

Feb. 19, 1946.

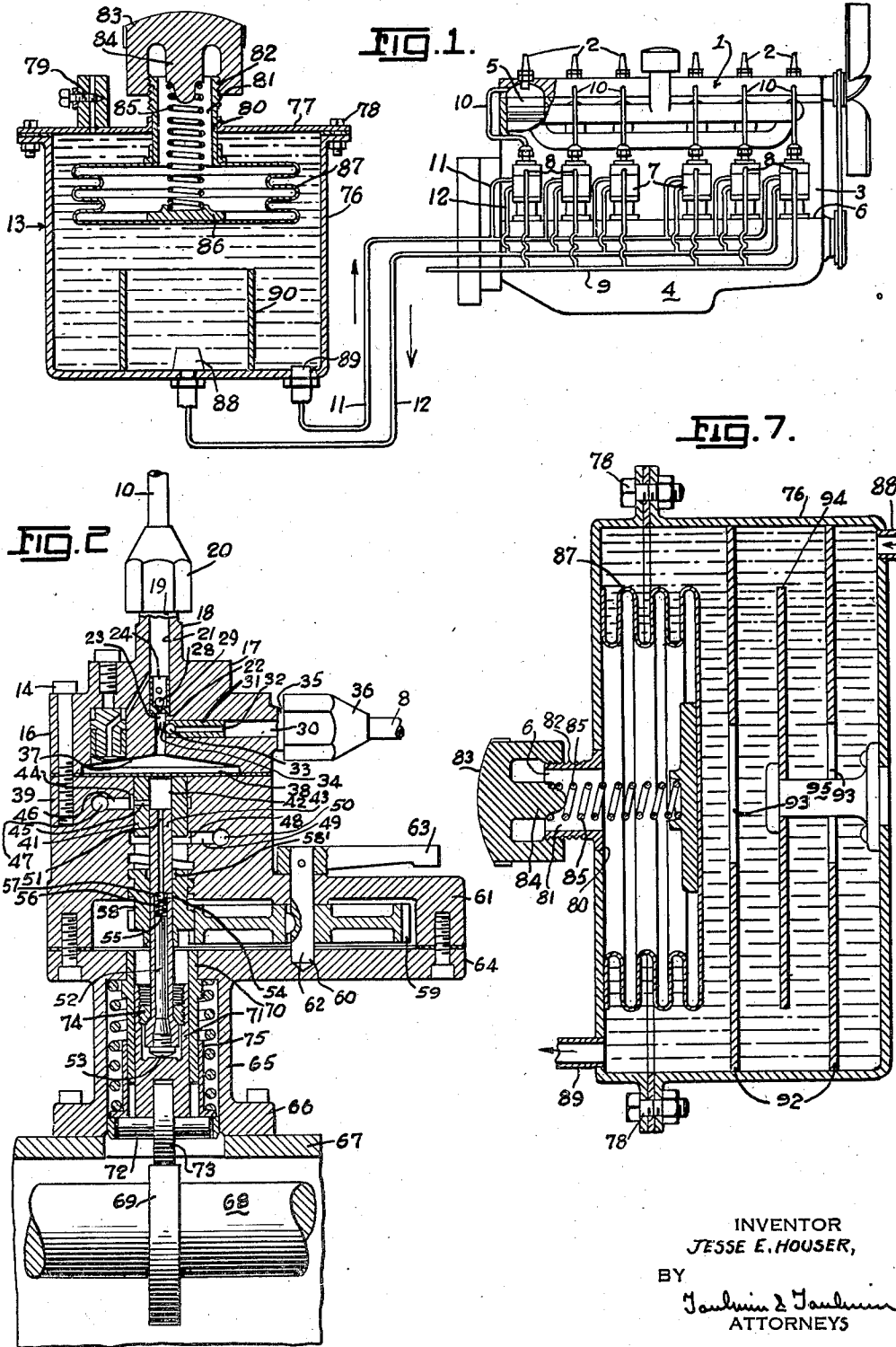
J. E. HOUSER

2,395,330

OIL CIRCULATORY SYSTEM EMPLOYED IN FUEL INJECTION PUMPS

Filed Sept. 11, 1942

2 Sheets-Sheet 1



INVENTOR
JESSE E. HOUSER,
BY
Toulmin & Toulmin
ATTORNEYS

Feb. 19, 1946.

