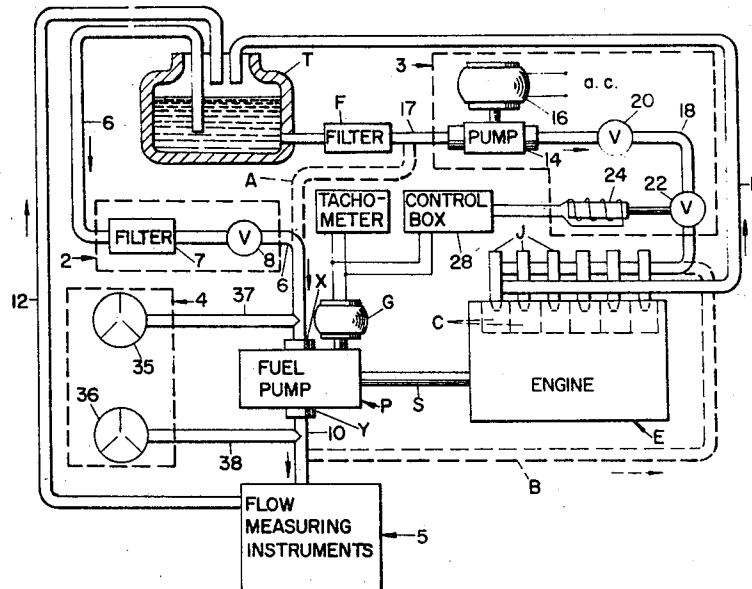


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[45] Patented **May 4, 1971**  
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[56] **References Cited**  
**UNITED STATES PATENTS**  
3,374,667 3/1968 Mayer..... 73/119(I)  
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[54] **FUEL PUMP TESTING METHOD AND APPARATUS**  
7 Claims, 3 Drawing Figs.  
[52] U.S. Cl. .... 73/119A  
[51] Int. Cl. .... G01m 15/00  
[50] Field of Search..... 73/118, 119  
(I), 168

**ABSTRACT:** Method and apparatus for testing and calibrating a fuel pump of the type used in "common rail" fuel systems for diesel engines. The fuel pump remains mounted on and driven by the engine. The method involves disconnecting the pump from the injectors, or other fuel delivery means of the engine, and connecting the pump to flow measuring apparatus. The pump remains mounted on and driven by the engine, and the engine in turn receives fuel for its operation from a second fuel pump. An important requirement of the test apparatus is that the pump to be tested must be driven at various controlled speeds. This is accomplished by means for controlling the pressure output of the second fuel pump.



