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2,918,079

FUEL FEEDING MEANS

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3 Sheets-Sheet 1

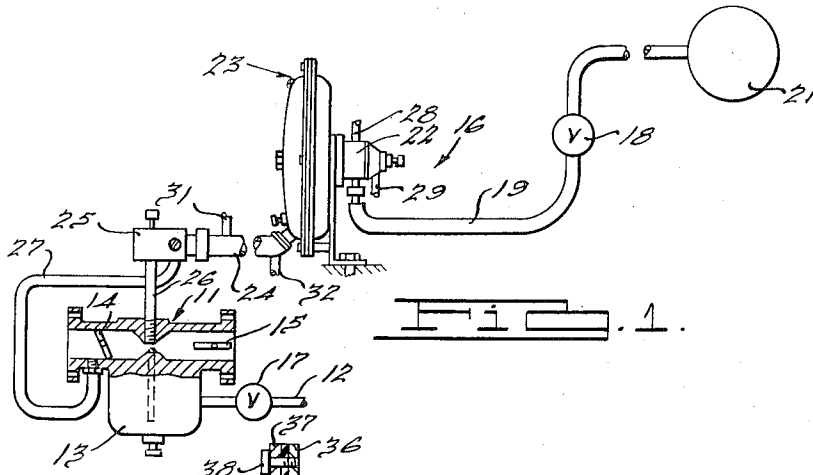


FIG. 1.

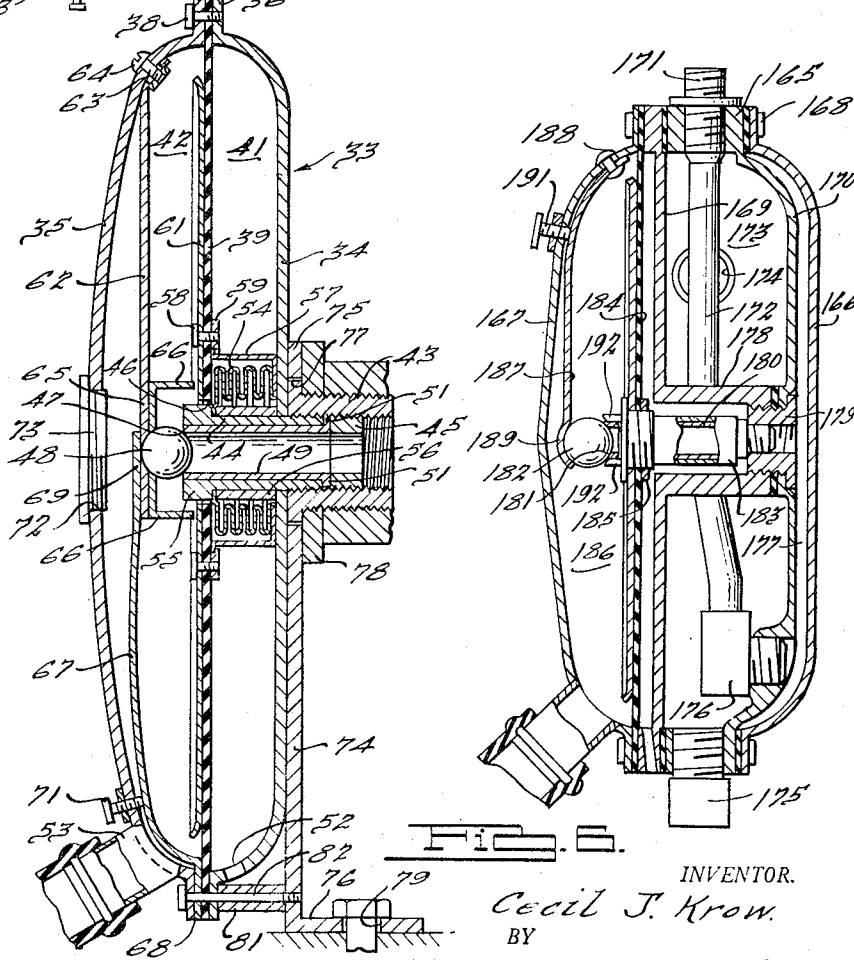


FIG. 2.

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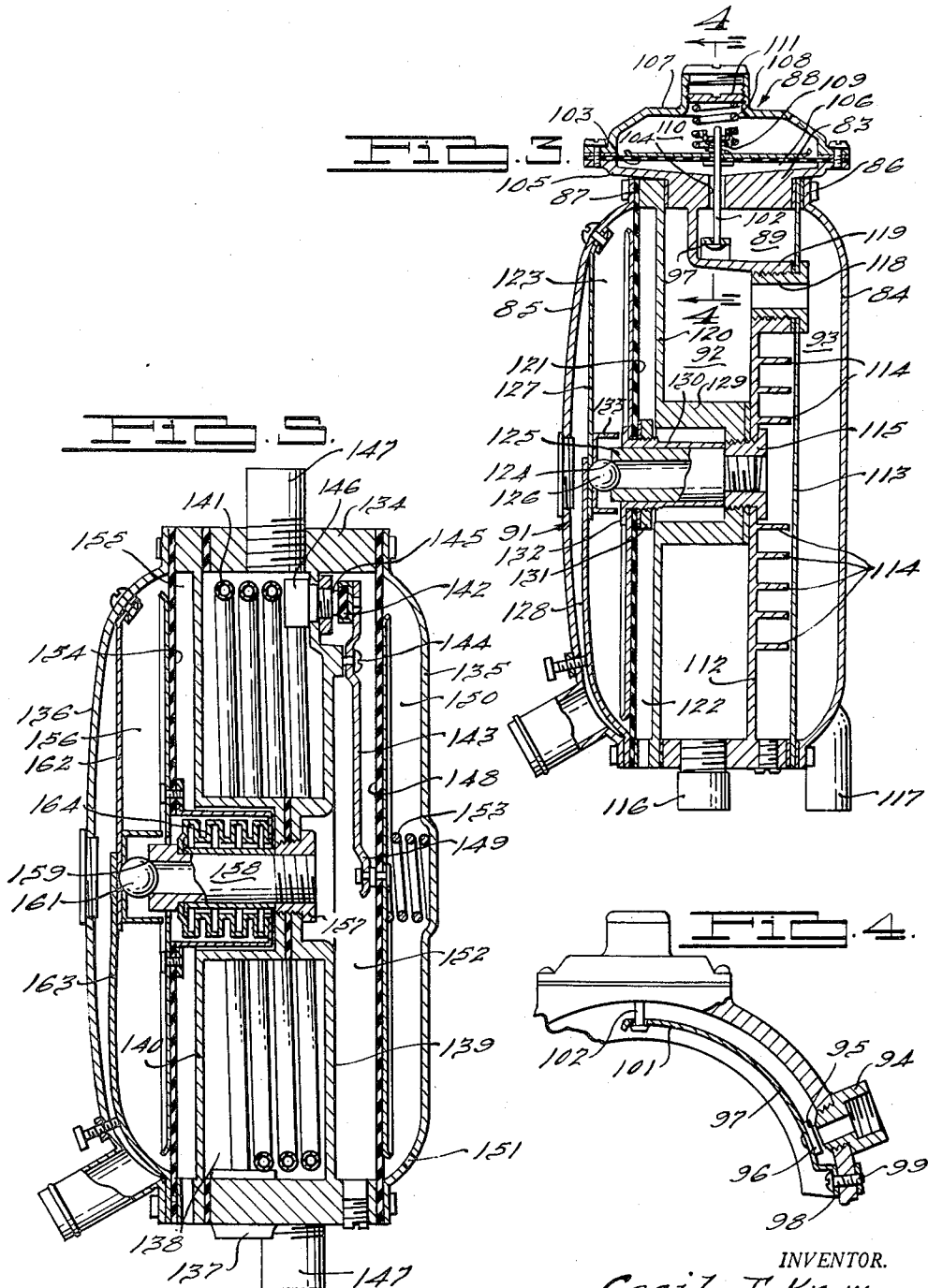
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3 Sheets-Sheet 2



