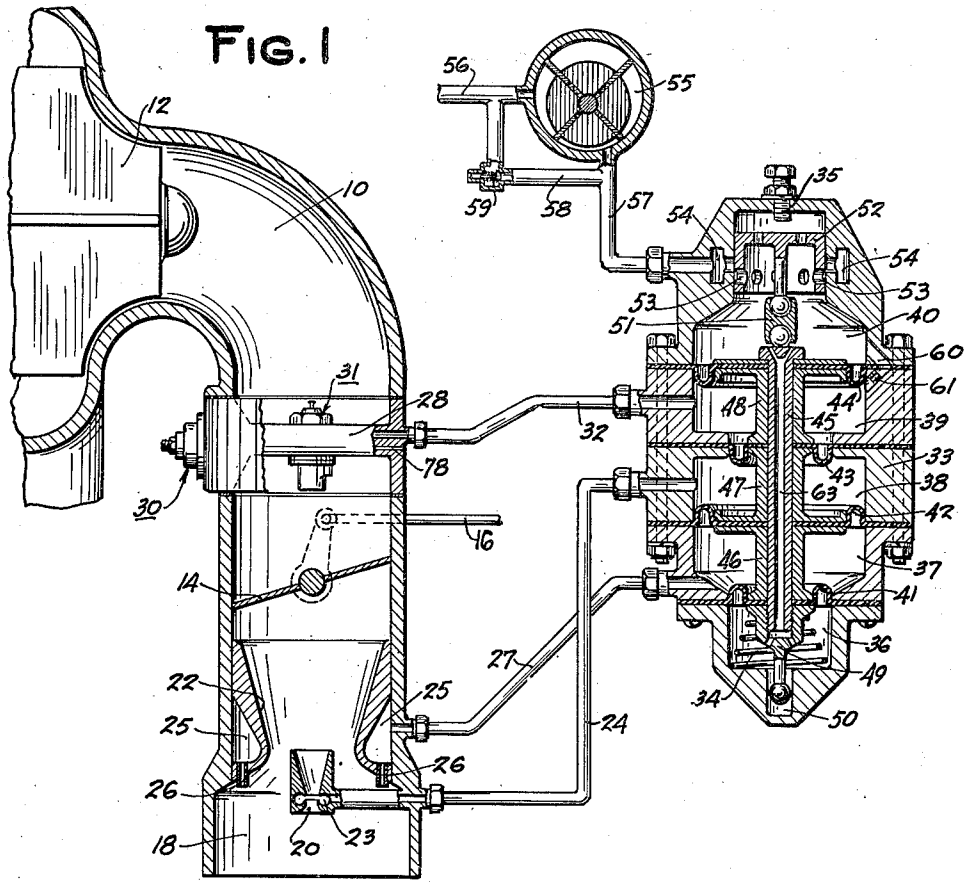
May 6, 1941. E. J. PARTINGTON 2,240,515

CHARGE FORMING DEVICE

Filed April 1, 1938

FIG. 1



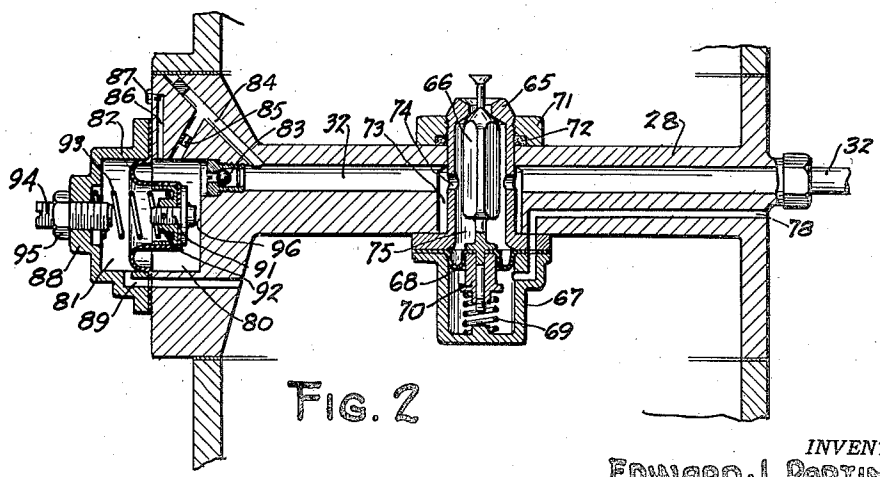




FIG. 2

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Patented May 6, 1941

2,240,515

# UNITED STATES PATENT OFFICE

2,240,515

## CHARGE FORMING DEVICE

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Application April 1, 1938, Serial No. 199,325

