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BOOSTER SYSTEM FOR HYDRAULIC GOVERNORS OF DIESEL ENGINES AND METHOD OF STARTING SUCH ENGINES

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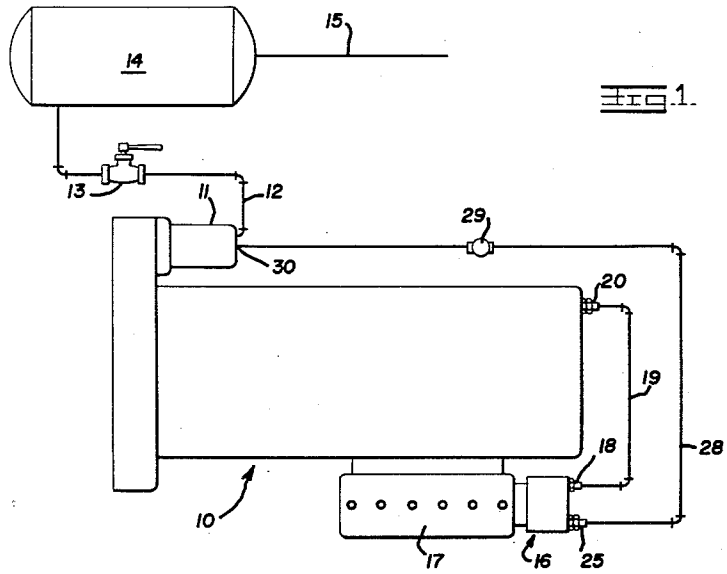


Fig. 1.

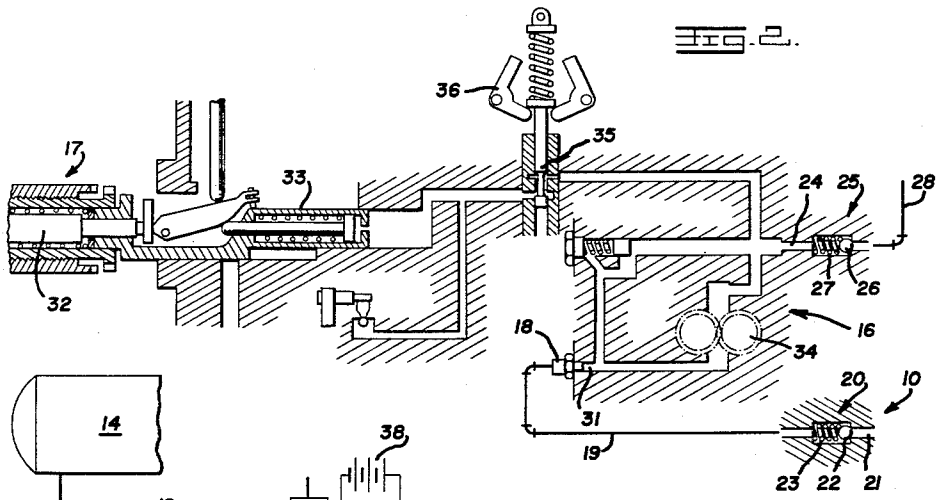


Fig. 2.

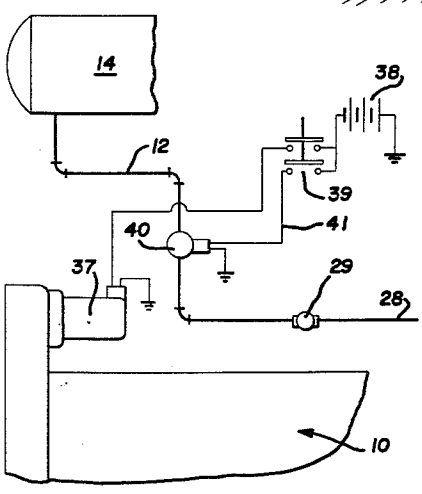


Fig. 3.

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# BOOSTER SYSTEM FOR HYDRAULIC GOVERNORS OF DIESEL ENGINES AND METHOD OF STARTING SUCH ENGINES

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8 Claims. (Cl. 123—179)

This invention relates to a compressed air booster system for hydraulic governors of diesel engines and to a method of starting such engines with the aid of the booster system.