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FUEL FEEDING MEANS

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Application June 24, 1955, Serial No. 517,881

25 Claims. (Cl. 137—340)

This invention relates to fuel feeding means, and more particularly to regulators for controlling the flow of combustible fuel such as liquid petroleum to internal combustion engines. This application is a continuation-in-part of applicant's copending application, Serial No. 233,582, filed June 26, 1951, now patent No. 2,746,479, dated May 22, 1956, and Serial No. 369,818 filed July 23, 1953 for Fuel Feeding Device, and is related in certain aspects to applicant's copending application, Serial No. 192,004, filed October 25, 1950, for Fuel Feeding Device, both Serial No. 369,818 and 192,004 having been abandoned.

In fuel feeding installations for internal combustion engines having liquid petroleum products such as butane or propane as an alternate source of power, regulators are provided for reducing the pressure of the liquid petroleum and for metering the vaporized liquid petroleum to the carburetor in accordance with the needs of the engine as determined by the intake vacuum. Regulators now in use for this purpose have several important disadvantages stemming from the valve and diaphragm construction, which prevent the metering of equal amounts of vapor fuel to each cylinder. Prior constructions, especially those depending on lever action between the diaphragm and the metering valve, are particularly unsuitable for use with engines having only two cylinders in which the suction strokes occur at uneven intervals, and it has been found necessary to use accumulators or reservoirs in conjunction with such regulators in order to improve their efficiency. Prior regulator constructions have also suffered from the disadvantages that the valve member is not free from shifting due to diaphragm distortion which may occur during operation, and the resulting poor seating of the valve produces inefficient engine operation.

It is an object of the present invention to overcome the disadvantages of previous regulators and to provide improved principles of regulator construction which assure sufficient and equal volumes of vapor fuel in each cylinder and maintain maximum engine efficiency without the necessity of additional accumulators or reservoirs.

It is a further object to provide an improved regulator construction of the above character which has a leverless valve action, thus reducing the required diaphragm travel and insuring proper seating of the valve despite distortion of the diaphragm or other parts of the regulator.

It is also an object in several forms of the invention to provide an improved regulator construction of the above nature, which combines the high pressure stage and the metering stage of the regulator in a single housing, thus forming an extremely compact and efficient unit.

It is another object to provide a regulator of the above character having means for mounting the regulator in a variety of positions so that the harmful effect of engine

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vibration is minimized and the fluid-conducting and valve portions of the regulator are self-cleaning.

Other objects, features and advantages of the present invention will become apparent from the subsequent description, taken in conjunction with the accompanying drawings.

In the drawings:

Figure 1 is a diagrammatic view of a portion of the fuel supply system of an internal combustion engine having the improved regulator of this invention installed therein, the view showing the carburetor and fuel supply arrangement for the engine;

Figure 2 is a cross-sectional view in elevation of one form of the metering regulator of this invention showing the valve construction and also showing the universal mounting bracket for the regulator;

Figure 3 is an elevational view in cross-section of a modified form of the regulator assembly in which the high pressure and metering regulators are combined with heating means for the liquid petroleum, this modification having a sleeve connection for the diaphragm instead of the bellows connection of Figure 2;

Figure 4 is a fragmentary cross-sectional view taken along the line 4—4 of Figure 3 and showing the inlet connection for the liquid petroleum as controlled by the high pressure regulator;

Figure 5 is a cross-sectional view in elevation of another embodiment of the invention generally similar to Figure 3 but with another type of high pressure regulator and a different heating arrangement;

Figure 6 is a cross-sectional view in elevation of still another embodiment of the invention generally similar to the other embodiments but in which a modified form of valve support is used, and which is adapted for a separately constructed high pressure regulator;

Figure 7 is a cross-sectional view in elevation of still another modification of the invention generally similar in principle to the previous embodiments but wherein the diaphragm is centrally as well as peripherally fixed, novel and improved actuating means being provided between the diaphragm and valve;

Figure 8 is a cross-sectional view taken along the line 8—8 of Figure 7, the ball valve being removed, and showing the slotted guide for the valve; and

Figure 9 is a cross-sectional view in elevation of still another embodiment of the invention similar to that of Figure 7 but including a high pressure regulator.