11 Claims. (Cl. 261—34)

This invention relates to carburetors and more particularly to carburetors of the pressure feed type disclosed in F. C. Mock application No. 118,718, filed January 2, 1937. The invention is more particularly concerned with provision of means for temporarily supplying the engine with additional fuel during periods of acceleration.

In all types of carburetors, including the pressure feed type mentioned above, an increase in the rate of air flow resulting from rapid opening movement of the throttle does not immediately produce a corresponding increase in the rate of fuel flow. This slight lag in fuel delivery accompanying a sudden opening of the throttle results in a temporary leanness of the mixture. In order to overcome this temporary leanness it has been common practice to use a piston type pump directly operable by the throttle shaft and so arranged that a small amount of extra fuel is immediately forced into the air stream as the throttle is opened.

Acceleration pumps of this type have several inherent disadvantages. The necessary kinematic relationship between the throttle and the pump is difficult to obtain in the design of some carburetors; the piston and the linkage are susceptible to wear; and the mechanical linkage between the throttle and the piston is especially hazardous in aircraft use since any sticking or jamming of the piston locks the throttle.

It is an object of the invention to provide improved means whereby the tendency for the mixture ratio to be temporarily lean immediately following an opening of the throttle is overcome.

It is a further object to provide a so-called acceleration pump having greater accessibility so that the pump capacity can be readily adjusted.

Further objects and advantages of the invention will be apparent from the following description, taken in connection with the accompanying drawing, in which:

Figure 1 is a diagrammatic sectional view of a device embodying the invention; and

Figure 2 is an enlarged sectional view taken through the nozzle adapter bar, the discharge nozzle, and the acceleration pump of Figure 1.

Referring more specifically to Figure 1, the carburetor proper comprises an induction passage 10 leading to a supercharger 12 of an internal combustion engine of any desirable type. The passage 10 is controlled by a throttle 14 operable by a rod 16 extending from the pilot's cockpit or driver's compartment. The operator therefore directly controls the air charge to the engine while the fuel charge is automatically controlled by the apparatus hereinafter described.

Anterior to the throttle 14 is an air inlet or scoop 18 leading to a primary venturi 20 located in series with a secondary venturi 22. Primary venturi 20 is formed with an annular chamber 23 opening into the venturi in the vicinity of the Venturi throat and communicating through pressure conduit 24 with the control unit hereinafter described. The secondary venturi 22 is formed with an annular chamber 25 communicating through a plurality of tubes 26 with the air scoop 18 and through pressure conduit 27 with said control unit.

Posterior to the throttle 14 is an adapter bar 28 in which is mounted an acceleration pump assembly indicated generally at 30 and a fuel discharge nozzle indicated generally at 31, both of which receive fuel from the control unit through a fuel passageway 32.

The control unit comprises a hollow casing 33, which may be formed from a plurality of die-cast sections, assembled and secured together as shown. The interior of the casing is divided into five chambers 36, 37, 38, 39 and 40 by four flexible diaphragms 41, 42, 43 and 44 each of which has its outer edge clamped between adjacent sections of the casing to form a fluid-tight gasket, and its central portion apertured and secured to a control rod 45 by means of hubs 46, 47 and 48 having flanges at their ends which clamp the diaphragms between them and limit flexure thereof to an annular looped portion between the flanges and the casing, which permits vertical movement of the control rod 45. The hubs and diaphragms are held in assembled relation on the control rod by means of a threaded cap 49 which terminates in a spherical end slidably movable in a recess 50 at the lower end of the casing, thus forming a guide bearing for the control rod assembly. A spring 34 in recess 36 yieldingly urges the rod upwardly as shown.

