United States Patent

Eheim

[15] 3,661,130

[45] **May 9, 1972**

[54] SAFETY DEVICE FOR LIMITING THE ROTATIONAL SPEED OF INTERNAL COMBUSTION ENGINES

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[22] Filed: **Mar. 17, 1970**

[21] Appl. No.: **20,276**

[30] **Foreign Application Priority Data**

Mar. 19, 1969 Germany......................P 19 13 808.0

[52] **U.S. Cl.**........................**123/140 A,** 123/102, 123/139 E

[51] **Int. Cl.**..**F02d 5/00**

[58] **Field of Search**................123/139 E, 97, 104, 102, 140, 123/198 DB

[56] **References Cited**

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[57] **ABSTRACT**

An electronically controlled diesel engine wherein the high-pressure chamber of the fuel injection pump is connected with the low-pressure chamber by a passage controlled by an electromagnetic valve which opens or closes when the rotational speed of the engine reaches a maximum permissible value. The speed is detected by an electrical counter which effects opening of the valve if the latter is installed in a passage which conveys fuel from the high-pressure chamber, or closing of such valve if the latter is installed in a passage which supplies fuel to the high-pressure chamber, whenever the engine speed reaches the maximum permissible value. The electrical connection between the speed counter and the valve comprises an amplifier whose input circuit contains an inductance of the speed counter and a first safety fuse and whose output circuit contains a relay switch for the circuit of the winding in the valve and a second safety fuse. The circuit of the winding can be completed by an auxiliary switch in response to actuation of the starter for the engine.