Diesel engines conventionally employ compressed air operated starter motors for cranking the engine during the starting cycle. Electric or hydraulically operated starter motors are also sometimes employed. Hydraulically operated governors are ordinarily used on the diesel engines and such governors include a hydraulically operated servo piston which operates the fuel injection pump means of the engine during the starting cycle, so that fuel may be supplied to the several cylinders of the engine. The hydraulic governor has its internal hydraulic passages directly connected with the pressure lubricating system of the diesel engine and receives lubricating oil under pressure from the engine for operation during the starting cycle and after the engine achieves running speed. After the starting cycle is completed, the governor serves additionally to regulate engine speed as controlled by the accelerator linkage, as is well known.

Difficulties arise in connection with the operation of the hydraulic governor during starting of the diesel engine by the compressed air operated starter motor. The engine is initially cold and its lubricating oil is cold and has relatively high viscosity. A definite amount of oil pressure must be developed in the system to enable the hydraulic governor and its built-in supply pump to function properly for operating the servo piston, which in turn actuates the fuel injection pump. It frequently happens during starting that before sufficient oil pressure is developed by the engine to enable the governor to properly operate the fuel injection means that the compressed air supply for the starter motor is diminished, and time must be allowed to compress additional air for further operation of the starter motor. It is often necessary to operate the starter motor a number of times before the engine oil pressure is built up sufficiently to properly operate the hydraulic governor, and the compressed air supply must be continuously replenished. This is a costly problem where a diesel engine operated truck or the like is stopped on the highway far from service facilities and cannot be started without exhausting its compressed air supply, which supply is normally continuously replenished when the engine is running. The same costly problem can arise where an electric starter is employed, because the storage battery may run down before the diesel engine can be started.

In accordance with this invention, the above difficulties are entirely overcome in a simplified and economical manner. Means are provided to divert compressed air from the air operated starter or from the compressed air reservoir directly to the hydraulic passages of the governor, during the starting cycle, to boost or assist the operation of the governor, independently of its normal lubricating oil supply from the engine but in conjunction therewith. The arrangement is such that the hydraulic



governor is efficiently operated by compressed air during the starting cycle so that the associated fuel injection mechanism will properly supply fuel to the engine cylinders to start the engine without difficulty, even when the engine lubricating oil pressure is much too low to effectively operate the governor for this purpose.

It is therefore a prime object of the invention to provide an air booster system for hydraulic governors of diesel engines and a method of starting such engines with the aid of the booster system, to facilitate rapid and sure starting of the engine under all conditions, and irrespective of a lag in the build up of lubricating oil pressure which normally operates the hydraulic governor.

A further important object is to provide in a governor air booster system of the above-mentioned character, novel check valve means to prevent the engine lubricating oil being supplied to the governor from being forced by the compressed air back into the crankcase of the engine; and to also prevent the oil within the governor from being forced into the compressed air supply line leading to the governor, during the starting cycle and the subsequent running cycle of the engine.

Further and more general objects are to provide an air booster systems for governors which is highly simplified, reliable and efficient in operation, inexpensive to manufacture, install and maintain, and which does not necessitate altering the conventional construction or normal operation of the hydraulic governor, starter motor or fuel injection mechanism.

Still another object is to provide an air booster system and method of the above character which may be employed with equal facility on diesel engines equipped with electrical starters or hydraulic starters.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawings, forming a part of this application and in which like numerals are employed to designate like parts throughout the same,

Figure 1 is a diagrammatic plan view of a compressed air booster system for the hydraulic governor of a diesel engine in accordance with the invention.

Figure 2 is a diagrammatic cross section of the hydraulic governor and associated elements, showing the connections of the engine lubricating oil system and the compressed air system with the governor and also showing the check valves.

Figure 3 is a fragmentary plan view of the booster system in accordance with a modification of the invention where the diesel engine has an electric starter.

In the drawings, wherein for the purpose of illustration are shown preferred embodiments of the invention, the numeral **10** designates a conventional diesel engine, such as a six cylinder engine commonly employed in trucks or similar automotive vehicles. It should be mentioned here that the invention is in no sense limited to use upon automotive diesel engines, and is applicable with equal facility to various types of diesel engine plants, such as marine power plants, industrial diesel power plants or stationary diesel engines of various types.

The diesel engine **10** has a compressed air operated cranking or starting motor **11** of any preferred conventional type, as shown diagrammatically in Figure 1. The starting motor **11** receives compressed air to operate the same through a pipe **12** having a manually operated control valve **13** connected therein, and leading to and connected with a suitable reservoir **14** for compressed air. The reservoir or tank **14** is supplied with compressed air through a pipe **15** from the usual air compressor, not shown, driven by the diesel engine **10**. To enable the engine to be started or cranked by the starter motor **11**, there must be a supply of compressed air in the

reservoir 14, built up by previous running of the engine, or if there is no such supply of compressed air in the reservoir 14, such air must be introduced into the system by external means.