The upper end of the control rod is connected through a double ball-and-socket universal joint 51, with a fuel valve 52 of the sleeve type having ports 53 controlling the admission of fuel to the upper chamber 40. An adjustable stop 35 limits upward movement of the control rod and valve 52. An annular fuel chamber 54 surrounds the valve 52, and has an annular groove adapted to register with the ports 53. Any commercial fuel pump arranged to deliver fuel at substantially constant pressure may be used to deliver fuel to said fuel chamber 54, the one shown at 55 being of a rotary type having a

fuel inlet 56, fuel outlet 57 and a bypass channel 58 controlled by a pressure responsive valve 59.

The diaphragms used in the control unit are preferably formed of material such as silk fabric impregnated with Neoprene or other artificial rubber compound. Such diaphragms have very little inherent resiliency.

In the operation of the device as thus far described, fuel is delivered at substantially constant pressure to fuel chamber 54, whence it flows through ports 53, the effective area of which is controlled by the axial movement of control rod 45, into the unmetered fuel chamber 40, and thence through a passageway 60 containing metering orifice 61, into the metered fuel chamber 39, and thence through passageway 32 to the discharge nozzle 31. Unmetered fuel chamber 40 also communicates, through a longitudinal passageway 63 in the control rod 45 and cap 49, with chamber 36, so that the pressures in the two chambers are at all times equal.

Chamber 37 communicates through passageway 27 with the annular chamber 25 in the secondary venturi and is therefore subjected to the pressure existing in the air scoop 18. Chamber 38 communicates through passageway 24 with the annular chamber 23 in the primary venturi 20 and is therefore subjected to the pressure existing at the throat of said venturi. The differential in pressure between air scoop and Venturi throat is proportional to the square of the rate of air flow. These two pressures acting on opposite sides of diaphragm 42 create a net force on the control rod which is also proportional to the square of the rate of air flow and is in a direction tending to open the ports 53 in slide valve 52 and increase the quantity of fuel flowing through the control unit to the nozzle as the rate of air flow increases.

Flow of fuel from chamber 40 through passageway 60 and restriction 61 into chamber 39 results in a pressure drop across said restriction which is proportional to the square of the quantity of fuel flowing. The difference in pressures acting on opposite sides of diaphragm 44 in chambers 40 and 39 creates a net force on the control rod which is proportional to the square of the rate of fuel flow and is in a direction tending to close valve ports 53 as the rate of fuel flow increases, thereby opposing the previously mentioned force generated by air flow. As a result, for any given conditions of operation, the control rod assembly and attached valve 52 will move to a position such that the respective forces are in equilibrium. Each of the four pressures utilized (unmetered fuel pressure, metered fuel pressure, Venturi depression, and air scoop pressure) acts in one direction on a large diaphragm and in the opposite direction on a small diaphragm, the net force in each case being $P(A-a)$, where P is the unit pressure, and A and $a$ are respectively the areas of the large and small diaphragms. In this way the square of the fuel flow is maintained in constant proportion to the square of the air flow, and hence the mixture ratio, that is the ratio of the weight of fuel to the weight of air, is maintained at a constant value unless altered by extraneous means such, for example, as those disclosed in F. C. Mock application Serial No. 118,718.

The discharge nozzle and acceleration pump are shown in detail in the enlarged sectional view, Figure 2, taken through the adapter bar 28.