9 Claims, 2 Drawing Figures

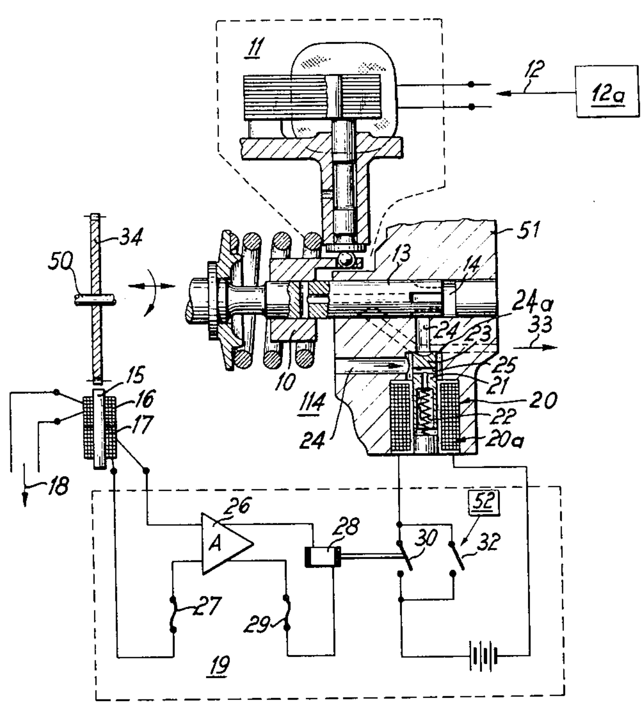

FIG. 1

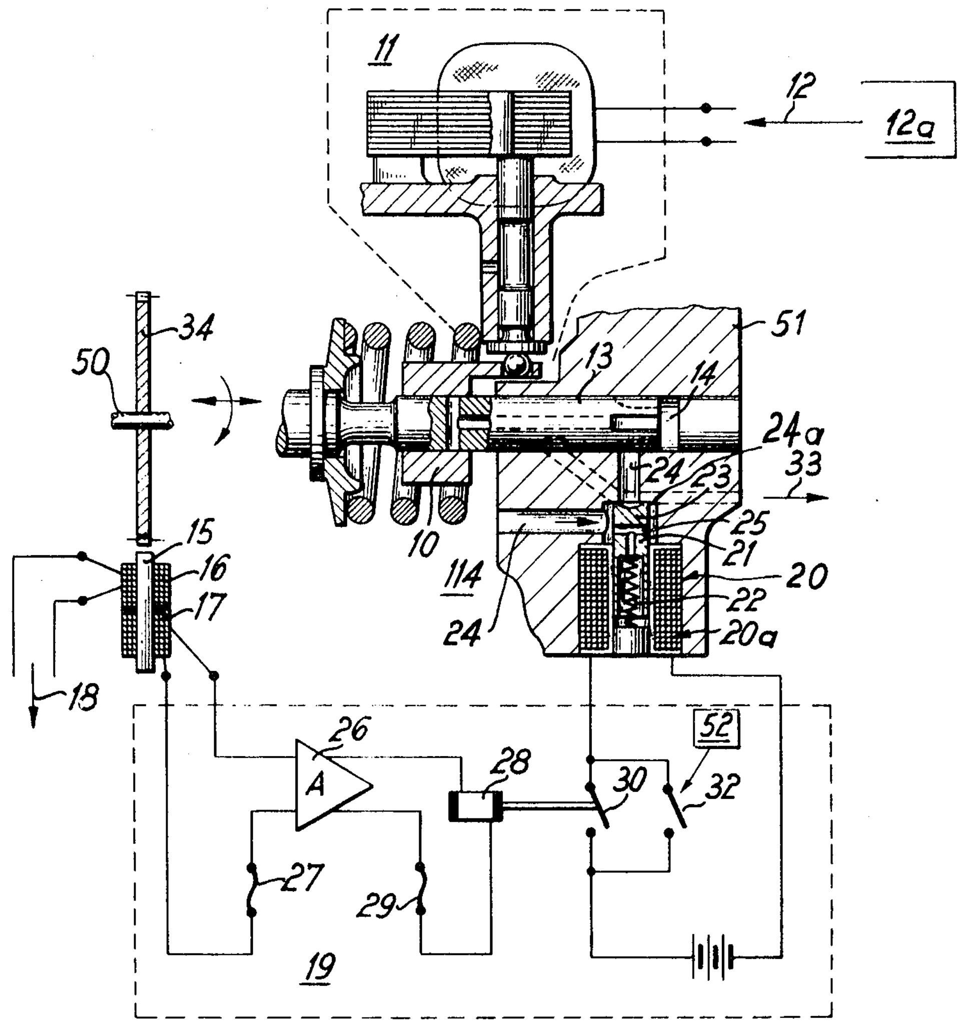

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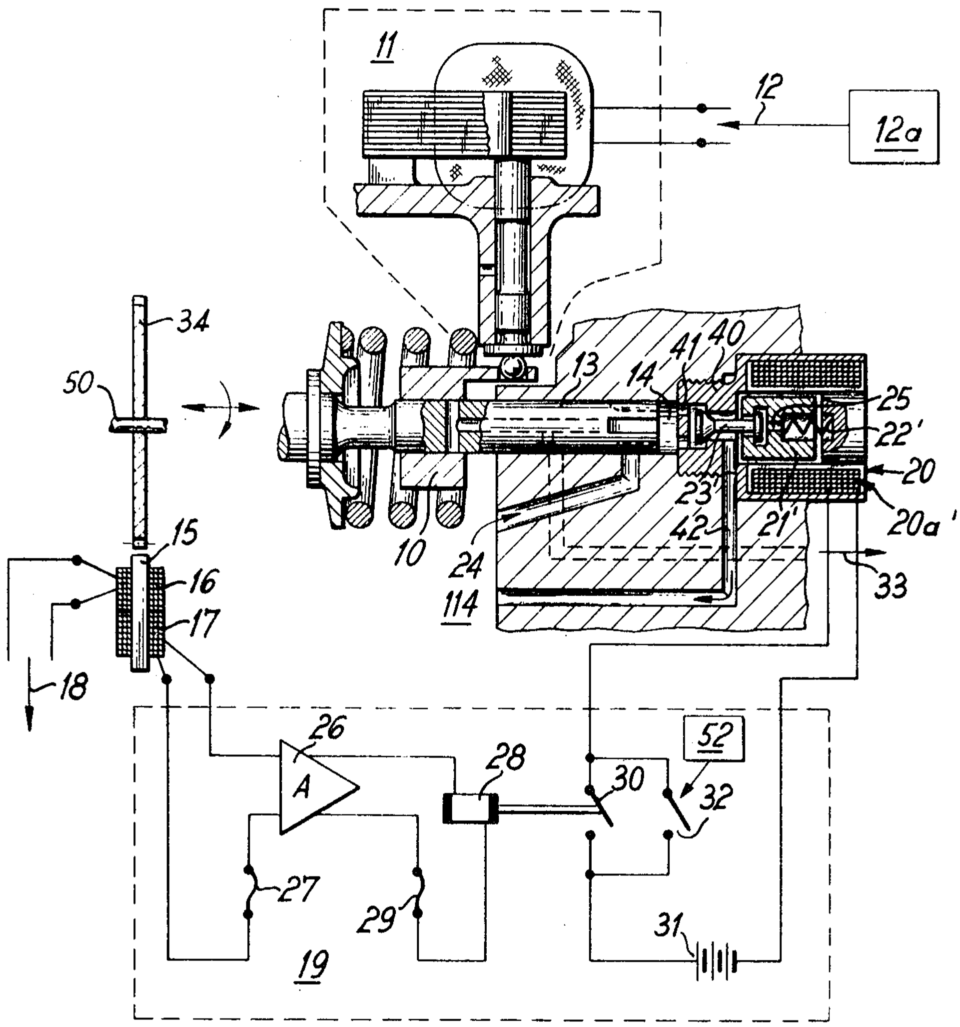
FIG. 2



