the cup shape cover to form a fluid pressure chamber **63**. The diaphragm in its central area, is operatively associated with the lower end of the piston valve, as with a head or flange member **64** preferably provided as an integral part of the piston valve. Moreover and as hereinabove indicated, diaphragm **62** is bossed or enlarged substantially at its center, to provide the stop projection **51** engageable with the casing stop **50**. The valve body recess **47** accommodates the piston flange **64** in upward displacements thereof in fluid pressure actuation of the diaphragm. Connecting the fluid pressure chamber **63** with the engine cooling water system is a conduit **66**, this conduit in the present example, being shown as extending to connection at **67** with the cooling water supply header **16** of the engine. However, the conduit **66** may be connected to any other suitable or convenient point in the cooling water pressure circulation system embodied in the engine assembly, as for instance, to any one of the cylinder jacket spaces **15**. Thus the pressure chamber **63** and diaphragm **62** in fluid pressure association with the engine cooling water system provides a fluid pressure actuator or fluid servo-motor for the piston valve element **38**.

In the operation of the control valve device **34** as the latter is now described, when the engine is stopped or at rest, the cooling water in the engine cooling system will be under low or minimum pressure insufficient to cause displacement of the diaphragm **62** from the position shown in Fig. 1, which is that corresponding to full-open position of the piston valve **38** wherein the abutment **51** is against stop **50**, as effected under the bias of valve spring **52**. In such position of the piston valve, communication is established by the latter between the valve inlet and outlet ports **39** and **46**, respectively, so that upon opening of main valve **32**, compressed air will flow from the source through conduit **26** and the valve **34** to the distributor **27**. As is usual in air start systems, the distributor permits compressed air delivery to at least one of the engine cylinders at the beginning of engine starting, and thereafter as the engine accelerates in starting, it determines air delivery to the cylinders in a given sequence, usually in accordance with the cylinder-firing order of the engine. Now, as the engine undergoes starting acceleration, with crankshaft drive of the cooling water pump **24** at correspondingly increasing speed, the pressure of the cooling water then circulating in the engine jacket system, rises proportionately. When, during such starting acceleration of the engine, the cooling water pressure rises to a point such that the pressure in the valve servo-motor chamber **63** exceeds the opposing pressure of the valve biasing spring **52**, the servo-motor diaphragm **62** will undergo fluid pressure displacement to

move the piston valve **38** upwardly toward and to a position closing the air inlet port **39**. With valve closure of port **39**, compressed air delivery through the valve to the distributor **27** is then cut-off or terminated. Thereafter and as the engine assumes normal running conditions, the cooling water pressure then obtaining in consequence of the operating speeds of the engine, adequately exceeds the biasing force of spring **52** such as to assure and maintain valve closure throughout engine operation. While not important to the present invention and hence not shown, upon closure of the control valve **34** air may be vented from the cylinder conduits **28**, and if desired also, from the portion of conduit **26** between valve **34** and the distributor **27**, in any suitable manner. Upon stoppage or shut-down of the engine, and assuming that the main valve **32** is actuated to closed position coincidentally therewith, the cooling water pressure will drop to a low value, so that the pressure in chamber **63** will become well below the opposing pressure of the control valve spring **52**. Whereupon, the spring will move the piston valve to its full-open position (Fig. 1), thereby conditioning the valve for operation in the next or succeeding engine starting period.

It is to be noted here that the valve biasing spring **52** is of selected capacity in relation to the full pressure range of the cooling water system of a given engine, so that under adjustment of the spring to impose a minimum biasing pressure, the valve will open against low or minimum fluid pressure of the cooling system in engine shutdown, and further, so that the spring may be adjusted to a condition in which it will be overcome only by that fluid pressure obtaining when the engine speed in starting acceleration, attains at most a predetermined speed which may be that speed at which the engine converts from air start to running on fuel. Any intermediate adjustments of the spring then will determine valve closure at a correspondingly lesser engine starting speed.

As shown in Fig. 1, included in the control valve device **34** is an indicator to provide visual indication of the open and closed conditions of the valve. Conveniently, the indicator is in the form of a rod **70** which may be carried by the spring washer **53** on the upper end of the piston valve, the rod extending upwardly in cap member **55** to and through an axial passage or bore **71** in the spring adjusting screw **58**, to exposure of its upper end **72** at the screw head **74**. In the full-open condition of the valve, the rod **70** will be retracted relative to the screw so that its exposed end **72** then may be approximately flush with the top of the screw head **74**, depending upon the spring adjusting position of the screw, while in the closed condition of the valve, the rod will project above the screw head **74**.