The discharge nozzle assembly comprises a nozzle body 65, valve 66, cap 67, diaphragm 68, compression spring 69 and nut 70, and is held securely in place in the adapter bar by retaining nut 71 and packing 72. Fuel under pressure is received from the control unit through passageway 32 whence it flows into annular fuel chamber 73 and through ports 74 into chamber 75, where its pressure is exerted upon diaphragm 68 to cause valve 66 to move off its seat against the action of the compression spring and thereby allows the fuel to discharge into the conduit 10. Nozzle cap 67 is vented to the atmosphere (or to the air scoop in installations wherein the air scoop pressure differs materially from atmospheric) through passageway 76. Spring 69 is generally so designed that only a relatively slight rise in fuel pressure in chamber 75 acting on diaphragm 68 is required to vary the valve from closed position to wide open position, and the nozzle therefore maintains the discharge pressure of the fuel very nearly constant. The value of pressure at which the valve begins to open can be readily varied in design by varying the initial tension of the spring in the closed valve position. In place of the specific nozzle disclosed herein, any of the nozzle arrangements disclosed in Mock-Partington application Serial No. 243,067, filed November 30, 1938 may be utilized. In one arrangement disclosed in said application, the nozzle cap 67 is vented to Venturi depression, with the result that when the throttle is suddenly opened the depression increases and draws valve 66 open. The acceleration pump 30 in such case may not actually increase the pressure of fuel in chamber 75, but instead may merely counteract, partially or completely, the tendency of the fuel pressure to drop when the valve 66 opens under increased Venturi depression. Nevertheless, since it increases the fuel pressure over what it would otherwise be, the action is for convenience referred to as increasing the fuel pressure.

The acceleration pump comprises two chambers 80 and 81 separated by a flexible diaphragm 82. The chamber 80, formed as a cylindrical recess in the wall of the section of air conduit containing the nozzle adapter bar, communicates with fuel passage 32 through a check valve 83 which is so arranged that fuel can be forced from chamber 80 into passageway 32 but is prevented from flowing through the check valve in the reverse direction. Chamber 80 also communicates with passageway 32 through a channel 84 which forms a bypass around the check valve 83. A relatively small orifice 85 placed in said channel highly restricts the rate of flow of fuel therethrough irrespective of the direction of flow. A passageway 86 connecting the uppermost portion of chamber 80 with atmosphere is provided for bleeding entrapped air from the unit during or just previous to the first period of operation. During normal operation, channel 86 is sealed by a plug 87.

Chamber 81 is formed by a cap 88 secured to the exterior end of the adapter bar, and is vented through a passageway 89 to the interior of the conduit 10 posterior to the throttle 14 and is therefore subjected to supercharger inlet depression.

Diaphragm 82 is secured at its central flat portion between a flat-headed bolt 91 and a nut 92 having an annular groove adapted to receive one end of a compression spring 93. A set screw 94, held in position by a locking nut 95, serves as an adjustable stop to limit the travel of the diaphragm to any desired value. Bolt 91 striking the conduit wall at 96 serves as a stop for the diaphragm in the opposite direction of travel.

Spring 93 may be so designed that with normal fuel discharge pressure acting in chamber 80 a depression of about 7" of mercury is required in chamber 81 to just make the diaphragm move clear of the stop 96, and a depression of about 16" of mercury is required to compress the spring to a point where the diaphragm is against the stop 94. These values, however, are given merely for purpose of illustration and should not be construed to mean the exact values to be used in any installation.

Assume that the engine is operating at relatively low speed and light load, the throttle being partially closed and a high degree of vacuum being present in the conduit 10 posterior to the throttle. Said vacuum acting in chamber 81, together with the normal fuel pressure acting in chamber 80, will draw diaphragm 82 to the left, drawing fuel through bypass 84 into chamber 80, until further movement of the diaphragm is arrested by stop 94. The acceleration pump is then fully charged. If the throttle is then suddenly opened, as for a quick acceleration, the depression at Venturi throat 23 increases, causing the control rod assembly and attached slide valve 52 to move upwardly, opening the valve ports 53. This movement of the control rod assembly decreases the volume of chamber 40 and increases the volume of chamber 39. Part of the fuel flowing through the metering orifice 61 during and immediately following the change in position of the control rod is utilized in caring for the increased volume of chamber 39 and hence is not discharged from the nozzle. This effect, in itself, gives a temporary insufficiency of fuel passing to the nozzle and would result in a temporary leanness unless means such as the acceleration pump were provided to overcome this leanness.