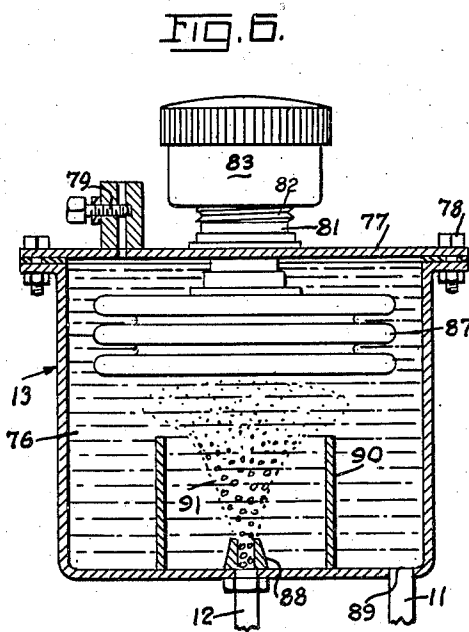
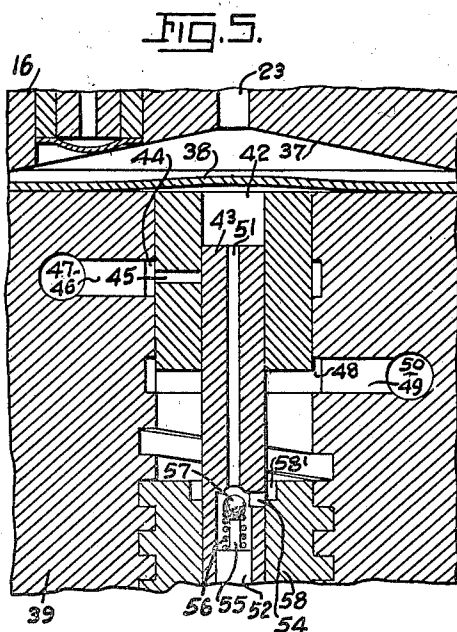
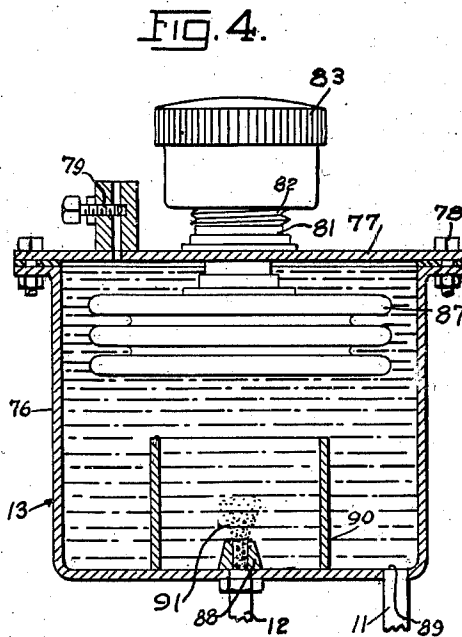
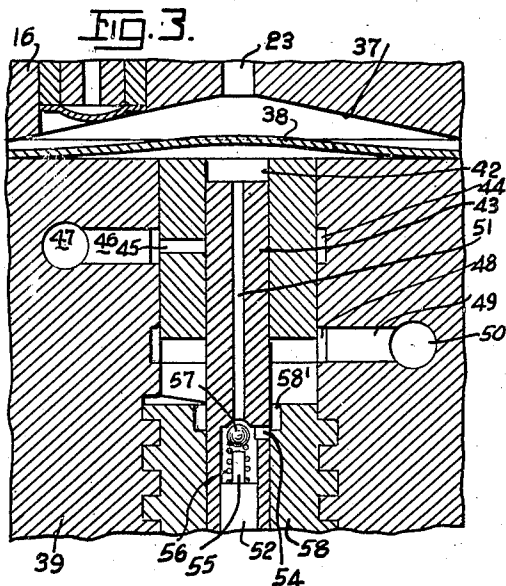
J. E. HOUSER

2,395,330

OIL CIRCULATORY SYSTEM EMPLOYED IN FUEL INJECTION PUMPS

Filed Sept. 11, 1942

2 Sheets-Sheet 2



INVENTOR
JESSE E. HOUSER,
BY
Paulsen & Paulsen
ATTORNEYS

UNITED STATES PATENT OFFICE

2,395,330

OIL CIRCULATORY SYSTEM EMPLOYED IN
FUEL INJECTION PUMPSJesse E. Houser, Dayton, Ohio, assignor to The
Dayton Liquid Meter Co., Dayton, Ohio, a cor-
poration of Ohio

Application September 11, 1942, Serial No. 457,965

12 Claims. (Cl. 103—44)

The present invention relates to improvements in a method of and apparatus for injecting fuel into automotive engines.

In the case of high power, high speed automotive engines, more particularly those employed in connection with aircraft, there has arisen a marked necessity for devices which will inject fuel of all kinds directly into the respective cylinders of the engine, or into the intake manifold, with a high degree of accuracy of measurement. These injectors are usually employed as a substitute for the ordinary forms of carburetion, leaving to the injection pump the very important function of accurately measuring the amount of fuel in the successive charges.