The invention is adapted to be used in the fuel supply system of an internal combustion engine (not shown) having a carburetor generally indicated at 11 which is fed by a conventional gasoline line 12 and has the usual bowl 13, throttle valve 14, and choke valve 15. As shown, the carburetor may be alternately fed with liquid petroleum such as butane or propane, and for this purpose a liquid petroleum supply system generally indicated at 16 is provided, the gasoline line 13 and the liquid petroleum system 16 having manually controlled shut-off valves 17 and 18, respectively, for the alternate operation. The liquid petroleum system includes a line 19 leading from a liquid petroleum tank 21 and in which valve 18 is interposed. Line 19 leads to a high pressure regulator or reducing valve 22 which reduces the liquid petroleum pressure to a normal range of between 5 and 9 p.s.i. The vaporized liquid petroleum then passes through a low pressure regulator or metering device generally indicated at 23 which further reduces the delivery pressure and meters the flow in accordance with the requirements of the engine as controlled by the carburetor throttle and choke valves.

From the low pressure regulator the liquid petroleum travels through a heated flexible hose 24, to a manifold

block 25 which has ports and valves for determining the further flow of the liquid petroleum. In particular, a line 26 leads from manifold block 25 to the venturi of carburetor 11, and a further line 27 leads from the manifold block to the vicinity of throttle valve 14 and serves as an idling feed. Since the vaporizing liquid petroleum draws heat from its surroundings, the high pressure regulator or reducing valve 22 has connections 28 and 29 which carry a heated fluid such as the engine coolant in heat transfer relation with the liquid petroleum, and further means such as connections 31 and 32 may be provided for similarly heating hose 24. Further details of the fuel supply system are not believed necessary since the invention resides in the particular construction of the regulators rather than in the fuel supply system itself, but reference is here made to said application No. 192,004 which describes the fuel system in somewhat greater detail.

Turning now to the low pressure regulator construction shown in Figure 2, this comprises a casing generally indicated at 33 which is made up of two halves 34 and 35 of generally saucer shape. The casing halves are provided with flanges 36 and 37 respectively held together by bolts 38. A flexible diaphragm 39 is disposed between the casing halves and divides the casing into chambers 41 and 42, the peripheral edge of diaphragm 39 being secured between flanges 36 and 37. The inlet side of the regulator, that is the side leading from the high pressure regulator or reducing valve, includes a threaded bushing 43 which is centrally secured to the outside of casing portion 34 by welding or other means. A tubular member 44 is threaded into bushing 43 and bears against a locking collar 45 which is threadably disposed within sleeve 43. Member 44, collar 45 and bushing 43 together form a fuel inlet passageway and it will be noted that member 44 may be interchanged with members having other orifice diameters so that the gas volume capacity of the regulator may be predetermined to suit engines of various horse-power ratings.

Member 44 is disposed within casing 33 and passes through a central aperture 46 in diaphragm 39. The inner end of member 44 is therefore disposed within chamber 42, and this inner end serves as a valve seat 47 against which a ball valve 48 seats when the regulator is closed. As will be seen below, the movement of ball valve 48 is controlled by diaphragm 39, which in turn moves in response to pressure differentials between chambers 41 and 42. In the illustrated embodiment, valve seat 47 is formed by a liner 49 within member 44 which is secured at its outer end 51 between member 44 and collar 45.

Chamber 41 serves as an atmospheric chamber, and for this purpose a vent opening 52 is provided in casing portion 34. Chamber 42 on the other hand is the low pressure chamber and leads to the carburetor through an outlet connection 53. Means are provided for sealing chamber 42 with respect to chamber 41, and in the embodiment of Figure 2 this means includes a flexible bellows 54 which is secured at one end to member 44 and at the other end to diaphragm 39. In particular, one end of bellows 54 is secured between a shoulder 55 on member 44 and a sleeve 56 which surrounds member 44 and extends between shoulder 55 and casing portion 34. The other end of the bellows is connected to an annular member 57 which has a flange portion secured to diaphragm 39 by bolts 58 and a ring 59. The diaphragm is also provided with a circular metal disk 61 which is in flush relation with the diaphragm on the side opposite bellows 54 and which functions during valve operation in a manner described below; bolts 58 secure disk 61 to the diaphragm.

The novel valve supporting and actuating means includes a flexible leaf type spring 62 which is secured at its outer slotted end 63 to a peripheral portion of the casing by means of a bolt 64. The inner end 65 of spring

62 has secured thereto the ball valve 48, the arrangement being such that the ball valve is centrally located with respect to valve seat 47. A pair of legs 66 are also secured to the inner end 65 of leaf spring 62, these legs extending toward circular disk 61 and being closely adjacent thereto. It will therefore be seen that a lost-motion connection is provided between diaphragm 39 and the valve. When diaphragm 39 flexes to the left as seen in Figure 2 due to the proper pressure differential, legs 66 will be engaged by disk 61 causing valve 48 to be lifted from seat 47 and permitting fuel flow through liner 49 into chamber 42 and thence outwardly through port 53.

Means are provided for adjusting the force required to lift valve 48 from its seat, and this means preferably includes a bowed leaf spring 67 which is secured at its outer end 68 to a peripheral portion of the casing, for example, between flanges 36 and 37. The inner end 69 of spring 67 overlies inner end 65 of leaf spring 62, and the spring is so arched as to apply additional closing pressure to valve 48. The pressure applied by spring 67 may be adjusted by a set screw 71 threaded into casing portion 35 so as to engage an intermediate portion of spring 67. By turning screw 71 the arch of spring 67 may be changed and stressed so as to vary its engaging pressure. It should be noted that there is only sliding engagement between springs 62 and 67 so that the adjustment of the latter spring will not affect the position of valve 48 on its valve seat.

Means are also provided for adjusting valve 48 on its valve seat when spring 62 is initially secured to the casing. This means may include an aperture 72 in casing portion 35 which is normally closed by a plug 73. By removing the plug and loosening screw 64, the slotted end 63 of spring 62 may be adjusted by an operator reaching through aperture 72 to seat valve 48 accurately.