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SAFETY DEVICE FOR LIMITING THE ROTATIONAL SPEED OF INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The present invention relates to internal combustion engines in general, and more particularly to improvements in safety devices which limit the rotational speed of internal combustion engines, especially of electronically controlled diesel engines. Still more particularly, the invention relates to improvements in safety devices for internal combustion engines with fuel injection.

It is well known that a diesel engine cannot be operated at speeds which exceed a certain value. Such value is determined by the structural characteristics of a particular engine. If the engine operates at a maximum permissible speed and its cylinders continue to receive fuel, the speed can increase beyond the permissible value but with the attendant danger of substantial damage. The likelihood of overspeeding is less pronounced in gasoline driven engines where the speed is limited by flow resistance of fuel supplying passages.

At the present time, diesel engines are normally equipped with centrifugal governors which control the flow of fuel to the fuel injection pump. The rate of fuel flow is reduced whenever the centrifugal governor detects a certain operating speed which should not be exceeded. Such centrifugal governors are rather bulky and expensive. Also, they are not ideally suited for use in internal combustion engines, particularly diesel engines, whose operation is regulated by an electronic control circuit.

SUMMARY OF THE INVENTION

An object of the invention is to provide an internal combustion engine, particularly an electronically controlled diesel engine, with a novel and improved safety device which limits the speed of the engine and is just as reliable as but more compact than a conventional centrifugal governor.

A further object of the invention is to provide a versatile safety device which can be used in many types of internal combustion engines.

An additional object of the invention is to provide a safety device which is constructed and assembled in such a way that it can prevent overspeeding of the engine even if one or more of its components happen to be defective.

An ancillary object of the invention is to provide a safety device which can be combined with or incorporated into the fuel injection pump of a diesel engine.

The invention is embodied in an internal combustion engine, particularly in an electronically controlled diesel engine, which comprises a fuel injection pump having a high-pressure fuel chamber, a low-pressure fuel chamber and a passage connecting the two chambers, a rotary member arranged to rotate at a variable speed which is proportional to (and may be identical with) the operating speed of the engine, electromagnetic safety valve means including a valve member installed in the fuel injection pump and movable between open and closed positions in which it respectively permits and prevents the flow of fuel though the passage, the valve member assuming one of its positions in response to energization and the other position in response to deenergization of the valve means, and electrical speed counter means operatively associated with the rotary member and arranged to effect a change in the condition of energization of the valve means when the speed of the rotary member reaches a predetermined maximum value.

The valve member is moved to closed position in response to deenergization of the valve means if it is installed in a passage which supplies fuel from the low-pressure chamber, and such deenergization takes place in response to a signal furnished by the speed counter means when the speed of the rotary member reaches the predetermined value.

If the valve member is installed in a passage which conveys fuel from the high-pressure chamber to the low-pressure chamber, it is caused to open in response to deenergization of the valve means, and such deenergization again takes place when the speed counter means produces a signal which is indicative of the predetermined maximum permissible speed of the rotary member.