For this purpose it has been customary to employ a plunger attached to a fuel suction line which reciprocates in a cylinder carrying a spray nozzle. This nozzle is sometimes introduced directly into the respective cylinders of the engine, and in other cases it is inserted in the intake manifold. In order to lubricate this fast moving plunger, passageways which extend from the interior of the cylinder, and a source of lubricating oil are employed. However, it has been found that this oil which thus accumulates on the periphery of the plunger tends to dilute the fuel, particularly as the engine runs hot, thinning the oil. Moreover, the sediment, and other foreign material which may be of an abrasive character and contained in the fuel, tends to find its way into the lubricating system, thus causing excessive wear on the reciprocating parts.

In the Houser et al. Patent No. 2,301,407, granted Nov. 10, 1942, there is disclosed apparatus and method by which these drawbacks are overcome. In general, this method employs the step of confining the fuel to be injected in a compartment having a flexible wall and causing flexure of the wall by pressure fluid, preferably oil, in timed relation with the operating cycle of the engine.

This method may be carried out according to the invention set forth in my patent by a fuel injector pump which includes a flexible member separating from each other two compartments, the first of which is adapted to receive fuel to be injected into an automotive engine, while the second compartment is adapted to receive fluid, preferably oil, and comprises means for subjecting the fluid to pressure in timed relation with the operating cycle of the engine to cause the flexible member to move in accordance with the igniting cycle.

In this way the fuel passing through the in-

jector pump is maintained entirely separate from the lubricating system so as to eliminate any transfer of oil into the fuel system, and also to prevent foreign matter from moving between the fuel system and the lubricating system. It has been found that when the oil content of the plunger compartment forms part of a closed circulatory system, certain gases such as vapor or air bubbles are driven out of solution from the oil due to surge effects and may remain out of solution for considerable periods of time. These non-condensables serve to reduce the accuracy with which the plunger translates its movement into changes of pressure at the diaphragm and therefore into changes of volume of the injected fuel.

The non-condensables are eliminated in accordance with the invention disclosed in said patent by means of a chamois separator which permits the oil in which the condensables are dissolved to pass but retains the free gas or other non-condensables. Apparatus of this character has operated satisfactorily in case the improved device is used in connection with vehicles which move substantially in a single plane, for example, automobiles passing along the highway. Satisfactory results are also obtained in the case of airplanes and particularly if the plane is not banked too steeply or otherwise where the changes of position are not too abrupt. Under these circumstances, the level of the fluid, oil, etc. within the separator remains substantially stationary.

In accordance with the present invention, improvements are introduced into the oil circulatory system by which the necessity for such a separator is eliminated in order to adapt the apparatus as a whole to vehicles which move in any plane or combination of planes or which shift from one plane to another at a steep angle. In general, this improvement consists in forcing the gas bubbles or other non-condensables immediately back into solution as the oil is being circulated so that there are no non-condensables in a permanently free state. The oil is placed under pressure of a predetermined and variable amount in such a manner that the gas bubbles or other non-condensables are caused to be instantly and completely re-absorbed within the oil.

The primary object of the present invention is to provide a practical device for maintaining the oil free of non-condensables or rather to prevent the gas bubbles which are thrown out of solution from returning to the plunger compartment through the closed circulatory system in a free

or dis-associated state and which might reduce the accuracy with which the improved injector meters the fuel. The general object of the invention is to provide an accurate measuring device for controlling the injection of fuel into automotive engines, and in which the force of injection is obtained through hydraulic pressure; and in which the non-condensables or other foreign material thrown out of the oil solution are caused immediately to be forced back into solution.

Other objects and features will be apparent as the specification is perused in connection with the accompanying drawings.

In the drawings:

Figure 1 represents a diagrammatic view of a typical engine provided with the improved injector pump for controlling the flow of fuel to the respective cylinders.

Figure 2 is a sectional view, partly in elevation of the improved pump together with an accessory by which dripping at the injection nozzle is prevented.

Figure 3 is a fragmentary sectional view of the improved injector pump showing the position of the various parts of the pump under full throttle conditions.

Figure 4 is a longitudinal sectional view, partly in elevation, of the improved compensator which is inserted in the circulatory system and serves to force the non-condensables back into solution. This figure also shows the condition of the oil, particularly the upward movement of the air or gas bubbles travelling through the oil under full throttle condition at the engine.

Figure 5 is a view somewhat similar to Figure 3 but shows the relative position of the parts of the injector under low throttle condition.

Figure 6 is a view similar to Figure 4 except that it shows the conditions within the oil pertaining to the low throttle adjustment illustrated in Figure 5.

Figure 7 is a sectional view of a modified form of compensator.

Referring more particularly to Figure 1, the reference character 1 generally designates a typical form of automotive engine as specifically six cylinders, indicated by the six spark plugs 2. The engine block is shown at 3 and the bed at 4. Only the left hand cylinder has been shown in detail and this cylinder contains a piston 5. The bed of the engine is provided with a flange 6, and on this flange rests as many injector pumps of the improved type as there are cylinders, these pumps being preferably secured to the engine and positioned directly below the respective cylinders.

