July 20, 1937. E. V. BEALS 2,087,792

CARBURETOR

Filed Jan. 30, 1933 5 Sheets-Sheet 1

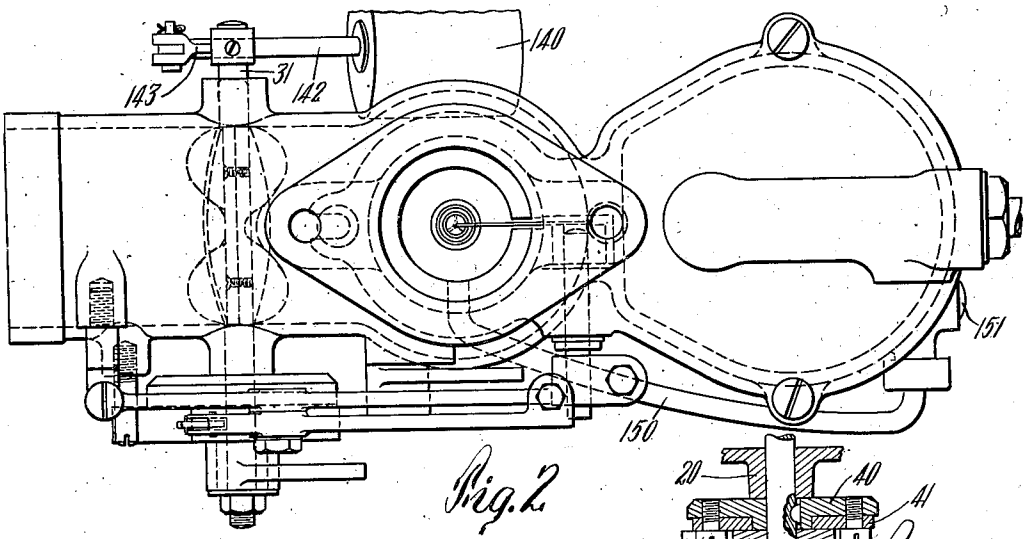


Fig. 2

Fig. 3

Fig. 1

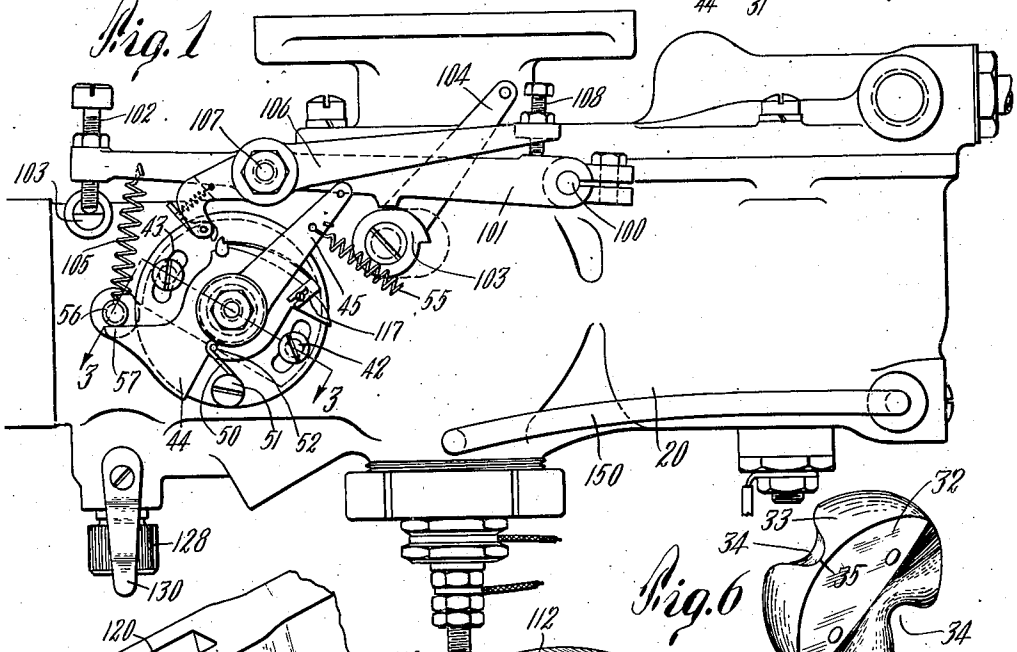


Fig. 6

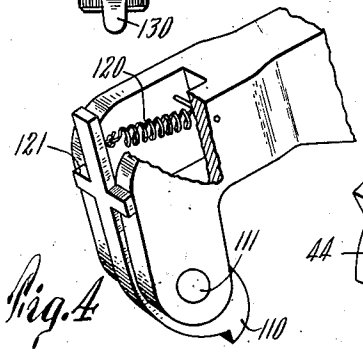


Fig. 4

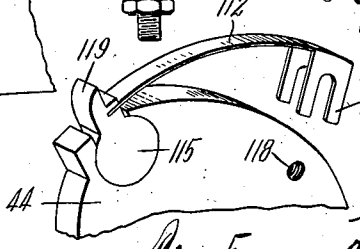


Fig. 5

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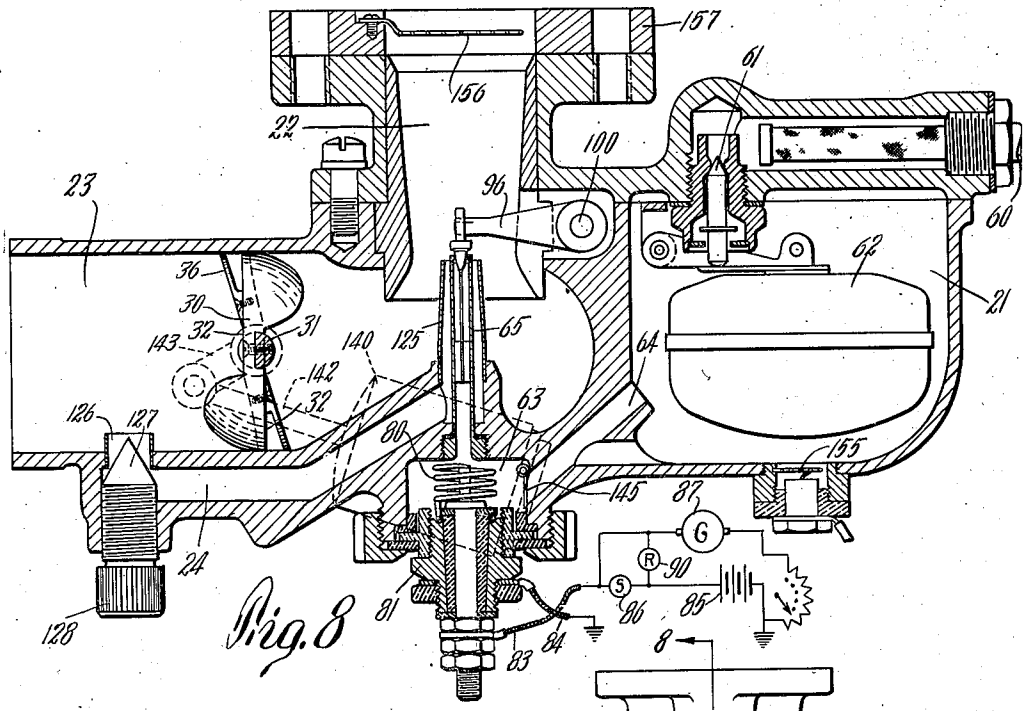