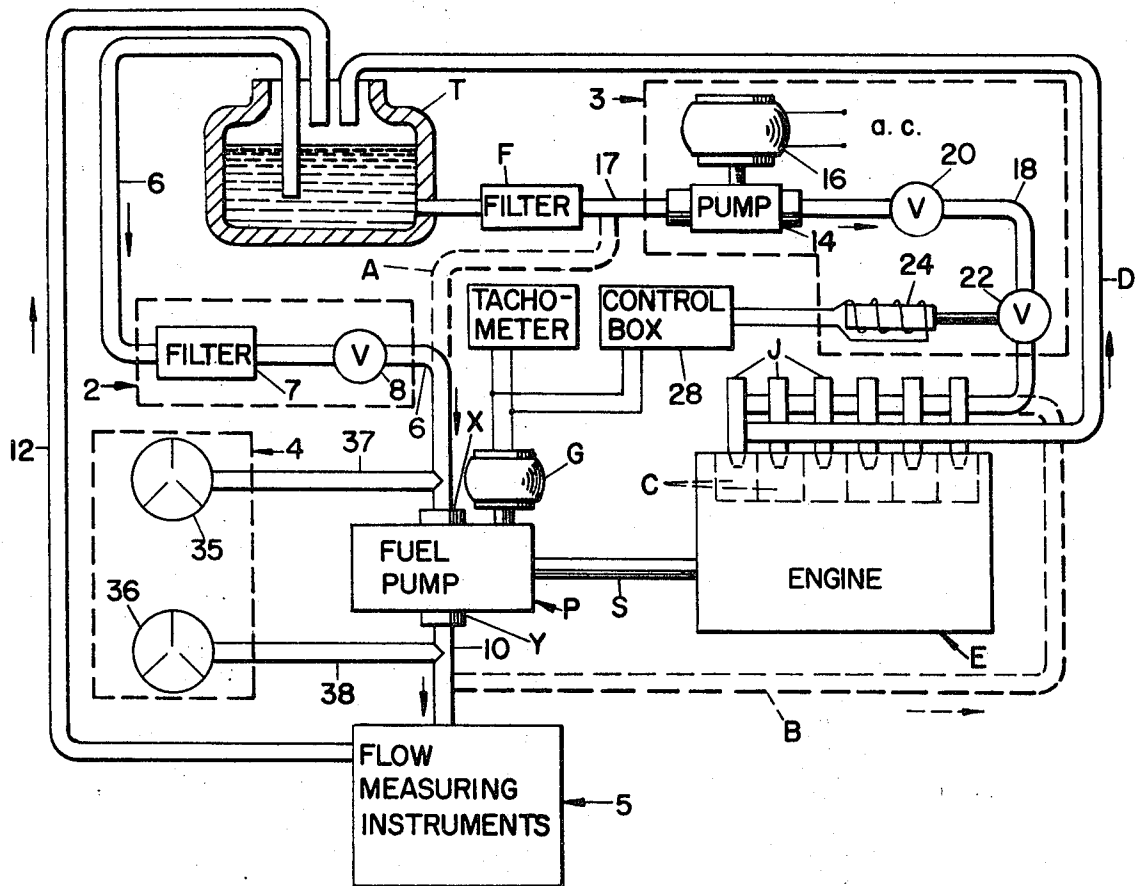


FIG. 1

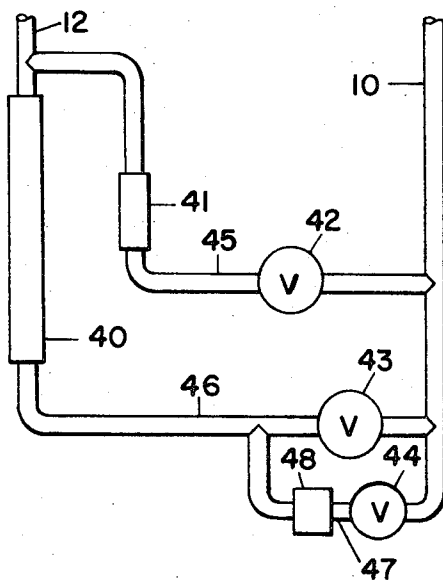


**FIG. 2**

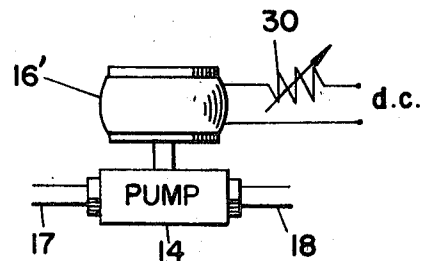


FIG. 3

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**FUEL PUMP TESTING METHOD AND APPARATUS**

This invention relates to a method and apparatus for testing a fuel pump. More particularly, the invention relates to the testing of a fuel pump for a diesel engine having a "common rail" type fuel distributing system. In such a fuel system, the pump supplies fuel to all of the injectors through a common rail. This is in contrast to a distributor type fuel system in which the pump feeds the injectors one at a time through separate fuel lines.

In the past, a common practice in testing a fuel pump for either a diesel or a spark ignition engine has been to remove the pump completely from the engine, mount it on a test stand, and drive the pump with a large electric motor supplied with the test stand. Fuel is delivered to the pump from a tank mounted on the test stand, and the output and input lines of the pump are connected to various pressure gauges and flowmeters. The motor is usually a variable speed DC motor, and the performance of the pump is usually measured by reading the various gauges and flowmeters at different speeds of the DC motor. This method and apparatus are described in detail in U.S. Pat. No. 3,340,728 to E. L. Taylor, et al.

There are a number of disadvantages in testing a pump with the foregoing apparatus and method. First, disconnecting the pump completely from the engine and remounting the pump on the test stand is a tiresome and time-consuming procedure. While such work is sometimes necessary if major adjustments are to be made to the pump, the pump usually needs only minor adjustments to recalibrate it, and these can be made while the pump is mounted on the engine.