The parts of the improved injector pump are contained within a casing 7, which may be of a general cylindrical form, and from the upper portion of each casing there is a fuel intake line 8 which connects through a common pipe 9 to a fuel tank (not shown). There are fuel discharge pipes 10 taken from the upper end of the casing 7 and terminating at each cylinder just above the uppermost position of the piston 5. There is also a set of pipes secured to the side of each casing 7, the upper pipe 11 serving as an oil inlet pipe and the lower pipe 12 serving as an oil outlet pipe, the circuit being completed through an improved oil compensator 13, the construction of which is shown to the extreme left in Figure 1. The details of the improved injector pump are illustrated in Figure 2.

The casing 7 is actually constituted of two members, joined together by screws 14. The up-

per casing 16 is provided with multi-shouldered portions 17, 18 the latter terminating in a screw threaded member 19 to which the pipe 10 is secured by any suitable form of coupling 20. There is a cylindrical opening 21 passing down through the casing 16 and in line with the opening in the discharge pipe 10.

The opening 21 has the same diameter down as far as the shoulder 22, and the opening emerges into another opening of smaller diameter, indicated at 23. At the lower part of the opening 21 and resting on the shoulder 22 there is a hollow assembled member 24 (Figure 2) which has a transverse portion (not shown) containing two diagonally directed openings (not shown). A pin (not shown) projects downwardly from the transverse portion or web (not shown), this pin being in line with a ball 28 which in cooperation with the opening 29 at the bottom of the thimble constitutes a check valve. It will be apparent that the pin referred to hereinbefore merely serves to limit the upward movement of the ball when pressure is applied to the fuel passing through the thimble 24. The upper casing 16 is also provided with a transversely extending opening 30, which contains a sleeve 31 having a centrally aligned aperture 32. The ball 33, forming part of a second check valve, is urged by the spring 34 against the left hand end of the opening 32. There is a projection at 35 extending to the right (Figure 2) of the casing 16, this projection being threaded to receive a coupling 36 for securing the fuel inlet pipe 8 to the casing in line with the opening 30.

The casing 16 is provided at its lower end with a countersunk conically shaped opening 37, this opening being adapted to receive a diaphragm 38, preferably of a steel composition which resists corrosion by all the known types of fuel. This diaphragm may have any desired figure but performs its function described herein-after particularly well when the thickness is left at $\frac{10}{1000}$ of an inch. The diaphragm is seated between an annular rim portion formed on the casing 16 at the upper surface of a lower casing 39 of the fuel injector pump which together contain the main part of the pump.

The bore which receives the cylinder 41 is provided with an annular groove 44, which is in communication with the bore 42 through a radial opening 45. This opening communicates with an opening 46 extending radially outward from the annular groove 44 through the casing 39 to an opening 47, which receives the pressure fluid inlet pipe 11 (Figure 1). Directly below the annular groove 44, there is a similar groove 48 which communicates through a radial opening 49 with another opening 50 for receiving the pressure fluid outlet pipe 12. The plunger 43 is provided with an axial opening 51 which terminates in a larger opening for receiving a screw headed plug 52. The lowermost portion of the plunger is enlarged so as to more readily accommodate the screw shank of the plug 52, the head of the latter projecting beyond the lower surface of the plunger and terminating in an arcuate portion indicated at 53. At the junction between the opening 51 and the larger opening which receives the plug 52, there is a radially extending opening 54, the purposes of which will be explained hereinafter. The upper end of the plug 52 terminates in a small diameter portion 55 which receives a compression spring 56 for urging the ball 57 against the underside of the opening 51.

There is a sleeve 53 provided preferably with screw threads on its periphery and positioned within the annular space between the plunger 43 and the opening in the casing 39. Threads of corresponding shape are cut in the casing to receive the sleeve 53. The latter is adapted to be rotated on its thread in a manner to be described presently, and while being thus rotated, its longitudinal position with respect to the plunger 43 and the casing 39 is accordingly changed. There is an annular opening 53' cupped into the upper surface of the sleeve 53. For rotating the sleeve, there is provided a gear 59 which is journaled at 60 in a projection 61 extending from the casing 39. The gear is keyed to a shaft 62 and the latter is adapted to be rotated by means of a hand operated throttle lever 63. The teeth of the gear 59 mesh with teeth formed at the lower end of the sleeve 53. Consequently, by rotating the lever 63 the sleeve 53 is rotated at a corresponding rate and is moved upwardly or downwardly, depending on the direction in which the lever 63 is moved.