Fig. 8

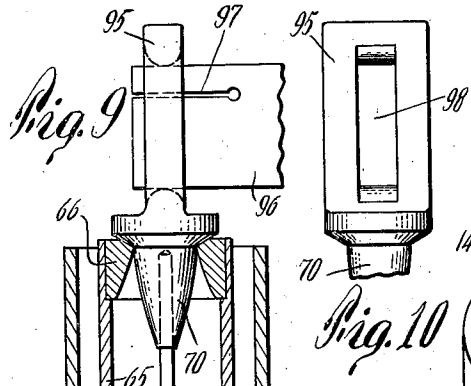
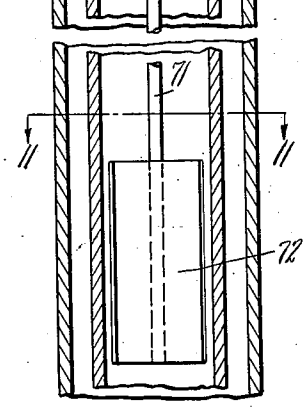


Fig. 9

Fig. 10



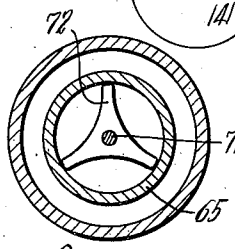


Fig. 11

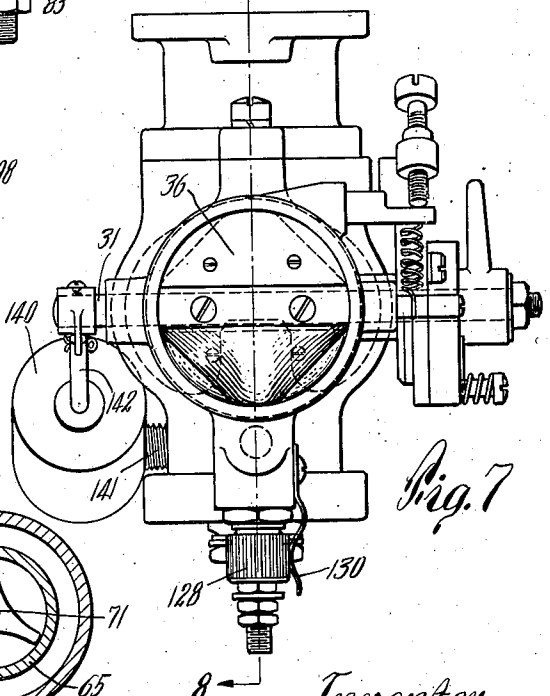


Fig. 7

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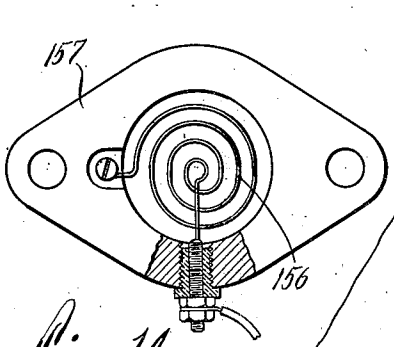


Fig. 14

Fig. 12

Fig. 15

Fig. 13

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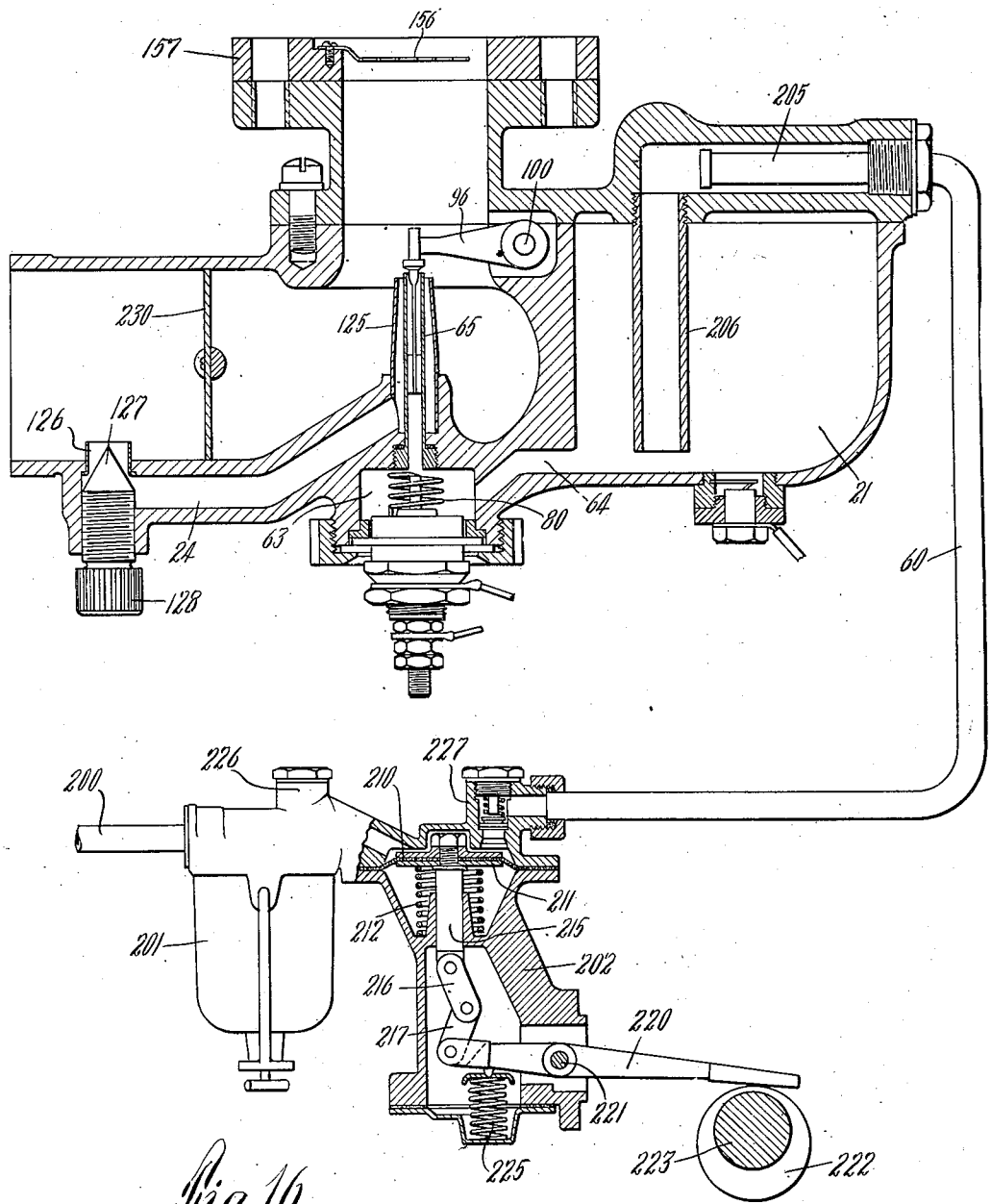