The operative connection between the speed counter means and the winding of the valve means preferably includes an electrical or electronic regulating circuit having an amplifier whose input circuit contains an inductance of the speed changer means and a first safety fuse and whose output circuit preferably contains a second safety fuse and a relay whose switch is in circuit with the winding of the valve means.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved safety device itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a fragmentary partly diagrammatic and partly sectional view of a diesel engine which embodies one form of the improved safety device; and

FIG. 2 is a similar view of a diesel engine which embodies a modified safety device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a portion of a fuel injection pump which may be of the type disclosed in the copending application, Ser. No. 12,409 filed Feb. 18, 1970 by Eheim et al. and assigned to the same assignee. The pump includes a pump piston **13** which is reciprocable and rotatable in a pump housing **51** by the rotary output shaft **50** of a diesel engine and serves to supply measured quantities of fuel to several fuel lines **33** (only one shown). The fuel metering unit which determines the beginning and the end of the interval of fuel injection into each fuel line **33** comprises a collar **10** which is movable axially of the piston **13**, a rotary electromagnet **11**, and an electronic control circuit **12*a*** which supplies to the electromagnet **11** signals by way of an electrical connection **12**, such signals serving to determine the extent of energization of the electromagnet **11** and hence the axial position of the collar **10**. The manner in which the pump piston **13** is rotated and moved axially in response to rotation of the rotary member **50** is fully disclosed in the aforementioned application of Eheim et al. The housing **51** of the fuel injection pump defines a high-pressure fuel chamber **14** which is connected with a low-pressure fuel chamber **114** by a fuel supplying passage **24** controlled by the pump piston **13** and by a novel electromagnetic safety valve **20**. The shaft **50** carries a toothed gear-shaped element **34** of ferromagnetic material which cooperates with a yoke **15** having two serrated or toothed arms or extensions which are adjacent to the teeth of the element **34**. The yoke **15** carries two inductance coils **16** and **17**. The coil **16** serves to transmit to the control circuit **12*a*** signals (by way of the connection **18**) which are indicative of rotational speed of the shaft **50**. Such signals influence the energization of the electromagnet **11**. The coil **17** supplies similar signals to an electronic regulating circuit **19** which controls the safety valve **20**. The parts **34, 15** and **17** constitute a speed counter which effects closing of the safety valve **20** when the rotational speed of the shaft **50** reaches a predetermined maximum permissible value.

The valve **20** comprises a ferromagnetic core **21** which is biased by a spring **22** and carries at one end a valve member **23**. When the spring **22** is free to expand, the valve member **23** engages a seat **24*a*** in the fuel-supplying passage **24** to prevent the flow of fuel from the lower pressure chamber **114** to the higher pressure chamber **14**. The interior of the safety valve **20** is connected with the low-pressure chamber **114** by bores **25** which compensate for differences in pressure and insure that the core **21** can move axially in response to energization or deenergization of the winding **20*a***.

The regulating circuit **19** includes an electronic amplifier **26** whose input is connected with the inductance **17** on the yoke **15**. A first safety fuse **27** is installed in the input circuit of the amplifier **26** and a second safety fuse **29** is installed in its output circuit which further includes a relay **28** having a relay switch **30** in the circuit of the winding **20a**. The latter circuit further includes a separate energy source **31**. The relay switch **30** is connected in parallel with a normally open auxiliary switch **32**; the switch **32** closes for a short interval of time in response to actuation of the starter **52**. Each fuel line **33** delivers pressurized fuel to a separate fuel injection nozzle (not shown).

The operation:

When the engine is idle, i.e., when the shaft **50** is at a standstill, the amplifier **26** does not receive signals from the inductance **17** and the relay **28** is deenergized. Thus, the relay switch **30** is open and the winding **20a** of the safety valve **20** is deenergized so that the spring **22** maintains the valve member **23** in engagement with the seat **24a** and prevents entry of fuel into the high-pressure chamber **14**. If the driver wishes to start the engine, the starter **52** is actuated and closes the auxiliary switch **32** to complete the circuit of the winding **20a** which moves the core **21** against the opposition of the spring **22** so that the chamber **14** communicates with the chamber **114** by way of the passage **24**. The auxiliary switch **32** opens automatically when the starter **52** is inactive but the engine is on and its shaft **50** rotates the element **34** of the speed counter to induce in the inductance **17** a voltage which causes the amplifier **26** to energize the relay **28** and to thus close the switch **30**. The circuit of the winding **20a** is completed and the valve member **23** is held in open position even though the auxiliary switch **32** is open. The shaft **50** effects axial and angular movements of the pump piston **13** which delivers to fuel lines **33** metered quantities of fuel from the high-pressure chamber **14**. The quantities of such fuel are determined by the collar **10** whose axial position is a function of rotational speed of the shaft **50** (see the inductance coil **16**) and also a function of certain other factors which influence the output signal from the control circuit **12a** to the electromagnet **11**. Such additional factors include the position of the gas pedal, the atmospheric pressure, and/or others.