There is a plate 64 screwed to the underside of the projection member 61 and the casing 39, this plate having depending therefrom a cylinder 65 which terminates in a flanged portion 66. The latter is secured to a portion 67 of the engine frame directly above a cam shaft 68. The latter may be any one of the cam shafts of the engine and have secured thereto a cam 69. The cylinder 65 is hollow and has a shouldered compartment in which is rigidly secured a sleeve 70. In the sleeve, there is a solid cylindrical member 71 adapted to reciprocate and carrying at its lower end a shaft 72 on which is mounted a cam follower 73 substantially of circular configuration. The upper portion of the cylinder 71 is countersunk to receive the lower or enlarged portion of the plunger 43. The latter is secured to the cylinder 71 by a nut 74 which fits about the upper side of the enlarged portion. There is a compression spring contained within the annular space between with sleeve 70 and the interior of the cylinder 65, the lower end of the spring surrounding the sleeve-like spring holder 75 which is secured to the sleeve 70. It is apparent that as the shaft 68 is rotated, the cam 69 will cause the follower 73 to move upwardly and downwardly and thereby causing reciprocations of the cylinder 71 and the plunger 43.

It was pointed out in connection with Figure 1 that the pressure fluid lines 11 and 12 communicate with an oil volume or pressure compensator 13. This compensator will now be described.

The element shown to the extreme left of Figure 1 represents only one of the many forms that the compensator may take. As illustrated, the compensator comprises a cupped shaped casing 76 preferably of metal with a cover 77 bolted thereto as indicated at 78. The cover 77 is provided with a needle release valve 79 to one side of its center and there is a large opening 80 in the center. A tubular member 81 is positioned within the opening 80 and the upper end of this member is provided with threads indicated at 82. A relatively thick metal cap 83 is threaded on its interior to engage the threads of the member 81. The cap is provided with a downwardly extending centrally disposed stub 84 which bears against the upper end of a compression spring 85. The other or lower end of the spring is seated on a cap 86 which is secured to the end of a Siphon bellows 87. The fixed end of the bellows is rigid-

ly secured to the lower end of the tubular member 81.

It is apparent that as the cap 83 is rotated the stub 84 forces the lower end of the spring 85 downwardly which in turn moves the lower side of the bellows. Inasmuch as the upperside of the bellows is fixed, the effect of rotating the cap 83 is to increase the length of the bellows and its volume. This in turn causes an increase of the pressure introduced into the surrounding fluid. Thus the cap 83 serves to place the oil or other fluid contained within the casing 76 under any predetermined and adjustable pressure.

The bottom of the casing 76 is provided with a central opening and an opening at the side into which inlet and outlet fixtures 88, 89 respectively may be fitted in order to receive the inlet and outlet pipes 12 and 11. A cylindrical barrier 90 may also be provided for purposes which will be explained presently, this barrier being secured to the bottom of the casing 76 and positioned so as to surround the inlet fixture 88. It will be understood that all of the joints about the casing including the inlet and outlet fixtures 88, 89 and the bolted edge 78 are made strictly fluid tight so that the casing 76 may be filled completely with oil or other pressure fluid for operating the injector pump shown in Figure 2. The needle valve 79 may if desired be used as a convenient way for introducing the oil into the casing although the main purpose of this valve is to relieve any excessive pressure that might develop within the casing 76 over a long period of time. Assuming that the casing 76 has been completely filled with oil, and the cap 83 given its proper adjustment, the compensator will serve to force the air and gas bubbles which had thrown out of solution at the position of the pump back into solution as the fluid makes its circulatory passage through the pipes 11 and 12. A detailed description of the operation of the compensator will be given in connection with the operation of the injector pump shown in Figure 2.

Operation of the fuel injection pump and its compensator accessory

Referring to Figure 2 which represents the starting position of the various parts of the pump, let us assume that the fuel has been drawn in from the pipe 8 through the opening 30, 32 past the check valve 33 and into the space directly above the diaphragm 38. The cam 69 is in its lowermost position causing the plunger 43 to be also withdrawn to its lowest position. Under these circumstances a partial vacuum will be formed within the bore 42 directly above the plunger, causing oil to be withdrawn from the outer annular space of the compensator 13 through the pipe 11, openings 47, 46 and 45. Thus the bore 42 is completely filled with oil or other relatively incompressible pressure fluid.

As the cam 69 rotates, the plunger 43 is caused to be elevated closing off the opening 45 and finally placing the trapped oil under pressure. The increased pressure produced by the plunger on the trapped oil serves to flex the diaphragm 38 causing a reduction in the volume of the space directly above the diaphragm. This, in turn, produces a large increase in pressure on the fuel trapped above the diaphragm, causing the ball 33 to be firmly seated against the sleeve 31, thereby closing off the inlet passage 32 and also forcing the ball 23 in the discharge passageway to be moved away from the opening 29. Fuel under pressure is therefore caused to pass upwardly

through the passageway 23, 29, through the diagonal passageways into the respective pipes 10 which lead to the cylinders of the engine. From the pipe 10, the fuel is caused to pass under extremely high pressure and to be ejected as a spray of circular configuration into the cylinder of the engine.