With continued reference to Figure 1, the numeral 16 designates generally a conventional hydraulically operated diesel engine governor of a type commonly employed on diesel engine operated trucks and the like. A preferable hydraulic governor is one manufactured by Woodward Governor Company, Rockford, Ill., although any other conventional hydraulic governor of a similar type may be employed. The governor 16 is mounted upon the fuel injection means 17 of the diesel engine as shown diagrammatically in Figure 1.

The hydraulic governor 16 normally receives engine lubricating oil under pressure through a suitable fitting 18, connected with an oil line 19, leading to and connected with a first one-way ball check valve unit 20, communicating with a port 21 of the engine lubricating oil system, Figure 2. The check valve unit 20 embodies a ball check valve element 22, maintained normally closed by a spring 23, and opening outwardly from the engine port 21 to admit engine lubricating oil to the line 19. The ball valve element 22 is normally closed against the port 21 to prevent the compressed air supplied to the governor from forcing the engine oil back through the engine oil passage to the crankcase, as will be further discussed.

The hydraulic governor 16 is adapted to receive compressed air in a passage 24, through a second one-way ball check valve unit 25, secured therein, and which check valve unit has a normally closed ball check valve element 26, acted upon by a spring 27 as shown in Figure 2. The ball check valve unit 25 serves to admit compressed air to the governor passage 24, and it prevents the oil within the governor from subsequently being forced into the compressed air system, as when the engine 10 is started and running at normal operating speed and no further compressed air is being introduced into the governor passages.

The ball check valve unit 25 is connected with a compressed air line or hose 28, preferably having a trap 29 for water or condensate connected therein, and the hose 28 leads to and is connected with the air starter motor 11 as at 30.

It may now be observed that the hydraulic governor 16 is adapted to receive in its internal passages 31 and 24, Figure 2, engine lubricating oil under pressure from pipe 19 and air hose 28 respectively. Due to the arrangement of the check valve unit 25, the oil under pressure entering the governor at 18 cannot pass into the compressed air hose 28, as previously explained. Likewise, due to the check valve unit 20, compressed air entering the governor passage 24 cannot force oil in the line or pipe 19 back into the engine oil port 21 or back to the crankcase of the engine. In some instances the check valve unit 20 may be omitted entirely from the system without adversely affecting the operation, but it is preferred to employ both check valve units in the system.

The fuel injection mechanism 17 previously mentioned is also of conventional construction and need not be described in detail. With reference to Figure 2, the fuel injection mechanism embodies the usual injection pump 32, operated by the servo means or piston 33 of hydraulic governor 16. The governor also has the usual built-in supply pump 34, spool type pilot valve 35 and associated fly balls 36, as well as other component parts, but these elements constitute no part of the present invention, and their normal constructions and modes of operation in the hydraulic governor are not affected in the slightest by the air booster system of the present invention. No further description of the conventional governor and fuel injection mechanism is therefore necessary in this application.

The operation of the system as shown in Figures 1 and 2 and the novel starting method made possible by the system is as follows:

When the diesel engine 10 is to be started, compressed air from the reservoir 14 is admitted to the air operated starting motor 11 by use of the manual valve 13. The starting motor 11 will immediately begin to crank the disel engine. Simultaneously compressed air from the starting motor 11 will enter the hose 28 and flow into the hydraulic passage 24 of the governor 16 to pressurize the governor during the starting cycle. The check valve unit 25 will open automatically to admit the compressed air into the governor. At the same time, cranking of the engine 10 will create some lubricating oil pressure in the pipe 19, and some oil under pressure from the pipe 19 may also enter the governor passage 31. However, for reasons previously explained, the oil pressure in the pipe 19 may not be sufficient to fully pressurize the hydraulic governor and cause proper operation of the servo piston 33 and associated elements which operate the fuel injection pump 32, and it is here that the air booster system comes into play to adequately pressurize the governor passages during the starting cycle when the hydraulic or oil pressure may be too low.

When the compressed air enters the governor at 24, the internal passages of the governor are pressurized and the servo piston 33 will operate effectively during the starting cycle and shift the injection pump 32 to the left, Figure 2, to effect the injection of fuel into the cylinders of the diesel engine so that starting will take place promptly and efficiently.