In operation, valve 48 will normally be seated against valve seat 47 preventing flow of liquid petroleum vapor into chamber 42. When the engine is operated and the pressure in chamber 42 is consequently lowered, diaphragm 39 will be flexed to the left, and the central portion of disk 61 will engage legs 66, lifting valve 48 from its seat and permitting vaporized fuel to flow through bushing 43, collar 45, and liner 49 of member 44 into chamber 42. It should be noted that the central apertures of the diaphragm 39 and disk 61 are of such size as to enable free movement with respect to member 44, and that during this movement the bellows 54 will be axially contracted. It should also be observed that since valve 48 is not carried by diaphragm 39 but is supported independently thereof, any distortion of diaphragm 39 will in no way affect the cooperation of valve 48 and valve seat 47. This cooperation, which is determined by the adjustment of spring support 62, will therefore always remain constant, insuring the firm seating of valve 48 when the diaphragm is again moved to its normal position. The latter of course occurs when the pressure in chamber 42 has been sufficiently increased to withdraw disk 61 from its engagement with legs 66. Should it be desired to change the pressure differential which will cause valve 48 to lift, this may be done by adjusting set screw 71 and thereby changing the pressure of spring 67 on the valve. This movement will likewise not affect the seating of valve 48 since spring 67 slidably engages the supporting elements of the valve.

The embodiment of Figure 2 also includes a novel and improved supporting bracket construction for casing 33, which comprises a mounting bracket 74 having one end 75 secured to casing portion 34 and a flanged end 76 adapted for securing to the regulator support. Bracket end 75 is apertured at 77 to pass over bushing 43 and is held to casing portion 34 by a nut 78 threaded on the bushing. Bracket 74 is of such length as to extend beyond the periphery of casing 33, and its outer flange portion 76 has an aperture 79 for securing to the regu-

lator support. Since the regulator is to be installed on different types of engines, it is desirable that the mounting bracket be capable of being secured in various positions, with the regulator either upright, mounted sideways or suspended with respect to the support. With the arrangement shown this is achieved, and it will be noted that any relative angularity in a vertical plane may be chosen between fuel outlet port 53 and bracket leg 76 so that a universal mounting bracket construction is achieved. Furthermore, the regulator may be mounted in a perpendicular position so as to be self-cleaning of oil and foreign matter which may accumulate in the fuel passages, and so as to minimize the effect of motor vibration on the diaphragm 39 and disk 61 which could cause undesired engagement of legs 66.

The mounting means also includes an additional support between bracket 74 and the casing to counter severe vibration conditions and stabilize the regulator operation. This strengthening bracket construction includes a sleeve 81 which is secured between the flange portion of the casing and the outer end of bracket 74. In particular, a long bolt 82 is passed through one set of the holes which accommodate bolts 38, bolt 82 being threaded into bracket 74 and firmly holding the outer edge of the casing against the bracket. Not only does this additional securing means serve to minimize vibration of the casing, but it will be seen that this mounting construction does not prevent the universal application of bracket 74 to various types of engines, since bolt 82 may be passed through any of the plurality of holes which pass through the casing flanges, and bracket 74 may therefore extend radially in any desired direction.

Figures 3 and 4 illustrate a second embodiment of the regulator construction in which the high pressure regulator or reducing valve and the low pressure regulator are combined in the same housing, and in which means are provided for supplying heat to the liquid petroleum passing from the high pressure to the low pressure regulator to enhance evaporation. The housing comprises a central casing 83 and end plates 84 and 85 secured to the central casing by flanges 86 and 87 respectively. Casing 83 carries a high pressure regulator generally indicated at 88 for admitting liquid petroleum to a chamber 89, and a low pressure regulator generally indicated at 91 which is constructed in a manner similar to that of Figure 2. The housing also encloses a heating fluid inlet chamber 92 and an outlet chamber 93 in heat transfer relation with the inlet petroleum chamber 89, and which is adapted to carry heated fluid such as engine coolant.

The high pressure regulator 88 is of a diaphragm-operated lever type, and in particular casing 83 is provided with an inlet connection 94 having a valve seat 95, and a valve 96 carried by a bowed spring lever 97 within the casing. Lever 97 is secured at one end 98 to the casing by means of a bolt 99, and the opposite end 101 of lever 97 is held by a pin 102 passing through a diaphragm 103. The lever is so bowed as to tend to curve inwardly, lifting valve 96 from its seat, but is restrained against such movement by pin 102. The pin passes through an opening 104 in casing 83, and the casing has a dish-shaped portion 105 formed thereon to provide a chamber 106 on one side of diaphragm 103, chamber 106 thus reflecting the pressure within chamber 89. A cap 107 secures the diaphragm to portion 105 and supports one end of a spring 108, the other end of this spring engaging diaphragm 103. A smaller spring 109 is disposed between diaphragm 103 and the outer end of pin 102, spring 109 maintaining engagement of the pin with lever 97.

The chamber 110 formed by cap 107 and diaphragm 103 is vented to atmosphere, while chamber 106 during operation will have a higher pressure, for example, between 5 and 9 p.s.i. It will therefore be seen that, depending on the force of spring 108 as determined by an adjusting member 111 threaded in cap 107, attainment

of a predetermined pressure in chamber 89 will cause outward deflection of diaphragm 103 and closing of valve 96. Reduction of pressure in chamber 89 will cause diaphragm 103 to flex inwardly as urged by spring 108 and spring lever 97, allowing the spring lever to bend away from casing 83 and opening valve 96. When the pressure within chamber 89 again becomes greater than the setting of spring 108, diaphragm 103 will again be flexed upwardly to prevent further flow of liquid petroleum until the pressure in chamber 89 has been further reduced.

Means are provided in chamber 89 for carrying the liquid petroleum at its reduced pressure in heat transfer relation with the heated fluid within chambers 92 and 93 so that vaporization may be accelerated. In particular, chamber 89 is formed by a wall 112 which is part of casing 83 and by a wall 113 secured between casing 83 and cap 84. A spiral rib 114 is also formed as part of wall 112 within chamber 89, so that liquid petroleum flowing through valve 96 will circulate in a spiral manner and in heat transfer relation with walls 112 and 113. The fluid will be guided toward the central portion of the housing where it will eventually flow into the fuel inlet passageway of the low pressure regulator which is formed by a threaded bushing 115. Chamber 92 is provided with a fluid connection 116 and chamber 93 has a connection 117, these two chambers being connected by a tubular member 118 threaded into a boss 119 in wall 112. It will therefore be seen that water or other heating fluid may be freely conducted between connections 116 and 117, the fluid passing through both chambers 92 and 93.