It will be understood that there are as many cams 69 and fuel injection pumps as there are cylinders, as indicated in Figure 1, and the cams are so positioned with respect to the cam shaft 68 (Figure 2) as to cause the circular spray to leave the respective nozzles in proper timed relation, depending on the firing order of the engine cylinders. As the plunger 43 (Figure 2) continues to rise, due to the actuation of the cam 69, fuel is ejected at the nozzle until the fluid pressure within the plunger bore 42 is released. This pressure releasing function is obtained by the upward movement of the radial opening 54, which as soon as it uncovers the annular opening 58' permits the oil under pressure in the bore 42 to pass through the longitudinal opening 51 and to unseat the check valve 57 against the spring 56, thereby allowing the oil to pass through the radial opening 54 in the plunger and through the annular opening 58'. This annular opening communicates with the openings 48, 49 and 50, thus permitting the oil to move through the pipe 12 into the inlet fixture 88 where the oil is subjected to the pressure exerted and controlled by the thickness of the Sylphon bellows 87 which in turn is controlled by the cap 83.

The compensator will serve in the manner described hereinafter to force all non-condensables such as air and gas bubbles back into solution and thus to assure the maintenance of a 100%, non-compressible fluid introduced into the bore 42. The upward travel of the plunger 43 is therefore translated directly and accurately into changes of pressure in the oil, which in turn, causes accurate flexing of the diaphragm 38 and an accurate measurement of the fuel expelled at the nozzle. The smallest amount of a compressible medium such as air or vapor in the oil, and particularly when this air or vapor appears as bubbles disassociated from the body of the oil, i. e. out of solution, may cause, for a given travel of the plunger, a disproportionate movement of flexing of the diaphragm, thus introducing errors in the amount of fuel ejected at the nozzle. These air or vapor bubbles may be driven out of the oil solution by extreme agitation produced in the oil when the pressure in the latter is released by permitting oil to flow through the opening 51, past the check-valve 57 and through the passageway 54, into the compensator 13.

It is apparent that the less the throttling effect produced by the upward movement of the sleeve 58, the less will be the tendency for the air or vapor bubbles to be driven out of the oil solution. This is because the agitation produced in the oil is less. Consequently, there is a greater tendency for the air or vapor bubbles to become disassociated from the oil solution when the ejector is so adjusted that the engine runs on only partial throttle. This greater tendency for the air and gas bubbles to become disassociated from the oil as the throttling effect at the injector pump becomes greater is significantly illustrated by a comparison of Figures 4 and 6. These figures have been placed opposite their respective injector setting in order to show the relative positions of the sleeve 58 for the different throttle conditions. Thus the condition shown in Figures 3

and 4 on the one hand, and in Figures 5 and 6 on the other hand represent full throttle and partial throttle respectively. In each of Figures 4 and 6 there is a plume arising from the inlet fixture 88, this plume taking the general form of an inverted cone the apex of which is contained within the fixture 88. This plume is made up of an extremely large number of air or gas bubbles of varying size, generally quite small which tend to diffuse upwardly and outwardly away from the fixture 88. The height and size of this plume gives an indication of the tendency of the air and gas bubbles to leave the oil solution. Under full throttle condition (Figure 4) this tendency is much less than under partial throttle (Figure 6). It is apparent that the function of the cylindrical barrier 90 is to prevent any stray gas or vapor bubbles from traveling directly between the inlet fixture 88 and the outlet fixture 89.

In accordance with the main feature of my invention, the plume 91 is completely eliminated or at least reduced to a minimum by applying pressure to the oil through the use of Sylphon bellows 87. It has been pointed out hereinbefore that as the cap 83 (Figure 1) is turned, the thickness of the bellows may be made greater or less depending on the amount of pressure desired to be introduced into the oil. In general the adjustment of the cap 83 is so determined that there is little or no plume, even when the engine is being operated under partial throttle conditions and under these conditions there is even less tendency for a plume to be present when the engine is being operated at full throttle.

This adjustment can be determined either visually as when the casing 76 is made of a transparent material or contains a window through which the plume can be observed, or if desired, the proper pressure introduced by the bellows may be determined experimentally by the manufacturer and the cap permanently left in an average position. An index (not shown) may be provided on the cap and the manufacturer may supply a chart with recommended adjustments for different engine performances.

It is apparent that the pressure exerted by the bellows 87 serves to force the air or vapor bubbles back into solution and the latter always remains either in a strictly incompressible state or has a constant amount of compressibility which does not affect the accuracy with which the metering is done. The constant pressure exerted by the bellows on the oil extends at least throughout the oil body within the compensator so that it is automatically and instantly effective to force the molecules back into solution as the oil reaches the compensator. Viewed from another aspect, the effect of the pressure is to assure that the oil in the compensator contains all of the air or vapor that it can possibly absorb at the given temperature and pressure so that the oil always acts as an incompressible medium. It should also be noted that inasmuch as the casing 76 is completely filled with oil, the compensator may be used in any position since there can be no swishing of the liquid in the oil system and the fluid system as a whole lends itself to use in connection with a vehicle moving in any plane, direction, or combination of planes or directions. It is also apparent that the flexible character of the compensator takes care of any air or gas leakage anywhere throughout the oil circulatory system including the injector pump, thus assur-

ing a relatively solid and incompressible column of oil within the system.