Once the engine has started and begins to achieve operating speed, the engine oil pressure in the pipe 19 will come up to normal so that the engine oil may adequately pressurize and operate the governor without further assistance from the compressed air booster means. That is to say, once the engine has been started by the procedure described, manipulation or release of the control lever on the valve 13 will stop the operation of the air starting motor 11, and the lubricating oil under pressure in the pipe 19 will continue to be fed to the governor for operating it in the normal manner, whereby the governor will continue to control the fuel injection means. engine speed, etc. Once the starting cycle has been completed as above-described, no further compressed air will be supplied to the hydraulic governor.

When the engine and its governor are thus normally operating without assistance from the compressed air booster system, the check valve unit 25 will serve to prevent the oil in the governor from being forced into the compressed air hose 28. As previously described, the check valve unit 20 prevents the compressed air fed to the governor during the starting cycle from forcing the engine oil back into the engine or engine crankcase. During normal operation of the engine and governor, the check valve unit 20 opens automatically to allow the passage of oil into the pipe 19 and into the governor, and during normal operation of the engine, the check valve unit 25 remains closed to prevent oil from entering the hose 28.

The system is entirely automatic and free of moving parts except for the two automatic check valve units 20 and 25. Installation of the simple air booster system necessitates no material alteration of the standard components of the power plant including the air starting motor 11 and the hydraulic governor 16. It is merely necessary to provide the compressed air hose 28 and connect it with the starter motor 11 and the hydraulic governor. The conventional governor ordinarily has a screw-threaded plug in its passage 24 which in practice may be removed and replaced by the check valve unit 25. The oil pipe 19 is a standard component part of the power plant in any event, and it is a very simple matter to install the other check valve unit 20 in communication with the pipe 19 and engine port 21.

In Figure 3 there is shown a modification of the

invention, wherein the diesel engine 10 is equipped with an electric starter motor 37 instead of the air starter motor 11. The electric starter motor 37 is powered by a battery 38, connected in circuit with a starter switch 39, operable within the cab of the truck. In lieu of the manual valve 13, a solenoid operated valve 40 is connected in compressed air pipe 12, and the solenoid operated valve is electrically connected at 41 with the starter switch 39 so that it may be operated simultaneously with the operation of the electric starter motor. All other parts of the system and their mode of operation are identical to the corresponding parts shown and described in connection with the prior form of the invention.

In operation, Figure 3, the switch 39 is closed manually to energize the starting motor 37 and to open the valve 40. The motor 37 cranks the engine as previously described, and compressed air from the reservoir 14 flows through the pipe 12 and into the hose 28 which is directly connected with the pipe 12 in Figure 3. The system operates during the starting cycle in the same manner described previously in the prior form of the invention. When the engine is successfully started, the switch 39 is released and opened, and this disconnects the starting motor 37 and closes the valve 40 so that no further compressed air is introduced into the governor 16. The governor now continues to be pressurized by the engine lubricating oil after the starting cycle as described in the prior form of the invention.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred examples of the same, and that various changes in the shape, size and arrangement of parts may be resorted to, without departing from the spirit of the invention or the scope of the subjoined claims.

Having thus described my invention, I claim:

1. A method of starting a diesel engine, said engine having a starter motor and a hydraulic governor and fuel injection means actuated by the governor, said governor having passages to receive fluid under pressure, the mehod comprising operating the starter motor to crank the engine and simultaneously introducing fluid under pressure into said governor passages to pressurize the governor sufficiently during the starting cycle to enable the governor to properly actuate said fuel injection means, and then introducing lubricating oil under pressure from the diesel engine into said passages of the governor when the engine is started to maintain the governor pressurized and stopping the introduction of said fluid under pressure into said governor passages.

2. A method of starting a diesel engine, said engine having a starter motor, oil pressure lubricating system, a hydraulic governor and fuel injection means operated by the governor, said governor having passages to be pressurized, said method comprising operating the starter motor to crank the engine and simultaneously introducing compressed air into the governor passages to pressurize the governor during the starting cycle so that the governor may operate the fuel injection means to start the engine, introducing engine lubricating oil under pressure into the governor passages after the engine is started and thereby maintaining the governor pressurized, discontinuing the introduction of compressed air into the governor passages after the engine is started, and preventing the passage of the engine lubricating oil within the governor passages into the compressed air system leading to the governor passages.