Fig. 16

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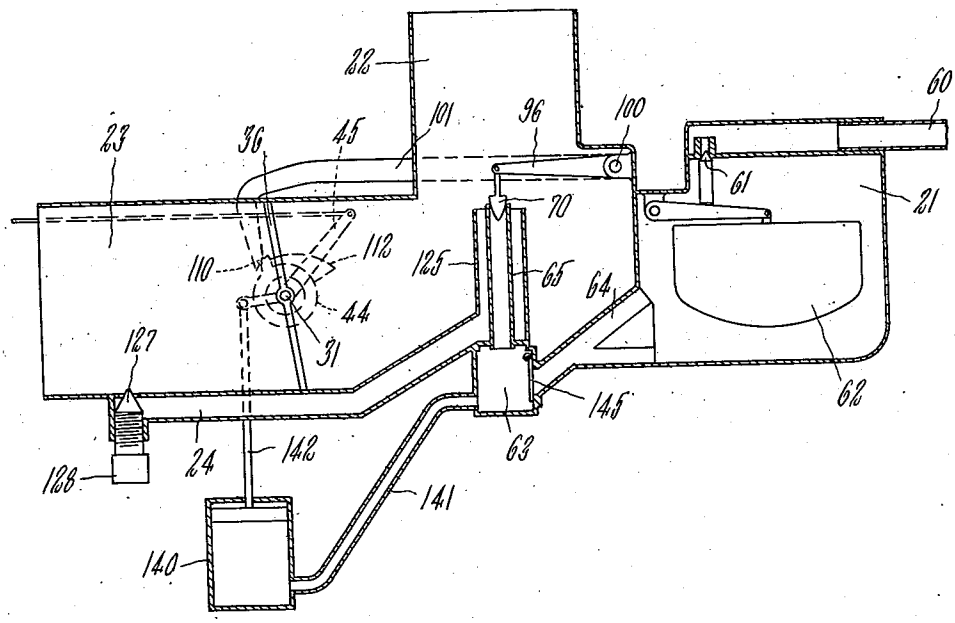


Fig. 17.

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2,087,792

UNITED STATES PATENT OFFICE

2,087,792

CARBURETOR

Erl V. Beals, Boston, Mass., assignor to Beals Fuel Oil & Gasoline Carburetor Co., Inc., Boston, Mass., a corporation of Massachusetts

Application January 30, 1933, Serial No. 654,187

11 Claims. (Cl. 261—50)

This invention relates to improvements in carburetor structure designed to produce more satisfactory results in the operation of an internal combustion motor to which such carburetor is attached when the motor is idling, when it is operating to produce power, and especially when it is being started. It is an object of the invention to provide novel apparatus including a carburetor which can be readily adjusted to meet the individual requirements of different sizes and kinds of motors to which it may be attached. It is a further object of the invention to provide a carburetor in which the necessary adjustments may be made by adjusting elements which are readily accessible during the operation of the motor. It is a further object of the invention to provide a carburetor which not only facilitates rapid acceleration of the motor for a quick getaway, but also is capable of using fuel oils as fuel instead of gasolene. Another important feature of the invention is the provision of apparatus for starting a cold motor with fuel oil of low volatility such as oil of the order of 26° to 32° Bé. For many purposes such as the operation of motor-boats and aeroplanes, the presence of gasolene is a serious hazard owing to its great inflammability and its consequent liability to ignite by contact with a hot exhaust pipe or by back-firing in the motor. For such purposes a motor which will operate entirely with a fuel oil of low inflammability is highly desirable. Furthermore, such a motor is also desirable for general purposes on account of relatively low fuel costs as compared with gasolene. According to the present invention, apparatus is provided for starting a cold motor of ordinary construction with fuel oil as fuel and for operating the motor satisfactorily with such fuel. The chief trouble with the use of fuel oil in the ordinary internal-combustion motor, especially when cold, arises from the difficulty with which such oils are changed to and kept in the vapor state. According to the invention, apparatus is provided for properly heating the fuel passing through the carburetor and maintaining the fuel at a sufficiently high temperature to avoid undue condensation in its passage into the explosion chambers, when the motor is starting cold. The carburetor hereinafter described and illustrated is also designed to be free from clogging of the fuel line and to economize in the consumption of the fuel so as to afford high efficiency of operation of the motor. To this end, several novel features are provided in my carburetor, these features including an air valve of novel structure located within the inlet leading to the mixing chamber of the carburetor. This air valve is operated through a lost-motion connection so that during the first small portion of the movement of the accelerator, there is no corresponding movement on the part of the air valve itself. Movement of the valve-operating mechanism, however, results in the operation of mechanism for admitting or forcing a charge of fuel into the mixing chamber to mingle with the fixed supply of air admitted for idling purposes before or as the main air valve is opened. This provides the fuel to produce a rich mixture and hence a surge of power to the engine in effecting a quick getaway. The fuel valve and supply orifice are furthermore so designed as to admit fuel to the mixing chamber in a very finely divided state, the fuel supply pipe being of substantial diameter so that the possibility of clogging is practically eliminated. The fuel valve itself is preferably of parabolic shape so that the clearance between the plug valve and the orifice in which it is adapted to seat is approximately proportional to the linear displacement of the valve from its seat. The fuel valve is arranged to be opened automatically by operation of the main air valve, a cam and cam follower being employed in the mechanism connecting the two valves. This cam is, according to the invention, made adjustable so as to vary the operating stroke of the fuel valve from its seated position. It is evident that if the stroke of the fuel valve can, for example, be doubled, the effect of this change of stroke is equivalent to doubling the size of a jet in an ordinary carburetor. Thus, in this carburetor, the size of jet can be easily adjusted as desired without pulling apart the carburetor structure. Other advantageous combinations and details of structure will be apparent to one skilled in the art from the disclosure of the invention in the following description and on the drawings, of which,—

Figure 1 is an elevation of a carburetor embodying the invention.