Figure 7 shows a modified form of compensator which lends itself all the more readily toward preventing any movement of the disassociated gas or vapor bubbles from the inlet fixture 88 to the outlet fixture 89 regardless of the instantaneous position that the compensator may take. As is the case in Figure 1 the unit shown in Figure 7 takes the form of a two-part casing of metal or other suitable material bolted together as indicated at 78. The top side of the Sylphon bellows 87 is secured directly to the left hand portion of the casing 76, and otherwise, the adjustment mechanism is exactly the same as has been shown and described in connection with Figure 1. There is a pair of baffles 92 extending across the main portion of the casing 76, these baffles being provided with a central opening indicated at 93. An intermediate baffle 94 is positioned between the baffles 92, this intermediate baffle being mounted in position on a stud 95 which may be conveniently secured to the bottom side of the casing. The inlet fixture is indicated at 88 and the outlet fixture is illustrated at 89 as in the case of Figure 1. It is apparent that should any plume of disassociated gas or vapor bubbles form near the inlet fixture 88, assuming that the cap 83 has not been properly adjusted, these gas or vapor molecules could not find their way to the outlet fixture 89 due to the extremely tortuous path provided between the various areas. This path is so long that the gas or vapor bubbles would be bound to enter the liquid and thus be absorbed thereby before they could reach the outlet fixture 89. It will be understood that if the bellows 87 were properly adjusted, all gas and vapor bubbles will have been forced back into solution regardless of the length or shortness of the path between the inlet and outlet fixtures. However, it may be advisable to provide the tortuous path as extra precaution particularly for example in the case of dive bombers or other fast moving vehicles which change their direction of movement rapidly. In such a case, the direction in which the disassociated gas and vapor molecules are caused to move by the action of gravity, should such disassociated molecules appear, would constantly change so that a baffle effect should be provided in each and every direction. This is effectively accomplished in the device shown in Figure 7.

While I prefer to use a Sylphon bellows for the pressure introducing element, other devices may be used to advantage such as a flexible wall or metal diaphragm which may be flexed by operating the cam 83. A spring biased movable wall may also be used for this purpose, in fact, any convenient device for applying pressure to the liquid and controllable at the cap 83. A rubber cylinder or ball filled with air under pressure and completely submerged in the oil could be used but in such a case there would be no adjustment possible at the cap 83. However, the cylinder or ball would serve continuously and automatically to increase the pressure applied to the oil until the pressure inside and outside of the submerged enclosure are the same, thus in effect, placing the oil or other pressure fluid under the proper amount of pressure to force the non-condensables back into solution.

It will be understood that I desire to comprehend within my invention such modifications as come within the scope of the claims and the invention.

Having thus fully described my invention, what

I claim as new and desire to secure by Letters Patent, is:

1. In combination, an injector pump which includes a plurality of compartments separated by a flexible wall, one of said compartments being adapted to contain fuel and the other of said compartments being adapted to contain pressure fluid, an injection chamber including a fluid circulatory system for causing the pressure fluid to flex said wall and thereby to place the fuel under pressure, means positioned in said circulatory system but positioned remote from said pump for placing the fluid in the system under pressure in order to force disassociated non-condensables in said fluid back into solution during the flexing of said wall.

2. In combination, an injector pump which includes a plurality of compartments separated by a flexible wall, one of said compartments being adapted to contain fuel and the other of said compartments being adapted to contain pressure fluid, an injection chamber including a fluid circulatory system but positioned remote from said pump for causing the pressure fluid to flex said wall and thereby to place the fuel under pressure, means positioned in said circulatory system for placing the fluid in the system under pressure in order to force disassociated non-condensables in said fluid back into solution during the flexing of said wall, said means comprising a casing which receives at least a portion of the pressure fluid and a volume-changing device in said casing for subjecting the fluid to a predetermined pressure.

3. In combination, an injector pump which includes a plurality of compartments separated by a flexible wall, one of said compartments being adapted to contain fuel and the other of said compartments being adapted to contain pressure fluid, an injection chamber including a fluid circulatory system for causing the pressure fluid to flex said wall and thereby to place the fuel under pressure, means positioned in said circulatory system for placing the fluid in the system under pressure in order to force non-condensables driven out of solution in said pressure fluid during the flexing of said wall back into solution, said means comprising a casing which receives at least a portion of the pressure fluid, and a volume-changing device in said casing for subjecting the fluid to a predetermined pressure, said device comprising a Sylphon bellows adjustable in size from the exterior of the casing.

4. In combination, an injector pump which includes a plurality of compartments separated by a flexible wall, one of said compartments being adapted to contain fuel and the other of said compartments being adapted to contain pressure fluid, an injection chamber for causing the pressure fluid to flex said wall and thereby to place the fuel under pressure, and means positioned remote from said pump for forcing non-condensables driven out of solution in said pressure fluid when the wall is flexed back into solution.