3. A method of starting a compression ignition type internal combustion engine, said engine having a compressed air operated cranking motor, an oil pressure lubricating system, a hydraulic governor and fuel injection means controlled by the governor, the governor having fluid passages to be pressurized for operating the governor, the method comprising introducing compressed air into said cranking motor to crank the engine and diverting compressed air from the cranking motor and introducing it into the fluid passages of the governor to pressurize the governor during the starting cycle of the engine when the lubricating oil pressure of the engine is too low to adequately pressurize the governor, allowing the engine to start and build up adequate lubricating oil pressure and then introducing the engine lubricating oil under pressure into said fluid passages of the governor to maintain the governor pressurized while the engine is operating at running speed, and blocking the passage of compressed air to the cranking motor and said fluid passages of the governor after the engine is started and the engine lubricating oil pressure is built up sufficiently to adequately pressurize the governor.

4. An air booster system for a hydraulic governor of a diesel engine, said engine having a fluid pressure operated cranking motor and fuel injection mechanism controlled by said governor and an oil pressure lubricating system, said governor having passage means for fluid under pressure, said system comprising conduit means for conveying fluid under pressure to said cranking motor and to the passage means of the governor for adequately pressurizing the governor when the engine is cranked and enabling the governor to properly activate the fuel injection mechanism, said conduit means communicating with the cranking motor and passage means of the governor, separate conduit means interconnecting the passage means of the governor and a passage of the engine lubricating system and adapted to convey engine lubricating oil under pressure to the passage means of the governor when the engine is started for maintaining the governor adequately pressurized while the engine operates at running speeds, valve means in the first-named conduit means for blocking the flow of said fluid under pressure to the cranking motor and passage means of the governor after the starting cycle of the engine is completed, and a check valve in the first-named conduit means near the governor passage means to prevent the engine lubricating oil within the governor passage means from entering the first named conduit means.

5. An air booster system for a hydraulic governor of a diesel engine according to claim 4, and a second check valve in said separate conduit means to prevent said fluid under pressure in the governor passage means during the starting cycle from forcing engine lubricating oil within the separate conduit means back into the crankcase of the engine.

6. An air booster system for a hydraulic governor of a diesel engine, said engine having a cranking motor and fuel injection mechanism actuated by said governor and an oil pressure lubricating system, said governor having passage means for fluid under pressure, said system comprising means to operate the cranking motor, means for simultaneously introducing fluid under pressure to the passage means of the governor for pressurizing the governor during the starting cycle of the engine, separate means for introducing engine lubricating oil under pressure to the passage means of the governor when the engine starting cycle is completed for maintaining the governor pressurized while the engine operates a running speed, valve means connected with the first-named means and operable to stop the passage of said fluid under pressure to the passage means of the governor after the starting cycle of the engine is completed, and check valve means associated with the governor passage means to prevent the passage of engine lubricating oil in the governor passage means to the first-named means.

7. In combination, a compression ignition type internal combustion engine, a cranking motor for said engine, fuel injection mechanism for said engine, a hydraulic governor associated with the engine and fuel injection mechanism and having passage means for fluid under pressure, means to operate the cranking motor, conduit means connected with the governor passage means for introducing fluid under pressure to the governor passage means while the

engine is being cranked, a check valve in said conduit means adapted to open automatically in one direction for allowing the fluid under pressure in the conduit means to enter the passage means of the governor and being normally closed to prevent back flow of fluid from the governor passage means to the conduit means, second conduit means interconnecting the passage means of the governor and the lubricating oil system of the engine, and a second check valve in the second conduit means adapted to open automatically in one direction for allowing engine lubricating oil to pass to the governor passage means and being normally closed to prevent back flow of engine lubricating oil to the engine.

8. A method of starting a diesel engine or the like, said engine having an oil pressure lubricating system, fuel injection means and a hydraulic governor associated with the fuel injection means to regulate the operation of the latter, said governor having passage means to normally receive engine lubricating oil under pressure for pressurizing the governor while the engine is operating, the method comprising cranking the engine, introducing a boosting fluid under pressure into the passage means of the governor while the engine is being cranked and while the engine lubricating oil pressure is inadequate to pressurize the governor and thereby adequately pressurizing it during the starting cycle, and allowing the engine to start and then ceasing to introduce said boosting fluid into the passage means of the governor and allowing engine lubricating oil under pressure to enter the passage means of the governor for maintaining the governor pressurized after completion of the engine starting cycle.

**References Cited in the file of this patent**

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,132,815 | Witzel et al. | Oct. 11, 1938 |
| 2,390,084 | Edwards | Dec. 4, 1945 |