Figure 2 is a plan view of the same.

Figure 3 is a fragmentary section on the line 3—3 of Figure 1.

Figure 4 is a fragmentary perspective view of a portion of the fuel valve operating mechanism shown in Figure 1.

Figure 5 is a fragmentary perspective showing the adjustable cam for the fuel valve operating means.

Figure 6 is a perspective view of the main air valve.

Figure 7 is an end elevation of the carburetor shown in Figure 1.

Figure 8 is a section on the line 8—8 of Figure 7, a wiring diagram for one of the heating elements being included in this figure.

Figure 9 is a portion of Figure 8 on a larger scale, showing the orifices for the fuel and idling air, together with the fuel valve.

Figure 10 is a fragmentary elevation of the fuel valve.

Figure 11 is a section on the line 11—11 of Figure 9.

Figure 12 is a side elevation of the carburetor including a portion of the intake manifold and apparatus connected thereto.

Figure 13 is a sectional view of a valve for controlling the introduction of priming charges into the intake manifold.

Figure 14 is a plan view, partly broken away, of a heater unit mounted in a gasket between the carburetor and the intake manifold.

Figure 15 is a fragmentary section on the line 15—15 of Figure 12.

Figure 16 is a view, chiefly in section, of a modified form of carburetor connected with a fuel pump.

Figure 17 is a diagrammatic view of the carburetor illustrated in Figure 1.

The carburetor thus illustrated on the drawings consists of a housing 20 containing the fuel supply chamber 21, a mixing chamber 22, a main air inlet 23 leading to the mixing chamber, and an auxiliary air inlet duct 24. The mixing chamber 22 is adapted to communicate directly with the manifold 25 of an internal combustion engine when the carburetor is attached to the engine. In the main air inlet pipe 23 and suitably spaced from the orifice thereof is a main air valve 30 which, as shown, is in the form of a valve of the butterfly type mounted to rock on a shaft 31. This valve is preferably of a peculiar shape illustrated in Figures 6 and 8, the valve consisting of two portions which are symmetrical to each other with respect to the rocking axis 31. Each portion has a semi-circular face 32 adapted to lie in a plane substantially perpendicular to the axis of the air inlet 23 when the valve 30 is in its fully closed position. Each of the two portions of the valve also has a spherical surface portion 33, this spherical surface being in the form of a sector of a sphere with a central indentation 34. When the valve is in its fully closed position as shown in Figure 8, the semi-circular faces 32 are adapted to fit snugly against the inner surface of the air inlet pipe 23 so that the passage of air through this pipe into the mixing chamber is substantially cut off. When the valve is rocked from its fully closed position, it is evident that the spherical sector surfaces 33 will continue to fit snugly against the inner surface of the inlet pipe 23 until the valve 30 has been swung through a material angle, say 30°. If the spherical surfaces 33 were uninterrupted, the valve would not open at all during the rocking of the valve from its closed position through this angle. In each spherical surface 23, however, a recess 34 is provided, this recess commencing at a point 35 adjacent the plane of the semi-circular face 32 and flaring in width as shown in Figure 6. Thus when the valve 30 is rocked from its fully closed position, no opening occurs for the first few degrees of rotation. The tips 35 of the recesses 34 then begin to provide small openings for air, these openings increasing first gradually and then rapidly as the valve is rocked further and further from its shut position. By suitably shaping the recesses 34, the size of openings corresponding to any given angle of rotation of the valve from its shut position can be obtained. A pair of segment plates 36 may be attached to the valve member 30 to act as stops by engaging the inner surface of the inlet pipe 23 when the planes of the semi-circular faces 32 are perpendicular to the axis of the pipe 23. These plates prevent the valve from swinging past its fully closed position. For the operation of the air valve 30, the rock shaft 31 on which it is mounted is projected through the casing 20. Upon the projecting portion of the shaft is suitably secured a disk 40, an auxiliary disk 41 being secured to the disk 40 as by a pair of set screws 42 which pass through slots 43 in the disk 41 so that the disks 40 and 41 may be secured together in adjusted angular relationship. An operating plate 44 is loosely mounted on the shaft 31, a lever arm 45 being secured to the plate 44 so as to rock the plate about the shaft 31. This plate may be yieldingly connected to the disk 41 as by a spring 50 which extends from a screw or pin 51 in the disk 41 and engages a pin 52 on the plate 44. A spring 55 is attached to the lever arm 45, this spring tending to swing the arm 45 and the plate 44 in a clockwise direction, as shown in Figure 1. The rocking movement of the arm and plate in this direction is limited by a stop 56 which is engaged by a projecting portion 57 on the plate 44. A suitable wire or cable (not shown) may be employed to connect the arm 45 with the accelerator pedal and throttle lever of the automobile so that the arm 45 may be rocked by the operator against the tension of the spring 55. The function of the spring 50 is to tend to rock the disk 41, and hence the valve 30, in a clockwise direction relatively to the plate 44. As a result of this structure, when the lever 45 is rocked in a counter-clockwise direction by actuation of the accelerator pedal, the first portion of this rocking movement does not result in any corresponding rocking of the valve 30, since the spring 50 is in the nature of a lost-motion connection between the lever arm 45 and the valve 30. When the plate 44 has been rocked sufficiently to engage the screw 51, further rocking movement of the plate 44 results in rocking of the disk 41 and the air valve 30. The purpose of this structure is hereinafter explained.