5. In combination, an injector pump which includes a plurality of compartments separated by a flexible wall, one of said compartments being adapted to contain fuel and the other of said compartments being adapted to contain pressure fluid, an injection chamber for causing the pressure fluid to flex said wall and thereby to place the fuel under pressure, and means positioned remote from said pump for forcing non-condensables driven out of solution in said pressure fluid when the wall is flexed back into solution, said means including a device for applying a constant predetermined pressure to said pressure fluid.

6. In an injector pump which includes two compartments separated by a flexible wall, one of said compartments being adapted to contain a pressure fluid and the other compartment being adapted to contain a fuel, means for placing the fluid under sufficient constant pressure to force non-condensables that had become dis-associated from the fluid back into solution, whereby as the flexible wall is flexed during operation of the pump, the fuel ejected from the fuel-containing compartment represents an accurate and predetermined amount.

7. In an injector pump which includes two compartments separated by a flexible wall, one of said compartments being adapted to contain a pressure fluid and the other compartment being adapted to contain a fuel, means for applying sufficient constant pressure to a segregated portion of the pressure fluid to force non-condensables that had become dis-associated from the fluid back into solution whereby as the flexible wall is flexed during operation of the pump, the fuel ejected from the fuel-containing compartment represents an accurate and predetermined amount.

8. In combination, an injector pump which includes a plurality of compartments separated by a flexible wall, one of said compartments being adapted to contain fuel and other of said compartments being adapted to contain pressure fluid, an injection chamber for causing the pressure fluid to flex said wall and thereby to place the fuel under pressure, means for forcing the non-condensables driven out of the fluid when the wall is flexed back into solution, said means comprising a casing through which the fluid is caused to flow, inlet and outlet fixtures in said casing, and a baffle between said fixtures, and means positioned within said casing for applying a predetermined pressure to said fluid sufficient to force the non-condensables back into solution during the flexing of said wall.

9. In combination, an injector pump which includes a plurality of compartments separated by a flexible wall, one of said compartments being adapted to contain fuel and the other of said compartments being adapted to contain pressure fluid, an injection chamber for causing the pressure fluid to flex said wall and thereby to place the fuel under pressure, means for forcing the non-condensables driven out of the fluid when the wall is flexed back into solution, said means comprising a casing through which the fluid is caused to flow, said casing having inlet and outlet fixtures for the fluid and a device adjustable from the exterior of the casing for applying a predetermined pressure to the fluid, and means include a plurality of laterally extending baffles which form a tortuous path for preventing a direct movement of the fluid between the inlet and outlet fixtures.

10. In combination, an injector pump which includes a plurality of compartments separated

by a flexible wall, one of said compartments being adapted to contain fuel and the other of said compartments being adapted to contain pressure fluid, an injection chamber for causing the pressure fluid to flex said wall and thereby to place the fuel under pressure, means for forcing the non-condensables driven out of the fluid when the wall is flexed back into solution, said means including a casing through which the fluid is caused to pass, said casing having a centrally disposed inlet fixture, an outlet fixture positioned remote from the inlet fixture, and a device for producing pressure in the fluid mounted directly above the inlet fixture.

11. In combination, a fuel injector pump which includes a plurality of compartments separated by a flexible wall, one of said compartments being adapted to contain fuel and the other of said compartments being adapted to contain pressure fluid, an injection chamber for causing the pressure fluid to flex said wall and thereby to place the fuel under pressure, means for forcing the non-condensables driven out of the fluid when the wall is flexed back into solution, said means comprising a casing through which the fluid is caused to pass and an adjustable device within the casing for subjecting the fluid to a predetermined pressure, said device including a Sylphon one end of which is immovably secured to the casing and the other end is movable with respect thereto in order to change its volume and thereby change the pressure exerted on the fluid, a screw element projecting from one side of the casing in line with the Sylphon, a cap adapted to engage the threads of said screw, an opening in the casing in line with said cap and Sylphon, and a spring interposed between the cap and the end of the Sylphon so as to apply pressure to the latter when the cap is turned on said screw element.

12. In combination, a fuel injector pump which includes a plurality of compartments separated by a flexible wall, one of said compartments being adapted to contain fuel and the other of said compartments being adapted to contain pressure fluid, an injection chamber for causing the pressure fluid to flex said wall and thereby to place the fuel under pressure, means for forcing the non-condensables driven out of the fluid when the wall is flexed back into solution, said means comprising a casing through which the fluid is caused to pass, a device within the casing and adjustable from the exterior thereof for applying a predetermined pressure to the fluid within the casing, inlet and outlet fixtures for said fluid secured to the casing, and means including at least one baffle so arranged that any non-condensables which may tend to be thrown out of solution will be prevented from passing directly between the inlet and outlet fixtures regardless of the instantaneous position of the casing in space.

JESSE E. HOUSER.