The low pressure regulator is formed by a wall 120 secured between casing 83 and cap 85, and into which bushing 115 is threaded. A diaphragm 121 is secured between wall 120 and cap 85 to form an atmospheric chamber 122 and a low pressure chamber 123. As in the previous embodiment, valve seat 124 of the low pressure regulator is formed by a removable tubular member 125 threaded into bushing 115, and ball valve 126 is carried by a spring 127 with an adjustable pressure spring 128, as in the previous embodiment. Chamber 122 is sealed from the high pressure regulator portion of the housing by a boss 129 on wall 120 which is held against wall 112 by bushing 115. The sealing means between chamber 123 and chamber 122 is somewhat different than in the previous embodiment, and comprises a sleeve 130 secured to diaphragm 121 by a nut 131 and having a close sliding fit with member 125. The inner end of sleeve 130 has a shoulder 132 engageable with legs 133 carried by spring 127, so that flexing of diaphragm 121 to the left in Figure 3 will lift valve 126 from seat 124. It will thus be seen that the principles of the invention are embodied in a very compact unit which includes not only the high pressure and low pressure regulators but the heating means as well.

Figure 5 shows another embodiment of the invention which, like the embodiment of Figures 3 and 4, combines the high pressure and low pressure regulators in a single unit, but which has a somewhat different heating and valving arrangement, the heat being supplied to the liquid petroleum before the first stage of pressure reduction. The housing includes a casing 134 having end caps 135 and 136 secured thereto. An inlet connection 137 is provided in casing 134 for the liquid petroleum, and a heating fluid chamber 138 is formed within the casing by a wall 139 which is part of the casing and a wall 140 secured between casing 134 and end cap 137. The liquid petroleum is carried from inlet connection 137 through a helical tube 141 which is disposed within chamber 138 and leads to the high pressure regulator valve 142. Valve 142 is carried at one end of a lever 143 pivotally supported by a pin 144 on wall 139. The valve is arranged adjacent a valve seat 145 which forms part of a connecting member 146 into which tube 141 leads, mem-

ber 146 being secured to wall 139. The liquid petroleum is thus heated before its arrival at the high pressure regulator valve by the heating fluid circulated in chamber 138, the chamber having fluid connections 147 for this purpose.

The high pressure regulator valve is operated by a diaphragm 148 secured between casing 134 and cap 135, the central portion of this diaphragm being secured to the inner end 149 of lever 143. A chamber 150 vented at 151 is formed between diaphragm 148 and end cap 135. When valve 142 is lifted from valve seat 145, the liquid petroleum flows into a chamber 152 formed between diaphragm 148 and wall 139, and it will be noted that chamber 152 is in heat transfer relation with heating fluid chamber 138. A spring 153 is disposed between end cap 135 and diaphragm 148 in such a manner as to urge valve 142 into its open position, the force of this spring being opposed by the pressure within chamber 152. It will therefore be seen that valve 142 will act as a reducing valve, admitting the fuel into chamber 152 when the pressure in this chamber is reduced sufficiently to flex diaphragm 148 to the left as shown in Figure 5.

The low pressure regulator portion of the unit is formed by wall 140 and end cap 136, a diaphragm 154 being secured between these members and forming an atmospheric chamber 155 and a low pressure or outlet chamber 156. A threaded bushing 157 is secured to and holds together the centrally upraised portions of walls 139 and 140 and acts as the fuel inlet connection to the low pressure regulator, and a tubular member 158 is threadably mounted in sleeve 157 and has a valve seat 159 formed at its inner end. A ball valve 161 is carried by a spring supporting member 162 as in the previous embodiments, with an adjustable pressure spring 163 mounted on end cap 136. The sealing means between chambers 155 and 156 comprises a bellows 164 as in the embodiment of Figure 2, this bellows being secured between the tubular member 158 and diaphragm 154. It will therefore be seen that a unitary construction has been provided which permits heating of the liquid petroleum before and after it passes through the high pressure regulator valve, thereby enhancing vaporization of the fuel.

Figure 6 illustrates still another embodiment of the invention which is generally similar in construction to the previous embodiments but in which the valve supporting means for the low pressure regulator is of modified construction, and which is adapted for connection to a separately enclosed high pressure regulator. The central casing 165 of this embodiment is provided with end plates 166 and 167 secured thereto by bolts 168, with walls 169 and 170 secured between the end plates. The high pressure regulator (not shown) is adapted to be connected to a nipple 171 secured to casing 165 and which leads to a conduit 172 within a heating fluid chamber 173. The latter chamber is provided with inlet and outlet heating fluid connections 174 and 175, and conduit 172 leads through a connection 176 to a chamber 177 formed by end plate 166 and wall 170. A boss 178 on wall 169 is secured in sealed relation with the central portion of wall 170 by threaded bushing 179 which serves as a conduit for the fluid leaving chamber 177. A removable tubular member 180 is threaded into bushing 179 and is disposed within boss 178, a valve seat 181 being formed at the other end of tubular member 180 which is engaged by a ball valve 182. A sleeve 183 is slidable on tubular member 180 and is secured to a diaphragm 184 by means of a nut 185. Diaphragm 184 and end plate 167 form a low pressure chamber 186, and valve seat 181 as well as valve 182 are disposed within this chamber.

The supporting means for ball valve 182 comprises in the present embodiment a cantilever type leaf spring 187 which is secured to end plate 167 at an outer edge portion thereof by a fastener 188. The inner end 189 of spring 187 is cupped to receive and loosely retain ball valve 182,

although it will be noted that the ball valve is not fastened or secured to the spring. An adjusting set screw 191 similar to those of the previous embodiments may be provided for presetting the tension in spring 187 which urges valve 182 into its closed position. The lifting means for the ball valve includes a plurality of spaced projections or legs 192 carried by sleeve 183 on the outer portion thereof which projects into chamber 186, two such legs being shown in the present instance. Legs 192 may be formed for example by milling a slot of appropriate width in the end of sleeve 183, and the legs are so spaced that they will simultaneously engage ball valve 182 when the sleeve is moved to the left in Figure 6 due to movement of the diaphragm. It will be observed that legs 192 are symmetrically spaced with respect to the path of movement of the ball valve so that the valve will be lifted with an even distribution of forces and will be resealed accurately on valve seat 181 when sleeve 183 is moved to the right. The fact that the ball valve is not fastened to spring 187 means that the valve is not restricted in any way from centrally engaging the valve seat. Since legs 192 are at all times properly related to the valve seat position, the proper seating of the ball valve will be automatic and not subject to variation.