Secondly, when the pump is mounted on the test stand, a considerable amount of power is needed to drive the fuel pump, and this power must be supplied by the electric motor on the test stand. For most diesel engine fuel pumps, a 5-horsepower motor is required, which is a heavy, bulky unit. Also, the electric motor must have a variable speed, so that the fuel pump can be run at different speeds. This means that the motor must be either a variable speed AC motor, or a DC motor equipped with an AC to DC converter. Either way, the motor is very expensive.

The foregoing disadvantages can be eliminated if the fuel pump can somehow be tested while it is mounted on and driven by the engine. With some types of engines, such as most spark ignition engines, the fuel pump can be so tested simply by disconnecting the fuel line from the pump to the carburetor, attaching the test apparatus to this fuel line, and running the engine with the fuel remaining in the carburetor float chamber. Such a pump test procedure is described in U.S. Pat. No. 3,292,428 to D. M. Motl. With this procedure, however, there is no way to control the fuel pressure, and such a control is necessary in a diesel engine if the engine and pump are to be run at a controlled speed during the test.

According to the present invention, a means and method are provided for testing an engine mounted fuel pump which provide for controlling the pressure of the fuel supplied to run the engine. This is accomplished by running the engine from a source of pressurized fuel which is separate from the engine's normal fuel supply system, and which is equipped with its own pressure control means. By adjusting this pressure control means, the engine and tested pump can be operated at a fixed desired speed, or at a number of different fixed speeds during the test.

One object of my invention is to provide apparatus for testing a fuel pump of the type used in common rail fuel systems for diesel engines, said apparatus enabling one to obtain the advantages of testing the pump while it is mounted on the engine, yet also providing a means for running the engine at a controlled speed to obtain an accurate calibration of the pump.

Another object of my invention is to provide apparatus for testing a fuel pump of the type used in common rail fuel systems for diesel engines, said apparatus comprising lightweight components which when put on a test stand can be transported easily from one place to another.

Still another object of my invention is to provide a method of testing fuel pumps of the type used in common rail fuel systems for diesel engines, said method involving both testing the pump while it is mounted on the engine, and attaining the advantages attendant therewith, and also at the same time running the engine at a controlled speed to obtain an accurate calibration of the pump.

These and other objects of the invention will be more apparent from the following detailed description, and the attached drawings in which:

FIG. 1 is a schematic diagram of apparatus for testing an engine mounted fuel pump;

FIG. 2 is a schematic diagram of the fuel test apparatus that is commonly included in one of the components of the apparatus shown in FIG. 1; and

FIG. 3 is a schematic diagram of a modified portion of the apparatus of FIG. 1.

Referring to FIG. 1, apparatus is shown for testing a fuel pump P that is driven by a diesel engine E through shaft S. The test apparatus includes components that are contained within heavy dotted line boxes 2, 3, 4, and flow measuring instruments contained in box 5. The components and instruments in boxes 2, 3, 4, and 5 are preferably mounted within a single test stand case, not shown. They are of such size and weight that a test stand holding them can be easily moved by a mechanic from one place to another.

The diesel engine E has a combustion means in the form of cylinders C, and injectors J which deliver fuel to the cylinders C. The engine E is also equipped with fuel tank T, shown in the upper left hand corner of FIG. 1. In the normal operation of the engine E, the fuel pump P draws fuel from the tank T through filter F and fuel line A, the latter being shown in dotted lines. The fuel enters pump P through inlet X and is pumped out through outlet Y. The fuel then flows through fuel line B, shown in dotted lines, to the injectors J. Fuel that is not injected by the injectors J into the cylinders C flows back to the fuel tank T through drain line D.

When testing or calibrating the fuel pump P, the inlet X of the pump is disconnected from fuel line A and is connected instead to a fuel line 6, which leads from tank T through components box 2 of the test apparatus. Inside the components box 2, a filter 7 filters the fuel flowing from tank T to pump P and valve 8 is provided for setting the desired inlet pressure to pump P.