The fuel for the carburetor is supplied to the fuel chamber 21 as by a suitable supply pipe 60 communicating with the chamber through a needle valve 61 controlled by a float 62 in a manner well known in the art. The fuel chamber 21 communicates with a small chamber 63 through a suitable passage 64. From the chamber 63 a pipe 65 of substantial diameter leads upwardly and terminates in an orifice centrally located in the mixing chamber 32. This orifice may be in a nozzle piece 66 set in the upper end of the pipe 65 as indicated in Figure 9. In the orifice of the fuel pipe is a plug valve 70, the surface of this plug valve being in the shape of a paraboloid so that the area of clearance between the size of the plug valve 70 and the orifice in which it seats is substantially proportional to the linear displacement of the valve from its seat. In order to keep the plug valve 70 suitably aligned with the axis of the pipe 65, a stem 71 may be provided to project from the lower end of the valve 70 downwardly within the pipe 65. At the

lower end of the stem 71 is mounted a guide member 72 which, as shown in Figure 11, may consist of a suitable number of vanes loosely engaging the walls of the pipe 65 to keep the stem 71 centered. By employing a pipe 65 of substantial diameter, small orifices which are liable to be clogged by particles of dirt or other foreign matter in the fuel, are avoided. Furthermore, the use of an orifice and plug valve of substantial diameter means that owing to the considerable length of the circumference of these elements, an opening of given area is in the form of a circular clearance of relatively small width so that as fuel is sucked through this narrow clearance, it tends to be broken up into very finely divided form, thus facilitating the vaporization of the fuel when it enters the mixing chamber. Any sediment which may find its way into the pipe 65 will tend to collect at the orifice, but will be swept out into the mixing chamber by the stream of fuel entering the mixing chamber when the valve 70 is momentarily opened wide as may frequently happen in the ordinary operation of the carburetor.

Within the chamber 63 is a suitable heating coil 80 of nichrome wire or other suitable material, for operating the motor with liquid fuels less volatile than gasolene. This coil of heating wire is conveniently shaped to fit within the chamber 63 and is preferably mounted on a plug 81 which with associated members forms the bottom of the chamber 63 and is readily removable therefrom as is evident from Figure 8. Suitable connecting wires 83 and 84 are provided for the ends of the heating coil 82, the connections being insulated from each other in a manner illustrated in Figure 8 and well known in the art. The current for heating the element 82 may be supplied by the battery 85 when the starting switch 86 is closed. After the engine has been started, it drives the usual generator 87 from which current is thereafter supplied for the heating of the coil 82, the amount of current being regulated as by a rheostat 88 mounted in any convenient location as upon the dashboard. An automatic relay switch 90 is provided to cut out the battery when the generator is supplying current to the heating coil. The coil is designed to heat the stream of fuel which flows through the chamber 63 to a temperature just below its boiling point, or to a point at which it vaporizes readily for mixing with the air stream in the mixing chamber. The actual temperature of the fuel within the chamber 63 at any instant will, of course, depend on a number of factors including the temperature of the fuel entering the chamber from the carburetor bowl, the temperature of the casing around the chamber, the current passing through the heating unit 80, and the rate of flow of fuel through the chamber.

For the operation of the plug valve 70, a loop 95 is provided to receive the end of a rock arm 96. This end of the arm may be split as at 97 so that the end of the arm will bear snugly within the opening 98 of the loop 95. The arm 96 is mounted on a rock shaft 100 which projects through the wall of the casing 20. On the projecting portion of the shaft 100 is mounted a lever arm 101. A screw 102 is provided at the free end of the arm 101 to engage against a stop 103, the screw 102 being available to vary the closed position of the plug valve 70. For suitable idling of the engine, it is usually desirable to have a small clearance between the plug valve 70 and the orifice in which it is seated, this clearance being determined by the setting of the screw 102. Since the arm 101 is of considerable length compared with the arm 96, the screw 102 facilitates a fine vertical adjustment of the plug valve 70. Due to the parabolic shape of the valve member 70, adjustments for idling are made when the upper portion of the member 70 is on a level with the nozzle piece 66. As the upper portion of the member 70 has a surface which is nearly vertical, a small vertical adjustment of the member 70 results in a much smaller change in the width of the clearance between the member 70 and the nozzle member 66. Hence, an exceedingly fine adjustment of the clearance around the valve member 70 is obtainable.

The plug valve 70 may also be held open temporarily any desired amount, as when starting the engine, by an eccentric cam element 103 which bears against the lower edge of the arm 101 and is rockable by an arm 104 to which a suitable cable (not shown) may be connected for operation. A spring 105 may be employed to maintain the valve 70 yieldingly in its adjusted closed position. The cam element 103 takes the place of the usual "choke", but acts in a different manner in that it does not affect any air valve, but simply opens the fuel supply orifice. Incidentally, it can be used to clear the pipe 65 of any sediment which may accumulate therein. An auxiliary lever 106 is pivoted as at 107 to the arm 101 at an intermediate point between the rock shaft 100 and the free end of the arm 101. The auxiliary lever consists of long and short arms extending in opposite directions from the pivot axis 107. The long arm is provided with a screw 108 which engages the upper surface of the arm 101 and is adjustable to provide a very fine vertical adjustment for a cam follower 110 which is carried by the short arm and may if desired be pivoted on a pin 111 in the end of the arm. The cam follower 110 is adapted to ride on the surface of a cam member 112 which is carried by the plate 44. The cam member 112 consists of a rigid arcuate portion attached to a pivot member 115 which is mounted to rock in a recess in the plate 44 so that the arcuate portion of the cam member 112 can swing toward or away from the plate 44. From this arcuate portion a forked lug 116 projects in such a manner as to engage a face of the plate 44. A set screw 117 is adapted to pass between the legs of the forked lug 116 and to enter a threaded hole 118 in the plate 44, the head of the screw 117 serving to clamp the lug 116 in adjusted position against the face of the plate 44. By this adjustment, the angular relation between the arcuate cam portion of the member 112 and the radius of the plate 44 through the pivot member 115 can be varied. As shown in Figures 1 and 5, the pivot member 115 may be provided with an upstanding lug 119 adapted to engage the cam follower 110 when the cam plate 44 is rocked. When the rocking movement is counter-clockwise, the contacting curved faces of the cam follower 110 and the lug 119 ride on each other and cause the lever 106 to rise sharply with its fulcrum 107 so that the arm 101 which carries the fulcrum 107 is swung upwardly, rocking the shaft 100 and the valve arm 96 so as to raise the plug valve 70. Thus the initial rocking of the plate 44 results in a very considerable opening of the fuel valve 70. At the same time, owing to the lost-motion connection 50 between the plate 44 and the air valve 30, there is no opening of the main air valve at this time. As the operating arm 45 and plate 44 are rocked further, the cam follower 110 falls behind the lug

119 permitting the fuel valve 70 to return to, or almost to, its closed position. Thereafter the cam follower 110 rides on the arcuate cam surface of the member 112 which results in a gradual opening of the fuel valve 70 as the plate 44 is rocked further and further. At the same time, the air valve 30 is being rocked from its closed position. The recesses 34 of the air valve are so shaped with relation to the parabolic surface of the valve 70 and the arcuate shape of the cam member 112 that a proper proportion of fuel and air is maintained for all degrees of opening of the fuel and air valve when the accelerator pedal is released so as to permit the spring 55 to pull the arm 45 and plate 44 back to idling position, the cam follower 110 again engages the lug 119. The pivoted mounting of the cam follower 110 on the pin 111 is arranged to permit the follower 110 to rock on its pivot in such a manner as to pass the lug 119 without raising the arm 106, and hence without opening the fuel valve 70. This rocking movement of the follower 110 is against the tension of a suitable spring 120 which holds the follower 110 yieldingly in its normal position, suitable lugs 121 being provided to act as stops for the spring 120.