Figures 7 and 8 show another embodiment of the invention generally similar in principle to the previous modifications, but in which the diaphragm and its connecting means with the valve are differently constructed. A casing generally indicated at 193 is provided, the casing comprising two saucer shaped halves 194 and 195 with mating flanges. Centrally secured at an apertured portion of casing half 195 is a bushing 196. This bushing may be secured to the apertured portion of the casing half by welding or other means, and is both internally and externally threaded as shown in Figure 7. A mounting bracket 197 is securable to the casing by means of nut 198, similar to the mounting of bracket 74 in the embodiment of Figure 2. The internally threaded portion of bushing 196 is adapted to receive a connection 199 from a high pressure regulator (not shown).

A combined fuel inlet connection and valve body 201 is secured at its reduced threaded end 202 in the internally threaded portion of bushing 196 and extends within casing 193. Inlet 201 is centrally bored and has a valve seat 203 of appropriate material secured therein. The inner end of inlet 201 carries a ball valve 204 for movement toward and away from valve seat 203. In particular, the inner end is slotted at 205, as shown in Figure 8, to form a plurality of axially extending guide projections or fingers 206. Four such projections are shown in Figure 8, it being understood that a different number could be utilized within the principles of the invention. The relative dimensions of projections 206 are such that the ball valve is permitted free movement toward and away from valve seat 203, but is at the same time held against unwarranted lateral movement. Slots or interstices 205 are preferably of such size as to permit free flow of vapor during operation of the device. Valve seat 203 may be held in position by a snap ring 207 or other appropriate means, the bases of projections 206 being so formed as to hold this ring in position.

The means for controlling the movement of valve 204 comprises a diaphragm 208 disposed within the casing and forming an atmospheric chamber 209 and a low pressure or outlet chamber 211 therein, a vent opening 212 being provided for chamber 209. The peripheral edge of diaphragm 208 is secured between the mating flanges 213 and 214 of casing halves 194 and 195, respectively. The center of diaphragm 208 is apertured and inlet connection 201 extends through this apertured portion. A shoulder 215 is formed at the inner end of inlet 201 by fingers 206, and means are provided for yieldably urging the central portion of diaphragm 208 against this shoulder. This means comprises a pair of washers 216 and 217 secured on either side of the apertured central por-

tion of diaphragm 208, and having an inner diameter sufficiently wide to clear inlet 201 and permit a predetermined slight lateral displacement. A washer 218 is secured over the apertured portion of casing half 195 by means of a shoulder on valve body 201. Washer 218 supports one end of a helical spring 219 disposed between this washer and washer 217. Spring 219 is a compression spring and urges washers 215 and 217, together with the central portion of diaphragm 208, against shoulder 215 of valve body 201. The characteristics of spring 219 are preferably such that the central portion of diaphragm 208 will be held stationary during normal operation, but, due to the yieldable nature of the connection, unusual axial or lateral stresses on the diaphragm will be accommodated. The connection also aids in alignment of the peripheral portion of the diaphragm during assembly.

It will be noted from an examination of Figure 7 that the area of diaphragm 208 is such as to permit a predetermined degree of curvature when the diaphragm is taut but unstressed, this curvature being changed in accordance with the pressure differentials existing between chambers 209 and 211. The actuating means for utilizing this movement to control valve 204 comprises a sheet metal shoe 221 engageable with the major portion of diaphragm 208 between its inner and outer edges. Shoe 221 is of annular shape and is of dished cross-section, as shown in Figure 7, with a curvature corresponding to the unstressed curvature of diaphragm 208. The shape of shoe 221 is such that it will engage the diaphragm at all points on its convex surface. Movement of diaphragm 208 to the left in Figure 7 under the influence of pressure reduction in chamber 211 will therefore act upon the entire surface of shoe 221 even after the diaphragm has undergone substantial leftward movement. Likewise, the shoe will accurately follow rightward movement of the diaphragm. Shoe 221 will thus be highly sensitive to forces imposed on the diaphragm by pressure differentials between chambers 209 and 211.

The means for connecting shoe 221 to valve 204 comprises a U-shaped bracket 222 having its legs 223 secured to shoe 221 and its central portion overlying valve 204. This bracket is secured at its central portion to an arm 224 by means of a rivet 225. The position of rivet 225 is such that one head thereof will centrally engage valve 204 when arm 224 is moved toward the valve. Arm 224 is pivoted to the peripheral portion of casing half 194 by means of a hinge 226. It will be observed that upon movement of shoe 221 the shoe as well as bracket 222 and arm 224 will swing about hinge 226. A spring 227 is provided for urging arm 224 in a direction such that shoe 221 will engage diaphragm 208, whereby rivet 225 will urge valve 204 into its closed position. An adjusting nut 228 may be provided for adjusting the compression of spring 227 in accordance with the desired operating pressure of the valve. It should be observed that the connections of the parts are such that during movement of arm 224 and its associated parts, no interference will be presented by diaphragm 208, since shoe 221 is free to slide slightly on the diaphragm in response to any slight lateral component of movement which may occur due to pivoting about hinge 226.

In operation, vapor will flow from the high pressure regulator through conduit 199 into inlet connection 201, tending to lift valve 204, and its flow into chamber 211 will be controlled by the forces on the valve. This in turn will depend upon the position of rivet 225 which is part of the assembly comprising shoe 221, bracket 222 and arm 224 hinged at 226. Should the engine requirements be such that pressure in chamber 211 is lowered, diaphragm 208 will be moved to the left by the pressure differential between chambers 209 and 211. As stated previously, the entire convex surface of shoe 221 will at all times be in engagement with the diaphragm so that

the shoe is highly sensitive to diaphragm movement. Rivet 225 will thus be swung slightly to the left in accordance with the diaphragm movement, permitting valve 204 to be lifted from valve seat 203. During this movement of spherical valve 204, it will be guided and supported by projections 206 so as to maintain its alignment with the valve seat. Vaporized fuel will flow through interstices 205 between projections 206 and into chamber 211, whence it will flow to the engine through outlet 229. When the pressure in chamber 211 is again increased, diaphragm 208 will move to the right and the valve controlling assembly will be urged rightwardly under the influence of spring 227. Valve 204 will again be closed until the drop in outlet chamber pressure again requires its opening. It should be observed that during this movement a clearance space is maintained between bracket 222 and the outer ends of projections 206 so that the projections will in no way interfere with valve operation.

