Dec. 13, 1938. S. SUGIHARA 2,139,981

AUTOMATIC DEVICE FOR REGULATING FUEL INJECTION IN AN INTERNAL COMBUSTION ENGINE

Filed Dec. 16, 1936

Fig. 1

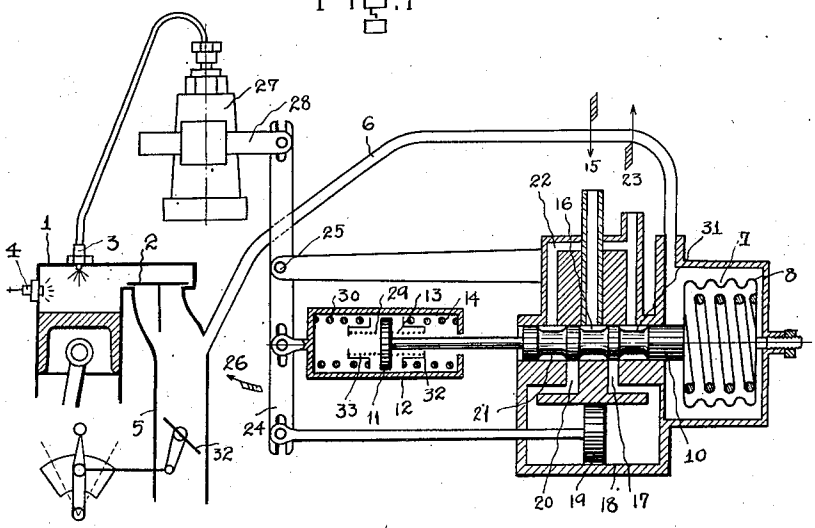


Fig. 2

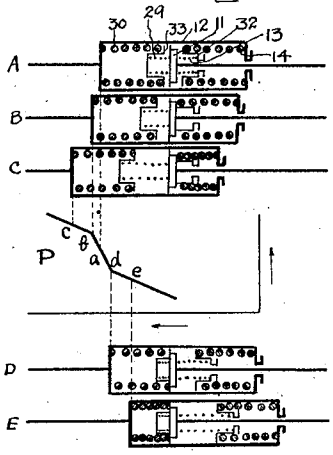
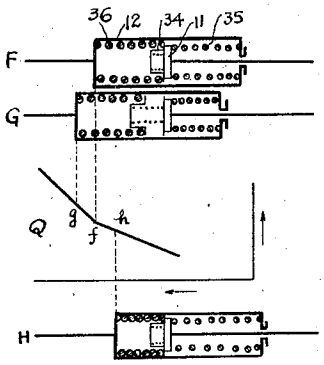


Fig. 3



Inventor:
S. Sugihara

By: Glascock Downing & Seebold
Attorneys.

Patented Dec. 13, 1938 2,139,981

UNITED STATES PATENT OFFICE

2,139,981

AUTOMATIC DEVICE FOR REGULATING FUEL INJECTION IN AN INTERNAL COMBUSTION ENGINE

Shuichi Sugihara, Toda-Machi, Naka-ku, Nagoya, Japan, assignor to Mitsubishi Jukogyo Kabushiki Kaisha, Tokyo, Japan

Application December 16, 1936, Serial No. 116,232
In Japan January 23, 1936

1 Claim. (Cl. 123—139)

This invention relates to an automatic device for regulating the amount of fuel supply from the fuel injection pump of an internal combustion engine responsive to variation of the pressure of the charging air.

In an internal combustion engine of the type in which volatile fuel such as gasoline is injected into the engine cylinder or into the suction pipe and is ignited by an electric spark, it is old to provide a bellows which functions responsive to the pressure variation in the suction pipe, and a servo-piston controlled by said bellows for automatically actuating a fuel injection regulating mechanism.

Further, it is also known that when carrying the device as above into practice, a proper ratio of fuel to air responsive to the output of the engine is obtained by employing a number of springs of different strengths so as to avoid the ratio being varied at a constant rate, because, the fuel-air ratio required by the engine takes a sudden change beyond certain output. For instance, in an aircraft engine, whilst it is desirable to maintain the fuel-air ratio as low as possible when the output is not so high, for instance when cruising, so as to attain economical fuel consumption, it is necessary to make the fuel-air ratio considerably higher in order to prevent overheating of the engine cylinders, exhaust valves, etc., when a higher output is temporarily required as when taking-off or climbing, although the fuel consumption increases thereby.

In hitherto known devices, however, the length of the bellows varies as the output of the engine and it lengthens or shortens in a wide range, so that durability of the bellows is impaired. As a rule, bellows are of little strength and easily broken so that when it is subjected to expansion or contraction in a wide range in use, the life is greatly shortened. This is the reason why their length is preferably kept as nearly constant as possible.

The present invention meets with the above requirement in that the bellows make a very small elongation or shrinkage only at a midway of change of pressure of the suction pipe and when the pressure of the suction pipe becomes a certain value, the bellows recover its original length so that this length is kept nearly constant with either a greater output or in a smaller output of the engine.

In the accompanying drawing, Figure 1 shows one form of the device according to this invention by way of example.

Figure 2 shows diagrammatically a joint having a pair of two different springs employed in this device, and a diagram illustrating the operation of the invention.