Also for testing the pump P, the pump outlet Y is disconnected from fuel line B to the injectors. Fuel line 10 leading to the flow measuring instruments in box 5 is then connected to the pump outlet Y. An example of the flow measuring instruments which can be contained in box 5 is shown in FIG. 2, to be described later. Fuel measured by the instruments in box 5 returns to tank T through fuel line 12.

Components box 3 contains equipment for supplying fuel to the engine E while the fuel from pump P goes to the test instruments in box 5. This equipment includes a gear pump 14, preferably driven by a synchronous AC electric motor 16. The size of the pump 14 and motor 16 will depend on the size of the engine E. A 1 gallon-per-minute pump driven by a one-third horsepower motor is sufficient for any diesel engine designed for on-highway use. The gear pump 14 is connected by fuel line 17 to the filter F, at the same place where the filter had been disconnected from the fuel pump P. Fuel line 18 connects the output of the gear pump 14 to the injectors J of the engine E. Valve 20 in the fuel line 18 regulates the pressure of the fuel supplied by pump 14 to the injector J.

An alternate way of controlling the pressure of the fuel supplied to injectors J is shown in FIG. 3. The valve 20 is eliminated and the synchronous AC motor 16 is replaced with a variable speed DC motor 16'. Variable resistor 30 controls the speed of motor 16', and in turn, the speed of pump 14 and the pressure in fuel line 18 leading to the injectors J.

Valve 22 in the fuel line 18 prevents the engine E from over-speeding. This valve and its control means are not absolutely necessary if the mechanic using the test apparatus is skilled

and alert. However, the valve 22 is a very desirable means of insuring that the engine will never operate above a maximum desired speed no matter how high the valve 20 or resistor 30 is turned. The valve 22 is normally closed and is held open by a solenoid 24 receiving current from a generator G. On many fuel pumps there is already mounted a generator G for supplying current to the engine tachometer M. For the purpose of operating valve 22, it is necessary to have attached to the tachometer a separate control box 28, commonly called an "overspeed cutout" device. This is available as an accessory to the tachometer from several manufacturers of tachometers, such as Standard Electric Time Company of Springfield, Mass. The "overspeed cutout" or control box 28 cuts off the current to solenoid 24 when the voltage generated by generator G indicates a speed above the maximum allowable speed of engine E.

The conventional instrumentation for measuring the flow output characteristics of pump P include pressure gauges 35 and 36 in components box 4 (FIG. 1). Static fuel line 37 connects the pressure gauge 35 to the inlet side of fuel pump P and static fuel line 38 connects pressure gauge 36 to the outlet side of fuel pump P.

Other conventional instruments for measuring the flow output characteristics of pump P are contained in box 5. As shown in FIG. 2, these instruments include a large flowmeter 40 and a small flowmeter 41, located in fuel lines 46 and 45 respectively. Valve 42 controls the flow of fuel through line 45 and flowmeter 41. Valve 43 controls the flow through fuel line 46 and flowmeter 40. Valve 44 controls the flow through fuel line 47, idle orifice 48, fuel line 46, and flowmeter 40.

Using the above apparatus, a mechanic can calibrate the pump P in the following manner. To simulate part load or full load engine operation, he starts the engine E and turns up valve 20, or variable resistor 30 if the embodiment of FIG. 3 is used. He turns the valve or resistor until engine E reaches one of the speeds at which the pump P is to be checked. Also, at the beginning of the calibration of each fuel pump, the mechanic adjusts valve 8 to obtain a desired fuel inlet pressure to pump P which is registered on pressure gauge 35. He then turns valve 43 until the desired flow rate from pump P is registered on the large flowmeter 40. Valves 42 and 44 remain closed. If under these conditions, pressure gauge 36 records a pressure within the limits specified on the pump calibration chart, no adjustment of the pump is required. If, however, the pressure indicated on gauge 36 is not within the specified limits, the fuel pump P is adjusted in a known manner.

The mechanic then moves to the next point on his calibration curve, turning the valve 20 to operate the engine E at another speed. He also adjusts the valve 43 to a new flow rate, and again reads the pressure on gauge 36. If necessary, he makes adjustments to the pump P. He repeats this procedure for each of the other points on the calibration curve.