The amplifier **26** is designed in such a way that it offers an accurately determined constant input resistance which remains unchanged during prolonged operation of the diesel engine. The strength of the current flowing in the input circuit of the amplifier **26** is proportional to voltage in the inductance **17**, i.e., to rotational speed of the shaft **50**. When the speed of the shaft **50** exceeds a permissible maximum value, the safety fuse **27** responds and opens the input circuit to deenergize the relay **28** in the output circuit of the amplifier **26**. The relay switch **30** opens and the winding **20a** is deenergized to permit closing of the valve member **23** under the action of the spring **22** so that the flow of fuel from the chamber **114** to the chamber **14** is interrupted in response to an increase in rotational speed of the shaft **50** beyond the permissible value.

The second safety fuse **29** constitutes an optional feature of the regulating circuit **19**. This fuse is provided to effect deenergization of the relay **28** and opening of the switch **30** in the event of failure of one or more electronic or other components of the amplifier **26**. For example, if a transistor in the amplifier **26** is damaged or destroyed, the output circuit of this amplifier might continue to furnish a high voltage signal subsequent to opening of the input circuit by the safety fuse **27**. The fuse **29** is designed to open the output circuit and to deenergize the relay **28** in response to the flow of a current which is indicative of the maximum permissible rotational speed of the shaft **50**. Thus, the winding **20a** can be deenergized by the fuse **27** or by the fuse **29**.

It will be noted that the regulating circuit **19** serves the sole purpose of establishing an operative connection between the speed counter **15, 17, 34** and the safety valve **20**. The inductance **17** constitutes a discrete galvanically separated output element of the speed counter; this insures that the functioning of the improved safety device is independent of adverse influences on the control circuit **12a** or other parts of the engine.

FIG. 2 illustrates a portion of a second fuel injection pump wherein the safety valve **20'** is installed in a fuel returning passage **42** which can deliver fuel from the high-pressure chamber **14** to the low-pressure chamber **114**. The body **40** of the safety valve **20'** is immediately adjacent to the chamber **14** and is provided with ducts **41** which can establish a connection for the flow of fuel from the chamber **14** to the passage **42** when the winding **20a'** is deenergized in response to opening of the switch **30**. The valve member **23'** of the core **21'** is of conical shape and its conical surface is biased away from a seat in the valve body **40** by the spring **22'** as soon as the circuit of the winding **20a'** opens, i.e., whenever the switch **30** is opened while the auxiliary switch **32** is open.

When the engine is idle, the switches **30, 32** are open, the winding **20a'** is deenergized and the spring **22'** maintains the valve member **23'** in open position. Thus, the passage **42** between the chambers **114, 14** is open and fuel cannot be forced into the fuel lines **33**. When the winding **20a'** is energized in response to closing of the switch **30** or **32** in a manner as described in connection with FIG. **1**, the core **21'** is moved axially against the opposition of the spring **22'** and the valve member **23'** moves to closed or sealing position to prevent the flow of fuel from the chamber **14** to the chamber **114**. Thus, the pressure in chamber **14** can be built up sufficiently to equal that pressure which is necessary to effect admission of fuel into the cylinders of the engine. The rising pressure in the chamber **14** acts on the valve member **23'** and assists the winding **20a'** in maintaining the safety valve **20'** in sealing position.

When the circuit of the winding **20a'** is opened on deenergization of the realy **28**, the spring **22'** is free to return the valve member **23'** to open position so that the pressure in the chamber **14** drops below that which is necessary for admission of fuel into the cylinders. The valve member **23'** can move to sealing position (under the action of spring **22'**) not later than in response to the first suction stroke of piston **13** following the opening of switch **30**. During such suction stroke of the piston **13**, the pressure in the chamber **14** drops sufficiently to permit opening of the valve member **23'** under the bias of the spring **22'**.