Figure 9 illustrates another embodiment of the invention which is generally similar to that of Figure 8, but which includes a high pressure regulator in the same housing as the low pressure regulator. A housing 231 is provided, this housing being constructed in one or more sections and having a wall 232 to which it attached a cover 233. The high pressure regulator is generally indicated at 234 and comprises an enclosure 235 fixed to the side of housing 231 and containing a diaphragm 236. This diaphragm separates enclosure 235 into two chambers 237 and 238. Chamber 237 is an atmospheric chamber while chamber 238 is a pressure or delivery chamber, the pressure differential between these chambers controlling the movement of diaphragm 236. A spring 239 urges diaphragm 236 toward chamber 238. The high pressure LP gas is delivered to chamber 238 by means of a tube 240 which leads to this chamber from a high pressure inlet valve 241. Valve 241 is mounted on the side of housing 231 opposite enclosure 235, and is connected to diaphragm 236 by an actuating rod 242 which extends within tube 240. The means for delivering the vapor from chamber 238 to the low pressure valve comprises a second tube 243 which is concentric with tube 240 and spaced outwardly therefrom. Tube 243 connects chamber 238 to an axial tube 244 secured to housing 231.

The low pressure portion of the regulator comprises, as in the previous embodiment, a fuel inlet connection 245 secured to the end of tube 244. This inlet carries a spherical valve 246 guided by projections 247 and controlled by the movement of a rivet 248 secured to an arm 249. The arm is hinged at 251 to cover 233 and is controlled by a shoe 252 engageable with a diaphragm 253 secured between housing 231 and the cover, as in the previous embodiment.

Means may also be provided in the embodiment of Figure 9 for heating the high pressure LP vapor. As shown, this means comprises a chamber 254 in housing 231 through which tubes 240 and 243 extend. Warming fluid connections 255 and 256 are provided for chamber 254 so that the LP vapor passing through tubes 240 and 243 will be heated. It should be noted that wall 232 of housing 231 effectively seals off the warming fluid from the low pressure portion of the device.

In operation of the embodiment of Figure 9, LP gas will flow into tube 240 through high pressure valve 241 until the pressure in chamber 238 is sufficient to cause upward movement of diaphragm 236, thus closing valve 241. An auxiliary spring 257 may be provided for aiding this movement, and valve 241 will open and close in accordance with requirements. The fluid will pass through tubes 240 and 243, being warmed by the fluid in chamber 254, and will pass through tube 244 into low pressure fuel inlet connection 245. Valve 246 will be controlled in accordance with the pressure differentials between an atmospheric chamber 258 and a delivery

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chamber 259 separated by diaphragm 253 and will deliver low pressure vapor to outlet 261 in the same manner as described with respect to the embodiment of Figures 7 and 8.

While it will be apparent that the preferred embodiments of the invention disclosed are well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. In a fuel regulating device, a casing, a diaphragm within said casing and forming a chamber therein, a fuel inlet connection extending through said casing and said diaphragm and into said chamber, a fuel outlet connection leading from said chamber, sealing means between said diaphragm and said inlet connection, a valve seat at the inner end of said inlet connection, a valve disposed within said chamber adjacent said valve seat in such manner that fluid pressure in said inlet connection tends to lift said valve, means supporting said valve for movement toward and away from said valve seat, said supporting means being secured to said casing whereby the valve is supported independently of said diaphragm, resilient means urging said valve in a direction against said seat, and actuating means operable in response to movement of said diaphragm towards said chamber for urging said resilient means in the opposite direction, whereby said valve will be lifted from said seat.

2. The combination according to claim 1, said valve comprising a spherical member, said supporting means comprising an arm having one end secured to said casing and its other end engageable with said spherical member.

3. The combination according to claim 2, said resilient means comprising a spring having one end engageable with said casing and its other end engageable with said arm.

4. The combination according to claim 1, said actuating means comprising an annular plate disposed between said diaphragm and said supporting means, one side of said plate being engageable by said diaphragm when the latter is moved toward said chamber, and a member carried by said supporting means and engageable by the other side of said plate when so moved by said diaphragm, said resilient means urging said last-mentioned member toward said plate.

5. The combination according to claim 1, said fuel inlet connection comprising a tubular member removably supported by said casing and having an axial passage therein, said tubular member being exchangeable for tubular members of different passage diameters.

6. The combination according to claim 1, said valve supporting means comprising an arm, said resilient means comprising a leaf spring secured at one end to said casing and slidably engageable with said arm at its other end, and adjusting means for predetermining the tension in said leaf spring.

7. The combination according to claim 1, said casing comprising two shell-like members having mating flanges, a mounting bracket for securing said casing to a support, said mounting bracket having one leg secured to said casing and a second leg adapted to be secured to a support, said first leg extending laterally on said casing to a point outwardly of said flanges, a post disposed between the outer end of said first leg and said flanges, and a fastener extending through a pair of the aligned apertures in said flanges and drawing said flanges and said bracket against said post.

8. The combination according to claim 1, said regulating components constituting a low pressure regulator, a high pressure regulator carried by said housing, a fuel inlet connection for said high pressure regulator, an intermediate chamber connected between the outlet of said high pressure regulator and the inlet of said low

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pressure regulator, a high pressure regulator valve, biasing means tending to bias open said high pressure regulator valve, a diaphragm forming part of said high pressure regulator and responsive to pressure in said intermediate chamber, and means connecting said diaphragm and said valve, said diaphragm serving to open said valve when pressure in said intermediate chamber is reduced.

9. The combination according to claim 8, the supporting means for said low pressure regulator valve including an arm carrying said valve and secured to said housing, said actuating means comprising an element carried by said arm and extending toward said low pressure regulator diaphragm, whereby movement of the latter toward said low pressure chamber causes engagement of said element.

10. The combination according to claim 8, said low pressure regulator valve supporting means including an arm carrying said valve and secured to said casing, said resilient means comprising a leaf spring secured to said casing and slidably engaging said arm, and means for adjusting the tension in said leaf spring.

11. The combination according to claim 8, said housing being further provided with a heating fluid chamber in heat exchange relation with said intermediate chamber, and means for conducting heating fluid to and from said heating fluid chamber.

12. The combination according to claim 8, the connecting means in said high pressure regulator between said diaphragm and valve comprising a lever fulcrumed at one point thereof and connected to said high pressure regulator diaphragm at another point thereof, said lever carrying said high pressure valve whereby the valve is movable in response to flexing of said diaphragm.