To check the performance of fuel pump P while engine E is idling, the mechanic turns down the valve 20 until the engine is running at idle speed as indicated on the tachometer M. Then he turns on valve 44 in fuel line 47 to its fully opened position. Valves 42 and 43 are closed. Under these conditions, the flow rate from pump P is regulated by the idle orifice 48. The mechanic then observes the pressure on gauge 36. If this pressure is not within specified limits, he adjusts the fuel pump accordingly.

To test the throttle leakage flow from fuel pump P, valves 43 and 44 are closed and valve 42 is opened. With the engine E operating at rated speed, the mechanic closes the throttle on fuel pump P, opens valve 42, and observes the throttle leakage flow on flowmeter 41. If the flow is not within specified limits, he makes the necessary adjustments to the fuel pump P.

Thus, with the foregoing method and apparatus, a mechanic can test a fuel pump of the type used in common rail fuel systems for diesel engines without dismounting the pump from the engine. This saves valuable labor, since the adjustments usually required on the pump as a result of the testing can also be made without dismounting the pump. In addition,

the size and weight of the equipment required on the pump test stand is greatly reduced. For instance, the 5 horsepower DC motor, which was formerly used to drive with fuel pump to be tested, has been replaced with a small 1 gallon-per-minute secondary pump and a small one-third horsepower AC motor. Furthermore, the only fuel supply required with the new apparatus is the tank T used by engine E, as opposed to the separate fuel tank required on many prior test stands.

Of course, many modifications may be made to the apparatus described above, while still practicing my invention. For instance, the pump 14 is shown only as an example of one of the many sources of pressurized fuel that can be used to run the engine E. The important feature is the means for controlling the fuel pressure to the engine E, so that the engine E and pump P can be run at a desired speed or speeds for testing the pump. Examples of such control means are the valve 22 in FIG. 1, or the variable speed DC motor 16, and variable resistor 30 of FIG. 3.

I claim:

1. Apparatus for testing a flow output characteristic of a fuel pump for a controlled pump operating speed, said fuel pump being driven by an engine that is powered by a combustion means and has a common rail-type fuel delivery means for introducing fuel into said combustion means, said apparatus comprising
  - a fuel line connected to the output of said fuel pump, means connected to said fuel line for testing a flow characteristic of the fuel flowing from said fuel pump,
  - a pressurized fuel supply means connected to said fuel delivery means of said engine, and
  - a fuel control means connected to said pressurized fuel supply means for controlling the pressure of the fuel flowing from said pressurized fuel supply means to said fuel delivery means of said engine, so as to operate said engine at a controlled speed and thereby operate said fuel pump driven by said engine at said controlled pump operating speed.
2. Apparatus of claim 1 in which said pressurized fuel supply means includes
  - a second pump,
  - means for driving said second pump, and
  - a second fuel line connected at one end to the output of said second pump and connectable at its other end to said fuel delivery means of said engine,
  - said fuel control means including a valve in said second fuel line for varying and controlling the fuel pressure in said second fuel line.
3. Apparatus of claim 2 in which said means for driving said second pump includes an electric motor.
4. Apparatus of claim 3, including a second valve in said second fuel line, and means responsive to the speed of said engine for closing said second valve to shut off the fuel flowing from said second pump to said fuel delivery means when said engine reaches a set maximum allowable speed.
5. Apparatus of claim 1 in which said pressurized fuel supply means includes
  - a second pump,
  - an electric motor for driving said second pump, and
  - a second fuel line connected to the output of said second fuel pump and connected at its other end to said fuel delivery means of said engine,
  - said fuel control means including means for varying the speed of said electric motor.
6. A method of testing a fuel pump that is driven by an engine, said method comprising the steps of
  - connecting the output of said fuel pump to a means for measuring a flow output characteristic of said fuel pump,
  - connecting a source of pressurized fuel to the means on said engine that supplies fuel to the combustion means for powering the engine,
  - setting the pressure of the fuel delivered to said fuel supply means on said engine, so as to operate said engine and driven fuel pump at a desired speed for testing said flow output characteristic.

7. The method of claim 6 including the step of setting various pressures the fuel delivered to said fuel supply means on said engine, so as to operate said engine and driven fuel pump

at various desired speeds for testing said flow output characteristic.

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