Referring to the drawing, particularly Figure 1, 1 designates an engine cylinder; 2 a suction valve; and 3 a fuel injection valve. 4 is an ignition plug, and 5 is a suction pipe. The pressure in said suction pipe is led through a conduit 6 into a chamber 7, in which is provided a bellows 8 which is maintained nearly at vacuum. When the pressure in the suction pipe 5 increases, said bellows 8 is slightly contracted. As the right-hand end of the bellows 8 is secured to the wall of the chamber 7, a pressure-oil distributing valve 10 secured to the left-hand end of said bellows moves to the right, compressing small spring 13 and large spring 14 in a box-like joint 12 by a disc 11 which is fixed to the lefthand end of the distributing valve 10. Therefore, the pressure-oil introduced in the direction of arrow 15 passes through a space 16 in the distributing valve and an oil conduit 17 into the righthand space in a pressure-oil cylinder 18 containing a servo-piston 19, so that the latter is moved leftwards. The oil in the lefthand space in the cylinder 18 is discharged through an oil conduit 20, a space 21 in the distributing valve, and an oil conduit 22 in the direction of arrow 23. As the servo-piston 19 moves leftwards, a lever 24 is oscillated about a pivot 25 in the direction of arrow 26, thereby shifting to the right a fuel supply regulating rod 28 of a fuel injection pump 27 for increasing the amount of fuel injection, at the same time also moving the joint-box 12 leftwards, so that the springs 13 and 14 are further compressed and tend to return the distributing valve 10 to the left. When the bellows 8 returns to its initial length, with the distributing valve closing the oil conduits 17 and 20, the servo-piston 19 is stopped. When the pressure in the suction pipe 5 decreases, the bellows 8 slightly expands, moving the distributing valve 10 to the left, so that the disc 11 compresses another small spring 29 and large spring 30. The pressure-oil introduced in the direction of arrow 15 flows through the space 16 in the distributing valve and the oil conduit 20 into the space left-hand to the servo-piston 19, moving the latter to the right, and the oil in the space right-hand to the servo-piston is discharged through the oil conduit 17 and a space 31 in the distributing valve in the direction of arrow 23. Upon rightward movement of the servo-piston 19, the fuel supply regulating rod 28 is moved to the left through the lever 24, decreasing thereby the

amount of fuel injection. At the same time, the springs 29 and 30 in the joint-box 12 are further compressed, tending to return the distributing valve 10 to the right and, when the bellows 8 returns to its initial length, closing the oil conduits 17 and 20, the servo-piston 19 is stopped. Thus, it will be seen that the springs in the joint-box 12 function responsive to the force exerted to the bellows 8 by the pressure in the suction pipe 5 and they produce the force just enough to return the pressure-oil distributing valve 10 to its initial position closing the oil conduits 17 and 20, and that the servo-piston 19 moves the lever 24 to the position in which said springs just produce the required amount of force.

Having substantially described the arrangement and operation of the device according to this invention, the operation of the springs in the joint-box 12 will now be described more in detail as follows:

In the embodiment shown in Figures 1 and 2, the box-like joint 12 contains two sets of spring device each consisting of two springs, one small and the other large. As shown in A in Figure 2, when the disc 11 on the lefthand end of the pressure-oil distributing valve lies in the central position in the joint 12 and the tensions on the righthand and lefthand springs are just equal, the springs do not act upon the distributing valve at all. In the diagram P in Figure 2, point *a* indicates the relation between the pressure in the suction pipe and the amount of fuel injection in such condition. When the pressure in the suction pipe 5 slightly increases, the small spring 13 will be immediately compressed, because the small springs 13 and 29 are extremely weak compared with the large springs 14 and 30, so that the lever 24 is oscillated in the direction of arrow 26 according to the movement of the servo-piston 19, whereby the fuel injection increases rapidly along the line *a*—*b* until the disc 11 comes in contact with a spring support 32 as shown at B in Fig. 2. When the pressure in the suction pipe further increases, the large spring 14 is compressed as shown at C in Fig. 2, so that the fuel injection is gradually increased along the line *b*—*c* in the diagram P. Now, when the pressure in the suction pipe 5 slightly decreases from that corresponding to the condition of A in Fig. 2, the small spring 29 will be immediately compressed, so that the lever 24 of Figure 1 is oscillated in the direction reverse to the direction of arrow 26 according to the movement of the servo-piston 19, whereby the fuel injection rapidly decreases along the line *a*—*d* until the disc 11 comes in contact with another spring support 33 as shown at D in Figure 2. When the pressure in the suction pipe further decreases, the large spring 30 is compressed as shown at E in Figure 2, so that the fuel injection is gradually decreased along the line *d*—*e*.

With the joint 12 of the above-mentioned nature, if the pressure in the suction pipe 5 is adequately selected so as to correspond with the point *d* of the diagram P of Figure 2 it is possible when the engine output is greater than that corresponding to said pressure in the suction pipe to make the fuel-air ratio considerably higher than that for the smaller output, whereby enabling to supply the adequate fuel-air ratio into the engine to suit varying operating conditions, so that the engine may be safely operated always maintaining good performance, without necessitating any special manipulation during operation.

What I claim is:

An automatic device for regulating fuel injection comprising a bellows adapted to expand and contract in response to pressure variations in the suction pipe of an internal combustion engine, a distributing valve, a servo-piston controlled by said distributing valve for regulating the fuel supply from a fuel injection pump to the engine, a spring case, said distributing valve being disposed between said bellows and said spring case, said bellows being fixed at one end and connected at its other end to one end of said distributing valve, a disc movable in said spring case and connected with the opposite end of said distributing valve, separate sets of springs located in said spring case, the springs of the respective sets being of different tension and acting against the opposite sides of said disc, and means connecting said spring case with said servo-piston.

SHUICHI SUGIHARA.