13. The combination according to claim 11, said intermediate chamber being further provided with a labyrinthine passage for conducting the fuel in heat transfer relation with said heating fluid chamber.

14. The combination according to claim 8, said sealing means including a sleeve secured to said low pressure regulator diaphragm and in close sliding engagement with said inlet fluid connection.

15. In a fuel regulating device, a casing, a diaphragm within said casing and forming a chamber therein, a fluid inlet connection extending through said casing and said diaphragm and into said chamber, a fuel outlet connection leading from said chamber, means sealing said diaphragm to said inlet connection, a valve seat at the inner end of said inlet connection, a valve comprising a spherical element disposed within said chamber adjacent said valve seat in such manner that fluid pressure in said inlet connection tends to lift said valve, means supporting said valve independently of said diaphragm, resilient means urging said valve in a direction against said seat, and actuating means operable in response to movement of said diaphragm toward said chamber to urge said resilient means in the opposite direction, whereby said valve will be lifted from said seat.

16. In a fuel regulating device, a casing, a diaphragm dividing said casing into an atmospheric chamber and an outlet chamber, a fuel inlet connection extending through said casing and said diaphragm into said outlet chamber, means connecting the outer edge of said diaphragm to said casing and the inner end to said inlet connection, the diaphragm being so proportioned as to have a predetermined curvature when in a taut but unstressed condition, a valve seat in said inlet connection, a spherical valve movable toward and away from said valve seat, fluid pressure in said inlet connection tending to lift said valve, means on said inlet connection for supporting said valve during its operative movement, a member engageable with said valve in a direction tending to move the valve against said valve seat, a spring urging said member against said valve, a shoe engageable with said diaphragm, said shoe having a dish-shaped cross section with its convex surface engageable on all portions thereof

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with the diaphragm, and means connecting said shoe with said member, whereby said spring will urge said shoe against said diaphragm.

17. In a fuel regulating device, a casing, a diaphragm dividing said casing into an atmospheric chamber and an outlet chamber, a fuel inlet connection extending through said casing and said diaphragm and into said outlet chamber, means connecting the outer edge of said diaphragm to said casing and the inner edge to said fuel inlet connection, a valve seat in said fuel inlet connection, a spherical valve movable toward and away from said valve seat, a plurality of spaced projections on said fuel inlet connection for supporting and guiding said valve, fluid pressure in said inlet connection tending to lift said valve, the interstices between said spaced projections permitting fluid flow from said inlet connection into said outlet chamber, a member engageable with said valve to move the valve against said valve seat, a spring urging said member against said valve, an annular shoe of dish-shaped cross section having its entire convex surface engageable with said diaphragm, and means connecting said shoe with said member, whereby movement of said diaphragm toward said outlet chamber will move said member away from said valve.

18. The combination according to claim 17, said member comprising an arm hinged at one end to said casing, said means connecting the shoe and member comprising a bracket, and a rivet securing said bracket to said arm, said rivet being engageable with said valve.

19. The combination according to claim 17, said diaphragm when in a taut but unstressed condition having a predetermined curvature, said spring urging said shoe against said diaphragm to urge the diaphragm toward said atmospheric chamber.

20. The combination according to claim 17, the means connecting said diaphragm to said inlet connection comprising a shoulder on said inlet connection, and a spring urging said diaphragm inner edge against said shoulder, the inner edge being spaced outwardly from said inlet connection to allow limited lateral play therebetween.

21. In a fuel regulating device, a casing, a high pressure regulator carried by said casing, said high pressure regulator comprising a diaphragm, a delivery chamber formed by said diaphragm, a high pressure regulator valve, an inlet for said high pressure regulator leading to said valve, a rod connecting said valve and said diaphragm, a spring urging said diaphragm in a direction tending to open said valve, a tube leading from said valve to said delivery chamber, a low pressure inlet connection secured to said casing, a second tube concentric with said first tube and leading from said delivery chamber to said low pressure inlet connection, a warming fluid chamber formed by said casing and surrounding said tubes, a low pressure diaphragm connected at its outer end to said housing and having a sealing connection at its inner end to said fuel inlet connection, said low pressure diaphragm forming an outlet chamber, an outlet connection for said outlet chamber, a valve seat in said fuel inlet connection, within said outlet chamber, a spherical valve within said

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outlet chamber movable toward and away from said valve seat, an arm hinged on said casing and having a portion at one end engageable with said valve to move the valve toward said valve seat, a spring urging said arm toward said valve, a plurality of spaced projections on said fuel inlet connection for guiding said valve, pressure in said fuel inlet connection tending to lift said valve, the interstices between said projections permitting said fluid to pass into said outlet chamber, an annular shoe of dish-shaped cross section engageable on the entire convex surface thereof with said low pressure diaphragm, and a bracket connecting said shoe to said arm whereby movement of said low pressure diaphragm toward said outlet chamber will permit lifting of said valve.

22. The combination according to claim 1, said supporting means comprising an arm having one end secured to said casing.

23. The combination according to claim 1, said sealing means comprising a sleeve secured to said diaphragm and slidable on said fuel inlet connection, said valve comprising a spherical member, and a plurality of projections carried by said sleeve and engageable with said valve when said diaphragm moves toward said chamber, whereby said valve is lifted from said seat.

24. The combination according to claim 23, said resilient means comprising a cantilever type spring secured at one end to said casing and retaining said valve loosely at its other end.

25. In a fuel regulating device, a casing, a diaphragm within said casing and forming a chamber therein, said diaphragm being movable toward and away from said chamber, a fuel inlet connection leading into said chamber, a fuel outlet connection leading from said chamber, a valve seat at the inner end of said inlet connection, a valve disposed adjacent said valve seat in such manner that fluid pressure in said inlet connection tends to lift said valve, a member engageable with said valve, means supporting said member for movement toward and away from said valve and preventing substantial lateral movement with respect to said valve, a spring urging said member in a direction tending to close said valve against its seat, and a shoe secured to said member and urged against said diaphragm by said spring, said shoe having a dish-shaped cross-sectional shape and being engageable at all portions of its convex surface with said diaphragm, the shoe and diaphragm being capable of relative shifting in a lateral direction, whereby operative axial movement of said diaphragm will control the position of said valve.

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