As shown in Figure 12, the lug 119 may be omitted from the cam 112, in which case the lever 106 may carry a cam follower in the form of a fixed finger 122 instead of the pivotally mounted follower 110.

For idling purposes, an auxiliary supply of air is introduced into the mixing chamber 22 through the duct 24, this duct terminating in a pipe 125 which surrounds the fuel pipe 65 and terminates substantially on a level therewith so that the air for idling enters the mixing chamber through an annular orifice surrounding the fuel supply orifice. The duct 24 preferably leads from an opening 126 in the main air supply pipe at a point between the intake orifice of this pipe and the main air valve 30. A needle valve 127 projects into the inlet 126 and is adjustable to regulate the supply of air for idling purposes. The needle valve may be conveniently operated by a knurled finger-piece 128 accessible from outside of the carburetor casing and held in adjusted position by a spring finger 130.

It is evident from Figure 1 that all of the adjustments of the carburetor are easily accessible while the carburetor is in position and the engine in operation. Thus when a carburetor is fitted to an engine, the fuel and air supply valves may first be adjusted for idling. The fuel supply for idling is determined by the setting of the screw 102. The air for idling is readily controlled through rotation of the finger-piece 128. This accessibility of the idling adjustments is important since for best results, adjustments must be made from time to time in accordance with changes of season, in addition to the original adjustment required when the carburetor is first attached to an engine. The angular position of the cam member 112 determines the magnitude of the difference between the idling position of the fuel valve and its fully opened position. It is evident that if the arcuate cam member 112 is adjusted away from the adjacent edge portion of the plate 44, the wide open position of the fuel valve will afford a considerably greater opening than the wide open position of the fuel valve when the arcuate cam 112 is adjustably fixed closer to the edge of the plate 44. Hence an adjustment of the cam 112 is equivalent to changing the size of a jet in an ordinary carburetor. It is apparent, however, that the adjustment of the cam member 112 can be made while the engine is running, and does not require any disassembling of the carburetor parts.

The use of an air valve in the air inlet rather than between the mixing chamber and the engine manifold results in the maintenance of a considerable vacuum or suction in the mixing chamber during the operation of the motor, this vacuum varying from a maximum when the motor is idling to a minimum when the air valve 30 is wide open. The level of the liquid fuel within the chamber 21 is preferably regulated by the float 62 so that it is slightly below the level of the orifice of the fuel pipe 65. Thus when the motor is not operating, fuel stands in the pipe 65 almost up to the top of the pipe but does not overflow. When the motor is idling the main air valve 30 is fully closed and a relatively high vacuum is maintained in the mixing chamber 22. If now the accelerator pedal is depressed to speed up the motor, the cam follower 119 is caused to ride over the lug 119, thus momentarily opening the fuel valve 70 a considerable amount just before the main air valve begins to open. The high vacuum in the mixing chamber tends to suck a substantial charge of fuel through the open valve into the mixing chamber. If desired, the effect of the suction may be augmented by extra pressure in the fuel chamber 63 when the accelerator pedal is pressed. To this end a simple plunger pump 140 may be mounted alongside of the fuel chamber 63 so as to communicate with the chamber by a connection 141. The pump 140 is provided with a conventional piston 139 connected by a piston rod 142 and crank arm 143 to the air-valve shaft 31. The connection is such that closing movement of the air valve 30 causes the pump to draw fuel into its barrel from the chamber 63. Opening movement of the air valve results in a discharge of fuel from the pump back into the chamber 63. When the pump is filling, fuel drawn from the chamber 63 is replaced from the bowl 21 through the passage 64. When the pump discharges back into the chamber 63 return through the passage 64 is prevented by a one-way valve such as a simple flap 145. Thus the discharge of the pump builds up pressure in the chamber and tends to force fuel through the jet into the mixing chamber, the amount of fuel forced through the jet depending on the extent of depression of the accelerator pedal. In order to make the pump and carburetor available for motors of different requirements, the pump may be made oversize, the excess fuel discharged therefrom being returned to the bowl 21 by a by-pass 150 which may be regulated as by a set valve 151 (Figure 15).

The carburetor as thus far described is very effective for quick acceleration when gasolene is used as a fuel. An important feature of the invention, however, resides in the provision of apparatus, including the carburetor, for employing fuel oils of a density up to 34° Bé. or so for the operation of ordinary internal combustion motors. Such fuel oils are highly desirable for use in motor-boats, aeroplanes, and the like where escape is difficult in case of fire. Such oils are not easily inflammable as compared with gasolene so that they are much safer in such circumstances. Their lack of volatility, however, makes difficult the use thereof in ordinary gasolene motors. In order to overcome this difficulty, heat is employed to increase the volatility of the oil to such a degree as will facilitate its mixture with

air. It is not enough, however, to form an explosive mixture of such an oil with air since the oil easily condenses if the temperature of the mixture is permitted to drop. After a motor has been operating for some time and has become thoroughly heated up, such condensation is avoided by the heat of the motor itself. The chief difficulty in the way of using heavy oils exclusively as fuel for motors is in the starting of a cold motor. According to the present invention I provide means for heating the fuel before it enters the mixing chamber, and further means for maintaining the explosive charge at a sufficient temperature during its passage through the intake manifold so that it enters the firing chamber in a condition to ignite readily. As hereinafter described, this involves the use of heating devices arranged along the path of the fuel from the carburetor bowl to the explosion chambers. Use of all these heating devices makes possible the starting of a cold motor with heavy fuel oil. When the motor has operated a sufficient time to warm up, some of the heating elements may then be turned off.