When the throttle is suddenly opened, however, the pressure posterior to the throttle valve immediately rises to a value approaching atmospheric pressure, and the resulting loss of suction in chamber 81 results in spring 93 suddenly forcing the diaphragm 82 toward the stop 96, thereby forcing fuel from chamber 80 through check valve 83, and a small amount through restriction 85 and channel 84, into channel 32. This sudden flow of fuel into channel 32, under greater than normal discharge pressure, increases the pressure in said channel and in the nozzle chamber 75, thereby causing nozzle valve 66 to open to a wider position and resulting in an immediate but temporary additional discharge of fuel to compensate for the leanness which would otherwise exist, and if necessary supplying sufficient additional fuel to overcompensate and give a temporary richness during the acceleration period. The quantity of fuel so discharge by the acceleration pump can be readily adjusted with the stop screw 94 so as to supply the proper quantity of fuel to obtain best acceleration. Other characteristics of the acceleration pump may be varied by varying the stiffness of spring 93 and the effective cross-sections of passages 84 and 89.

If the throttle is now brought back to its closed position, a high vacuum will obtain in the conduit 10 posterior to the throttle and hence in chamber 81, which will draw the diaphragm assembly back against the stop 94 and refill chamber 80 with fuel drawn from passage 32. Since the fuel flowing from the control unit into passage 32 is metered in proportion to the air flowing through the conduit, any fuel flow into chamber 80 results in a decreased quantity discharged from the nozzle, and hence in a deficiency of gasoline discharged into the air stream. If chamber 80 were allowed to fill rapidly with fuel the nozzle would be so severely "robbed" that the temporary ratio of gasoline and air reaching the engine would be excessively lean, tending to make the engine misfire. Check valve 83, however, prevents flow of fuel therethrough from passageway 32 into chamber 80, and therefore fuel flow in this direction is solely through passageway 84 and restriction 85, which so restricts the rate of fuel flow that the nozzle "robbing" effect is decreased to a value which will not interfere with the engine operation.

It has been found that certain engines require so small an acceleration pump charge that "robbing" of the nozzle following a closing of the throttle is of negligible proportion. In installations on engines of this character, check valve 83 and bypass channel 84 with restriction 85 can be omitted, thereby allowing unrestricted communication between passageway 32 and chamber 80.

In the description of the several embodiments of the invention, the terms "upward" and downward" have been used for convenience, but it will be understood that the control mechanism may be inverted relative to the carburetor, or the control unit and carburetor may both be inverted relative to the engine, or the engine and all its accessories may be inverted (as in acrobatic flight) without greatly affecting the operation as above described. In other words, the device is substantially unaffected by forces of gravity and acceleration, and is therefore especially suitable for inverted or acrobatic flight.

Although the invention has been described with specific reference to a certain embodiment thereof, it should not be inferred that it is limited thereto nor otherwise except in accordance with the following claims.

I claim:

1. A charge forming device for internal combustion engines comprising means forming an induction passage leading to the engine, a throttle controlling said passage, a fuel nozzle discharging into said passage, means for supplying fuel to said nozzle under pressure including a valve, a fuel metering orifice, a metered fuel chamber receiving fuel through the orifice and communicating with the nozzle, said chamber having a movable wall connected to said valve whereby the volume of the chamber increases when the valve is opened to correspond to an increased throttle opening, and an expansible fuel chamber communicating with the nozzle and controlled by pressure in the induction passage posterior to the throttle to reduce its volume when the throttle is opened to compensate for the increase in volume of the metered fuel chamber.

2. A charge forming device for internal combustion engines comprising means forming an induction passage leading to the engine, a throttle controlling said passage, a fuel nozzle discharging into said passage, means for supplying fuel to said nozzle under pressure including a valve, a fuel metering orifice, a metered fuel chamber receiving fuel through the orifice and communicating with the nozzle, a movable wall in said chamber connected to the valve whereby the chamber expands to increase its volume when the valve is opened to correspond to an increased throttle opening, a fuel chamber communicating with the nozzle and closed on one side by a mov-

able wall, resilient means urging the wall in a direction to decrease the volume of the fuel chamber, and a connection from the opposite side of the wall to the induction passage posterior to the throttle to urge the wall in a direction to increase the fuel chamber volume in response to vacuum in the induction tube, said wall moving to decrease the volume of the fuel chamber when the throttle is opened to compensate for the increase in volume of the metered fuel chamber.