At least one of the safety fuses **27, 29** may be an electronic fuse which is responsive to a predetermined voltage or intensity of current and which opens when the current intensity or voltage in the corresponding (input or output) circuit of the amplifier **26** exceeds a predetermined value corresponding to the maximum permissible rotational speed of the shaft **50**. Also, at least one of these fuses can be designed to complete the circuit as soon as the voltage or current strength drops below that which is indicative of excessive rotational speed of the shaft **50**. In its simplest form, the fuse **27** and/or **29** may include a fusible conductor which melts when the strength of the current in the corresponding circuit rises beyond a permissible value.

It was found that the improved safety device (including the speed counter **15, 17, 34**, the regulating circuit **19** and the safety valve **20** or **20'**) is at least as reliable as conventional centrifugal governors which are used in many presently known diesel engines. It was also found that the expenditures involved in the provision and mounting of such safety device in an engine whose operation is regulated by an electronic control circuit are warranted and reasonable, partly because the amplifier **26** can receive current from the source which supplies current to the control circuit **12a** and also because at least some components (such as the inductance **17**) can be mounted on parts (yoke **15**) which are necessary for proper operation of the control circuit. The overall cost of the components of the safety device is considerably less than that of a conventional centrifugal governor. Furthermore, the improved safety device is so versatile that it can be used in nearly all types of electronically controlled diesel engines. The amplifier 26 and the fuses 27, 29 can be readily designed to respond to a predetermined maximum speed of the engine. Still another advantage of the improved safety device is that the fuel injection pump can deliver fuel to the fuel lines 33 only at a time when the energy source 31 is in circuit with the winding 20*a* or 20*a'* of the safety valve 20 or 20'. Thus, eventual damage to or malfunction of that part of the regulating circuit 19 which includes the amplifier 26 merely results in closing of the safety valve (FIG. 1) or opening of such valve (FIG. 2) to prevent delivery of fuel to the fuel lines 33.

Each circuit of the amplifier 26 can include two or more fuses.

A circuit, which works as a electronic fuse, is disclosed in the Publication from Siemens, Schaltungen mit Halbleiterbauelementen, Band 2, 1965, page 163. An amplifier, capable of being used in the circuit 19 FIG. 1 or FIG. 2 is disclosed in the same publication on page 117.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. In an internal combustion engine, a combination comprising a fuel injection pump having a high-pressure fuel chamber, a low-pressure fuel chamber, and a passage connecting said chambers; a rotary member arranged to rotate at a variable speed which is proportional to the operating speed of the engine; electromagnet safety valve means including a valve member installed in said pump and movable between open and closed positions in which it respectively permits and prevents the flow of fuel through said passage, said valve member being arranged to assume one of said positions in response to energization and the other of said positions in response to deenergization of said valve means; electrical speed counter means comprising a serrated ferromagnetic element driven by said rotary member, a yoke having at least one serrated portion adjacent to said ferromagnetic element, a first and a second inductance on said yoke; a regulating circuit connecting said first inductance to said safety valve means to effect a change in the condition of energization of said safety valve means when the speed of said rotary member reaches a predetermined value; an electric control circuit connected to said second inductance; and means connected to said electronic control circuit for regulating supply of fuel by said injection pump to said engine in dependence on the speed of said rotary member.

2. A combination as defined in claim 1, wherein said passage is arranged to supply fuel from said low-pressure chamber to said high-pressure chamber and wherein said valve member is moved to closed position in response to said change in the condition of energization of said safety valve.

3. A combination as defined in claim 1, wherein said passage is arranged to convey fuel from said high-pressure chamber to said low-pressure chamber and wherein said valve member is moved to open position in response to said change in the condition of energization of said safety valve.

4. A combination as defined in claim 1, wherein said regulating circuit connecting said speed counter means with said valve comprises amplifier means having an input circuit including a portion of said speed counter means and an output circuit arranged to effect changes in energization of said safety valve means in dependency on the condition of said input circuit.

5. A combination as defined in claim 4, wherein said output circuit includes a relay having a switch in circuit with said safety valve means.

6. A combination as defined in claim 5, wherein at least one of said input and output circuits includes a safety fuse arranged to open the respective circuit when the speed of said rotary member reaches said predetermined valve.

7. A combination as defined in claim 6, wherein said fuse is an electronic fuse.

8. A combination as defined in claim 6, wherein each of said input and output circuits includes at least one fuse.

9. A combination as defined in claim 1, further comprising starter means actuatable to start the engine and means for effecting a change in the condition of energization of said valve means in response to actuation of said starter means.

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