The heating element 80 in the fuel chamber 63 is preferably of sufficient heating power to heat the fuel stream passing through the chamber sufficiently to form an explosive mixture in the mixing chamber during the operation of the motor, provided the motor has been previously warmed up by sufficient operation. This heating element is connected to the battery 85 so it may be employed when the motor is being started. The battery is preferably cut out by a suitable relay 90 when the motor is in operation so that the current through the heater 80 is thereafter derived from the generator 87. Since the current delivered from the generator depends to a large extent upon the speed of operation of the motor, the heating current in the element 80 will vary with the speed of the motor and hence will roughly correspond to the rate at which the stream of fuel flows therethrough on its way to the mixing chamber 22. For starting purposes, additional heating elements are necessary. Such elements may include a heating unit 155 mounted in the bottom of the bowl 21 so as to heat the initially cold fuel oil in the bowl before it passes into the fuel chamber 63. In order to prevent immediate condensation of vaporized liquid discharged into the mixing chamber through the jet, I may provide a heating unit 156 consisting of a grid of resistance wire mounted on a suitable gasket 157 which is secured between the carburetor casting and the manifold 25. For prompt starting, I may also employ an additional device 160 preferably attached to the intake manifold as near as possible to the motor valves. This device consists of a small chamber 161 in which is located a heating element 162. Fuel oil is supplied to the device through a supply pipe 163, the oil entering a chamber 164 past a controlling valve 165 which is operated by a solenoid 170. The device also has an air inlet 171 controlled by a valve 172 which is also operated by the solenoid 170. When the device is in operation, an electric current simultaneously opens the fuel valve 165 and the air valve 172 and energizes the heating element 162. The latter is preferably designed to use a considerable current so as to effect a rapid heating action. Thus in a few seconds the small quantity of fuel oil in the chamber 161 is sufficiently heated so that when the motor is turned over by the starter, a charge of hot explosive mixture is sucked directly into the explosion chambers. The distance travelled is so short that condensation is not sufficient enough to prevent immediate action by the motor. This gives the motor a start while the train of heated fluid from the carburetor to the explosion chambers is being set up through the mixing chamber. In employing the heating elements for starting a cold motor, a set of switches 180, 181 and 182 may be mounted in a convenient position such as on the dash board of the car. Before attempting to start the cold motor, the switch 180 may be closed first to heat the fuel in the carburetor bowl. Then the switch 181 may be closed to energize the grid in the gasket between the mixing chamber and the manifold. The switch 182 is then closed so as to heat up a priming charge in the device 160. Lastly, the starter switch 86 is closed, this resulting in the energization of the heating element 80 first by the battery 85, then by the generator 87 when the starting switch is open. When the starting motor turns over the engine, the motion of the pistons creates a suction in the manifold which draws the hot priming charge from the device 160 into one of the explosion chambers. This results in a prompt operating explosion which starts the operation of the motor. At the same time, fuel is drawn through the jet into the mixing chamber, this fuel having been pre-heated by the heating units 155 and 80. In the mixing chamber the heated fuel is mixed with idling air supplied through the passage 24. This mixture is drawn into the manifold past the heated grid 156 which keeps up the temperature of the mixture and prevents undue condensation. By the time the motor has used up the priming charge in the device 160, additional explosive mixture is provided through the mixing chamber and manifold to keep the motor in operation. After the first one or two revolutions of the motor the switch 181 is opened, permitting the valves 165 and 172 to close so that the device 160 is thereafter inoperative until it is needed again for starting the motor. After the motor has warmed up sufficiently to prevent condensation of the fuel in the manifold, the switch 182 may be opened. The carburetor bowl 21 is preferably mounted near the exhaust manifold of the motor so that after the motor has been operating a short time heat from the exhaust manifold warms the carburetor thus making unnecessary further use of the heating element 155. Thus a cold motor may be successfully started on heavy fuel alone.

In addition to the desirability of heavy fuel oils on account of their comparative safety and freedom from fire hazard, such oils are also desirable because of their relatively low cost. In cases where the question of fire hazard is not of paramount importance, as in the case of automobiles, the starting of a cold motor is more readily accomplished by the use of a small amount of gasolene for priming, gasolene being admitted into the manifold to mix with the fuel charges until the motor has warmed sufficiently to operate on the heavier fuel oil alone. For such purposes, I may employ in the place of the priming device illustrated in Figure 12, a priming device for admitting gasolene as illustrated in Figure 13. This may consist of a needle valve 190 pressed by a suitable spring 191 into a normally closed position in which it shuts off a supply pipe 192 from communicating with a jet 193 leading into the manifold 25. An operating stem 195 is connected to the valve 190, this stem being connected by a

suitable flexible wire (not shown) to an operating handle on the dash board by which the needle valve may be opened. In starting the motor, the operating handle is manipulated to open the needle valve 190, thus permitting the motor to suck gasolene directly into the manifold when the motor is started. This results in a prompt starting of the motor. The gasolene may be permitted to enter the manifold until the engine is warm enough to operate on the heavier oil without the admixture of gasolene.

A somewhat modified structure is illustrated in Figure 16, in combination with a fuel pump for supplying fuel to the carburetor at a positive pressure of substantial magnitude. As shown, the general structure of the carburetor may be substantially as illustrated in Figure 8, except for the omission of the Venturi throat in the mixing chamber and the float and float valve in the carburetor bowl. The fuel is drawn from the tank (not shown) through a pipe 200 into a sediment collector 201, and thence is pumped by a suitable pump 202 through a pipe 60 and strainer 205 to discharge through a pipe 206 into the lower portion of the bowl 21. This bowl serves as an air dome to smooth out the impulses of the delivery pump 202.

The pump 202 is preferably of a type designed to maintain a definite predetermined pressure within the bowl 21. As shown, it may consist of a flexible diaphragm having a stiff central plate 211 abutted by a compression spring 212 of suitable stiffness, depending on the magnitude of the pressure to be maintained in the bowl 21. The plate 211 is secured to a plunger 215 which in turn is connected by toggle links 216 and 217 to the end of a rocking lever 220 pivotally mounted as at 221, the further end of the lever 220 bearing on an eccentric cam 222 mounted on a cam shaft 223. The lever is held against the cam as by a spring 225. The pump is equipped with the usual set of check valves 226 and 227. In operation, the plunger 215, and hence the diaphragm, is operated downwardly by the rocking lever 220, but is moved upwardly only by the spring 212. When sufficient pressure is built up in the bowl 21 to resist the pressure of the spring 212, the diaphragm is held in its lower position by the pressure, and the lever 220 rocks idly. The pressure in the bowl 21 extends to the jet at the upper end of the fuel pipe 65 so that action of the suction in the mixing chamber on the fuel in the pipe 65 is augmented by the positive pressure in the bowl 21. The suction in the manifold varies according to operating conditions in the motor, and depends chiefly on the amount of opening of the air valve 30. When the motor is idling, the pressure in the manifold may be from 9 to 10 pounds below atmospheric. By the use of the fuel pump, this effect of the suction may be augmented by 5 pounds or so of positive pressure in the bowl 21. Other pressures may be had as desired by the use of a spring 212 of corresponding stiffness. When positive pressure is thus maintained in the bowl 21, the rate of flow of fuel through the orifice of the fuel pipe 65 is dependent to a greater degree on the position of the plug valve 70, and to a lesser extent on the magnitude of the suction in the mixing chamber. Hence an ordinary butterfly disk valve 230 may be employed in the main air inlet.