3. In a charge forming device having a throttle controlled induction passage, a fuel duct receiving fuel from a source of fuel under pressure and discharging in said induction passage and having a metering restriction, unmetered and metered fuel chambers communicating with said duct respectively anterior and posterior to said restriction, a fuel valve controlling the flow of fuel through said duct, and movable wall means in said fuel chambers connected to said valve and arranger such that the volume of the metered fuel chamber increases upon opening movement of the fuel valve as an incident to the opening movement of the throttle: the combination therewith of an acceleration pump to compensate for the increase in the volume of the metered fuel chamber comprising a fuel chamber communicating with said duct, a variable pressure chamber connected to the induction passage posterior to the throttle, and a spring loaded pumping diaphragm separating said acceleration pump chambers for pumping fuel to the induction passage upon increase in pressure in the induction passage.

4. In a charge forming device having an induction passage controlled by a throttle, a fuel duct leading from a source of fuel to the induction passage, a valve in said duct, a fuel chamber in said duct having a movable wall connected to said valve and arranged such that opening movement of the valve corresponding to an opening movement of the throttle increases the volume of the fuel chamber: the combination therewith of an ecceleration pump having a fuel chamber receiving fuel from said duct, a variable pressure air chamber connected to the induction passage posterior to the throttle, and a spring loaded pumping diaphragm separating said chambers for pumping fuel to the induction passage upon increase in pressure in the induction passage accompanying opening movements of the throttle.

5. In a charge forming device having an induction passage controlled by a throttle, a fuel duct leading from a source of fuel under pressure to the induction passage posterior to the throttle, and a valve responsive to fuel pressure controlling the discharge of fuel from said duct: the combination therewith of an acceleration pump comprising a fuel chamber communicating with said duct, a variable pressure chamber connected to the induction passage posterior to the throttle, a spring loaded pumping diaphragm separating said chambers and arranged to forcefully displace fuel upon sudden rise in pressure in the variable pressure chamber to temporarily increase the pressure of the fuel supplied to said pressure responsive valve.

6. The invention defined in claim 5 wherein the pumping diaphragm has an annular groove preformed therein.

7. The invention defined in claim 5 comprising in addition an adjustable stop for limiting the movement of said pumping diaphragm.

8. In a charge forming device for an internal combustion engine having an induction passage, a throttle controlling the same, a fuel nozzle discharging in said induction passage posterior to the throttle, a pressure responsive valve controlling said nozzle, and a control unit responsive to the rate of air flow through the induction passage for supplying fuel to said nozzle comprising an unmetered fuel chamber receiving fuel under pressure, a metered fuel chamber supplying fuel to said nozzle, a calibrated passage connecting said chambers, a fuel control valve, and movable wall means in said chambers for actuating said valve: in combination therewith of an acceleration pump including a fuel chamber communicating with the metered fuel chamber of the control unit, a suction chamber connected to the induction passage posterior to the throttle, a spring loaded pumping diaphragm separating said fuel and suction chambers and arranged to forcefully displace fuel from the acceleration pump fuel chamber upon a rise in pressure in the suction chamber.

9. The invention defined in claim 8 wherein the communication between the acceleration pump fuel chamber and the metered fuel chamber comprises parallel passages, one of said passages being provided with a check valve and the other with a restricted orifice.

10. In a charge forming device having an induction passage, a throttle therein, a fuel nozzle discharging fuel under superatmospheric pressure into the induction passage, a source of fuel under pressure, a fuel conduit connecting said source and the nozzle, and a control unit in said conduit for normally controlling the flow of fuel to said nozzle in response to the air flow through the induction passage and including a metering orifice: in combination therewith of a diaphragm forming a portion of the wall of said conduit posterior to the metering orifice, means for subjecting the other side of said diaphragm to a pressure derived from the induction passage posterior to the throttle whereby said diaphragm is moved in a direction to increase the volume of said fuel conduit in response to a decrease in said pressure, and a spring urging said diaphragm inwardly whereby the volume of said fuel conduit will be suddenly reduced upon a rise in pressure in the induction passage posterior to the throttle accompanying a rapid opening movement of the throttle.

11. The invention defined in claim 10 comprising in addition an adjustable stop for limiting the movement of said diaphragm.

EDWARD J. PARTINGTON.