In the embodiment of the invention according to Fig. 2, shown in essentially diagrammatic manner, the engine **80** includes a cooling water circulating system indicated in part at **81**, in which the pressure of the cooling water is in accordance with engine speed, as in the embodiment of Fig. 1 for example. The starting provision for the engine may comprise an electric motor **82** having its output shaft **84** connected to the engine crankshaft **85** through a clutch device **86** of any suitable form. The clutch is here indicated as including a clutch element **88** movable to and from clutching engagement with a complementary clutch element **89**, with movement thereof under control of a lever **90** pivotally supported at **92** intermediate its length. The lever is biased by a suitable spring **93** in the direction to locate clutch element **88** out of engagement with clutch element **89**, while lever actuation to cause clutch engagement is effected by the movable armature of a solenoid motor device generally indicated at **94**. The solenoid motor has its movable armature **96** connected by a link or rod **97** to the clutch lever at **98**, and its energizing winding **100** connected to power supply lines L_1 and L_2 including in the line L_2 a switch

101. Starting motor 82 is energized from supply lines L_1 and L_2 over leads 102 and 104, the lead 104 being connected to line L_2 at a point 105 between the switch 101 and the solenoid winding 100. Thus, when the switch 101 is closed the solenoid motor 94 is energized to draw-in its armature 96 and actuate clutch lever 90 to engage clutch element 88 with element 89, and simultaneously the starting motor 82 is operated to cause through the then engaged clutch device, starting of the engine 80. Opening of switch 101 effects de-energization of both the starting motor and the solenoid motor, and hence termination of starting motor drive of the engine crankshaft, with disengagement of the clutch under the bias of spring 93.

Control of the switch 101 is effected through a fluid pressure servo-motor 106 having a diaphragm or movable piston element 108 in a fluid pressure chamber 109, the chamber being connected by a conduit 110 to a suitable point in the engine cooling water circulating system 81. Switch 101 has an operating rod 112 extending to connection with the servo-motor piston or diaphragm 108, and includes a suitable bias, as the compression spring element 113, acting on the diaphragm and rod in the direction to effect switch closure and location of the diaphragm in an initial position. The switch-closing effect of the spring 113 is adjustable, as through the adjusting screw 114 in support of one end of the spring.

In engine starting, when the main supply line switch 116 is closed and since switch 101 then is closed under its bias spring 113, the solenoid motor will be energized to engage the clutch, while the starting motor simultaneously energized, operates through the clutch to turn the engine crankshaft. Now as the engine is accelerated in starting, the cooling fluid pressure rises in the engine cooling system 81 and consequently in the servo-motor chamber 109. When the pressure in chamber 109 exceeds the opposing bias of spring 113, the piston or diaphragm 108 responds by fluid-pressure displacement in the direction to open the switch 101, thereby terminating engine starting drive by the motor 82 as hereinabove described. Thereafter and throughout running operation of the engine, the spring 93 retains the clutch element 88 disengaged from the clutch element 89 on the engine crankshaft, since the switch 101 then is maintained in open condition by the fluid pressure servo-motor which remains in pressure operated condition during normal operation of the engine cooling fluid circulating system. It is to be noted that by adjustment of the switch bias spring 113 through the adjusting screw 114, pressure operation of the servo-motor to open the switch 101 and hence terminate operation of the engine starting provision in the manner described, may be regulated to occur at a selected speed in engine starting acceleration. In respect to a given engine to which the starting system is applied, such adjustment normally will be made so that the servo-motor will act to open switch 101 and stop the starting drive when the engine starting speed is at or slightly above the speed point at which the engine converts to fuel operation.

Upon stoppage or shut-down of the engine, the pressure of the fluid in the engine cooling system drops to a low or minimum value, whereupon spring 113 closes switch 101 to condition the energizing circuit for operation of the starting motor 82 and operation of the solenoid motor 94 to engage the clutch 86. The engine then may be again started by closure of the main supply switch 116.