In view of this augmented pressure-difference between the mixing chamber and the interior of the fuel pipe 65, the valve 70 must be set downward nearer its seat for optimum operation. This results in a very fine clearance around the valve 70 which, in conjunction with the high pressure difference forcing the fuel through this clearance, results in a more effective breaking up of the fuel into extremely fine droplets. This is of great practical importance as the performance of the motor appears to depend in large measure on the fineness of the droplets of liquid fuel delivered into the intake manifold.

It should be understood that the invention is not to be limited to the specific embodiments thereof herein described and illustrated but may include various modifications and changes of structure coming within the spirit or scope thereof as defined by the following claims.

What I claim is:

1. In a carburetor, a housing containing a mixing chamber and a main air inlet, a fuel supply duct terminating in an orifice located centrally in said chamber, a parabolic plug valve in said orifice, a butterfly valve in said air inlet shaped and mounted so that when rocked from its closed position, it blocks the air inlet completely during the initial portion of the rocking movement, then opens an aperture first gradually, then more rapidly, an auxiliary air duct of adjustable fixed capacity leading into said mixing chamber, and adjustable means correlating the operation of said air valve and fuel valve.

2. In a carburetor, a housing containing a mixing chamber and a main air inlet, a fuel supply duct terminating in an orifice centrally located in said chamber, a plug valve in said orifice, an auxiliary air duct opening into said chamber adjacent to said fuel orifice, a butterfly valve rockable upon an axis in said main air inlet, said butterfly valve including a pair of spherical sectors on opposite sides of its axis to fit closely against the wall of the inlet when the valve is closed or nearly closed, said sectors each having a flaring recess in the face thereof whereby as the valve is rocked on its axis from the closed position, the area of opening increases very gradually at first, then more rapidly, and means for simultaneously operating the air and fuel valves.

3. In a carburetor having a mixing chamber and a main air inlet, an air valve in said inlet rockable on an axis, a valve-operating member rockable on the same axis and having a lost-motion connection with said air valve, a cam carried by said member, a fuel supply duct leading into said chamber, a fuel valve in the discharge orifice of said duct, operating means for said fuel valve including a follower cooperating with said cam to open said fuel valve during the operation of the air valve operating means to take up the lost motion in said connection.

4. In a carburetor having a mixing chamber and a main air inlet, an air valve in said inlet rockable on an axis, an air valve operating member rockable on said axis, a fuel supply duct leading into said chamber, a fuel valve in the discharge orifice of said duct, and fuel valve operating means including an adjustable cam carried by said air valve operating member, and a cam follower operatively connected with said fuel valve, said cam being shaped for an opening and closing movement of the fuel valve during the initial portion of the operation of the air valve operating member, said cam being adjustable to vary the rate of opening movement of the fuel valve during the remainder of the operating stroke of the air valve operating member.

5. In a carburetor having a mixing chamber

and a main air inlet, an air valve in said inlet rockable on an axis, an air valve operating member rockable on said axis, a fuel duct leading into said chamber, a fuel valve in said duct, means for operating said fuel valve including an adjustable cam carried by and movable with said member, said cam having a projecting portion extending radially from said axis and a portion increasing gradually in radial distance from the axis, said fuel valve operating means also including a cam follower bearing against said cam, said cam follower having a yielding portion adapted to ride operatively on the projecting portion of the cam when the air valve is being opened, and to move inoperatively past said projecting portion of the cam when the air valve is being closed.

6. In a carburetor, a housing containing a mixing chamber and a main air inlet, a butterfly valve rockable in said inlet, a rock shaft carrying said valve and projecting through the wall of said casing, a disk mounted on the projecting portion of said shaft, an auxiliary disk coaxial with the first disk and adjustably secured thereto, an operating member loosely rockable on said shaft, a resilient lost-motion connection between said operating member and said auxiliary disk, a fuel supply duct leading into said chamber, a valve in said duct, and means responsive to rocking movement of said operating member for operating said fuel valve.

7. In a carburetor, a housing containing a mixing chamber and a main air inlet, a butterfly valve rockable in said inlet, a rock shaft carrying said valve and projecting through the wall of said casing, a disk mounted on the projecting portion of said shaft, an auxiliary disk coaxial with the first disk and adjustably secured thereto, an operating member loosely rockable on said shaft, a resilient lost-motion connection between said operating member and said auxiliary disk, a fuel supply duct leading into said chamber, a valve in said duct, means operatively connected to said shaft for injecting fuel into said chamber through said duct under pressure in response to rotative movement of said shaft in a direction to open said butterfly valve, and means responsive to rocking movement of said operating member for operating said fuel valve.

8. In a carburetor having a mixing chamber and a main air inlet, a fuel supply duct opening into said chamber, said duct including a pipe of substantial internal diameter terminating at an orifice in said chamber, a parabolic plug valve in said orifice, means for moving said valve from and toward said orifice, and means for keeping the axis of the plug substantially aligned with the axis of said pipe, said last-named means including a stem projecting from the inner end of said plug, and guiding vanes on said stem loosely engaging the inner surface of said pipe.

9. In a carburetor having a mixing chamber and a main air inlet leading to said chamber, an air valve in said inlet, a fuel supply duct including a pipe of substantial diameter terminating in an orifice located in said mixing chamber, a parabolic plug valve adapted to seat in said orifice, operating means for said air valve, operating means for said fuel valve including a cam member movable by said air valve operating means to move the fuel valve through an operating stroke from closed to open position, said cam member being adjustable to change the pitch of the cam whereby the stroke of the fuel valve is adjustably altered.

10. In combination, a carburetor comprising a housing containing a mixing chamber and a main air inlet, a valve in said main air inlet, a fuel supply duct having a discharge orifice in said mixing chamber, an auxiliary air-duct leading into said chamber and terminating in an orifice adjacent to said fuel orifice, a valve element of the plug type projecting into the orifice of said fuel duct, and means for maintaining in said fuel duct a pressure substantially greater than atmospheric.

11. In combination, a carburetor comprising a housing containing a mixing chamber and a main air inlet, a valve in said main air inlet, a fuel supply duct having a discharge orifice in said mixing chamber, an auxiliary air-duct leading into said chamber and terminating in an annular orifice surrounding said fuel orifice, a valve of the plug type projecting into said fuel orifice, means for adjusting the clearance of said plug valve for its idling position, and means for maintaining in said fuel duct a predetermined pressure substantially greater than atmospheric.

ERL V. BEALS.