While in the embodiments of Figs. 1 and 2, termination of operation of the engine starting provision is controlled from the engine cooling water circulating system in the manner now fully described, such control may be effected from the engine lubricating system in engines providing pressure feed of lubricating fluid wherein the oil pressure varies proportionately with engine speed. For example, as shown diagrammatically by Fig. 3, an engine 120 has a suitable oil pump 121 illustrated as of a gear type, driven from the engine crankshaft represented by the broken line 122. The pump may take oil from the engine crankcase sump 124 and deliver under pressure to a pressure supply manifold 125 from which branch conduits, as 126, lead to points of pressure lubrication in the engine. Now, with the air start system of Fig. 1 applied to this engine, the pressure fluid conduit 66 leading to the fluid pressure servo-motor of the control valve 34 may be connected to the oil pressure system at any suitable point therein, as at 128 in the manifold 125. Similarly in the instance of application of the electric motor and clutch starting system of Fig. 2 to the engine 120, the servo-motor conduit 110 may be connected to the same point 128 of the pressure oil manifold 125. It will be understood that because of the usually higher pressures in the lubricating system as compared to the pressures obtaining in the conventional cooling water pressure circulating system, where the air start system of Fig. 1 is used, the valve-opening and servo-motor biasing spring 52 in the valve device 34 will be selected as to capacity, such as to accommodate the higher oil pressures. Likewise, in the instance of use of the motor starting system of Fig. 2, the switch-closing and servo-motor biasing spring 113 will be similarly selected as to capacity.

Having now illustrated and described several embodiments of the present invention, it is to be understood that modifications of the embodiments shown, as well as other embodiments, may be made within the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. In combination with an internal combustion engine having a fluid pressure system in which the pressure of the fluid therein is proportional to engine speed, fluid pressure starting means for the engine including a control valve normally biased to an open condition, and a fluid pressure actuated servo-motor in constant open communication with said fluid pressure system, effective for closing said control valve in response to fluid pressure obtaining in said fluid pressure system when the engine attains and exceeds a predetermined engine speed.

2. In combinaiton with an internal combustion engine having a fluid pressure system wherein the pressure of the fluid therein is proportional to engine speed, fluid pressure starting means for the engine including a control valve, fluid pressure actuated valve closing means in constant open communication with said fluid pressure system, and valve opening means effective to open and retain said control valve open when the fluid pressure acting on said valve closing means is in an initial pressure range corresponding to the engine speed range from zero speed to a predetermined engine speed less than the normal running speed of the engine.

3. In an internal combustion engine having a cooling fluid jacket system, engine driven pump means for circulating cooling fluid in the jacket system at a pressure increasing with increasing engine speed, and a compressed air starting system, the combination therewith of a control valve in the compressed air starting system, said control valve providing a movable valve element and yieldable means biasing the valve element to a valve open position, and fluid motor means connected to the engine jacket system and operatively related to said valve element, said fluid motor means operating in response to fluid pressure obtaining in the engine jacket system when the engine attains a predetermined engine speed, to move said valve element to a valve closed position.

4. In an internal combustion engine having a cooling fluid jacket system, engine driven pump means for circulating cooling fluid in the jacket system at pressures corresponding with engine speeds, and a compressed air starting system, the combination therewith of a control valve in the compressed air starting system, said control

valve providing a movable valve element, fluid motor means connected to the engine jacket system and to said valve element, operable by cooling fluid pressure for moving said valve element to a valve closed position, and yieldable means acting on said valve element in opposition to said motor means, for moving the valve element to a valve open position, said yieldable means yielding to permit valve closing movement of the valve element by said fluid motor means only when the jacket fluid pressure attains and exceeds a pressure value corresponding to a predetermined engine speed.

5. In an internal combustion engine having a cooling fluid jacket system, engine driven pump means for circulating cooling fluid in the jacket system at a pressure increasing with increase in engine speed, and an air start system including a compressed air supply line, the combination therewith of a control valve in said air supply line, the control valve providing a movable valve element, fluid motor means actuated by fluid pressure in the engine jacket system and operable on said valve element for moving the latter to a valve closed position, yieldable spring means biasing said valve element to a valve open position and imposing through the valve element, a force on said fluid motor opposing fluid pres-

sure actuation of the latter, said spring means yielding only when in engine starting acceleration, the engine speed attains a value establishing a fluid pressure in the engine jacket system effective on the fluid motor means to overcome the opposing force of the spring means and cause actuation of the motor means to move said valve element to a valve closed position, and spring adjusting means selectively operable for determining the opposing force of the spring means relative to said fluid motor means.

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