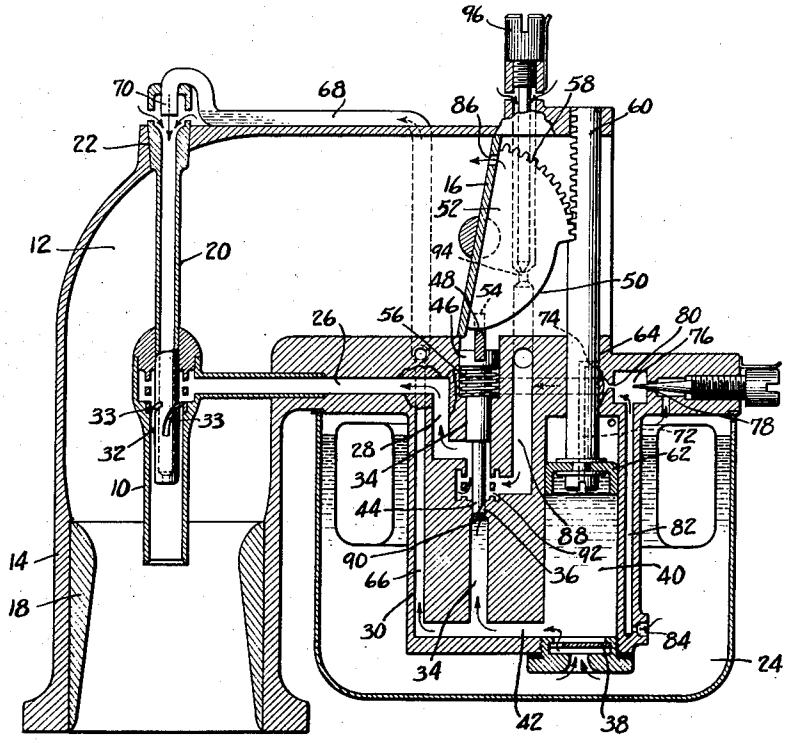
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ANTERIOR THROTTLE CARBURETOR

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ANTERIOR THROTTLE CARBURETOR

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My invention relates to means for and methods of proportioning the fuel and air and forming homogeneous charge mixtures for internal combustion engines, and particularly to anterior throttle carburetors, such as disclosed in my copending applications Serial No. 525,992, filed March 28, 1931, and Serial No. 591,040, filed February 5, 1932, in which the throttle controls passage of air only, and is located ahead of the point of fuel discharge into the air stream passing from the atmosphere to the engine.

Anterior throttle carburetors have frequently been proposed, but prior to my invention have not gone into practical use because of failure to meet certain of the highly varied conditions of internal combustion engine operation, and particularly those encountered in motor vehicle engines.

A principal object of the invention is to provide an anterior throttle carburetor which meets the various conditions and requirements of operation of such engines throughout the entire speed and load ranges, which responds practically instantaneously to changes from one to another of such conditions, which enables operation at low speeds without stalling, and which is simple, compact and inexpensive. Other objects will appear from the following description.

The depression on the fuel nozzle for effecting fuel delivery is preferably increased as compared to general intake depression by means of a Venturi effect thereon, which is particularly useful in promoting fuel flow at low speed operation and especially at full load, low speed operation calling for good power mixtures. Such venturi need not be highly constricted.

It will be observed that except at the minimum depression at low speed operation, there is always much more depression available at the fuel nozzle than needed to raise fuel, and that, with the exception at low speeds productive of minimum depressions, which has been noted, the fuel can be efficiently metered even though only a small part of the available depression is made use of for such purpose.

The fact that depression varies directly with the engine speed is favorable to use of the depression to produce fuel flow, since both vary in the same direction and no change or reversal of direction is called for. All that is called for is to so regulate or control relations between depression changes due to speed and load changes and the flow of fuel as to secure proper consonance therebetween throughout the various phases of engine operation.

By interconnecting the air throttle and a metering pin for metering the fuel flow through a metering orifice therefor, I can avoid any unfavorable effect due to the fact that changes in depression arising from throttling or progressive restriction of the principal air passage are inversely related to fuel requirements, and furthermore by using point-to-point control, such as a cam contour for such interconnection, I can have the fuel metering orifice openings for part load air passage openings such that good economical mixture ratios can be had during part load operation. Such economical part load operation is rendered possible by the fact that at part throttle operation, power mixtures are not needed, since the throttle can always be opened more to get additional power, and such economy part load operation is rendered desirable by the fact that the major part of operation, (particularly motor vehicle engine operation) takes place at part load, wherefore economical engine operation under such operating conditions is important because reflected in useful saving of fuel.

However, if the full depression be utilized under all conditions for producing fuel flow, and particularly if the regulable fuel passage orifice or port be annular, a point of throttle movement toward a closed position will be reached, which gives a fuel metering orifice of such restriction that friction of the fuel on the walls of the small orifice required to pass the required fuel for the current depression value will be productive of unevenness of flow. This is particularly noticeable, and may be even cumulative in character, with an annular fuel metering passage, and even with the concentrated or integrated form of fuel passage as employed in the present invention, such as can be obtained for example with the use of a metering pin with a working fit in the circular passage, and with a slab or tapered cut taken from one side of the end thereof, there will not be entire freedom from frictional interference with smooth and even fuel flow when the depression rises towards its higher values.

If under such circumstances, less than the current depression be utilized for getting the fuel through the metering orifice, it becomes possible to increase the corresponding fuel orifice area, and secure the passage of the desired fuel without material frictional interference with its flow, since the fuel which will be passed is always substantially a simple function of the product of the fuel orifice area and the depression to which same is subjected.

I find that a desirable way to so reduce the depression utilized for producing fuel flow is by

opening up a communication from the atmosphere to the fuel conduit leading from the fuel metering orifice to the fuel discharge point in the Venturi throat, whereby the metering orifice is subjected to a flow of primary air in sufficient quantity to allow at the highest depression the use of maximum metering orifices while keeping the fuel flow within economical mixture ratios and preventing at engine idling and other low speeds undesirable speeds due to the introduction of too much primary air. The reduction of depression by primary air introduction allows the fuel metering orifices to be kept large, particularly with the slab form of fuel passage opening, to pass the required fuel through the metering orifice without troublesome and uneven frictional effects on the fuel flow.

Full load operation is different from all other operation of the engine, not only because at full load, low speed the depression is minimum, just when the higher power mixture ratio is needed, but also because good power mixture ratios are wanted throughout substantially the entire speed range at full load, and this must be effected without further opening of the throttle, or of the metering orifice, to further increase the power. At this stage of operation the fuel metering orifice is of maximum area to supply the fuel required for maximum power, and even at low depression is not appreciably subjected to unfavorable frictional coefficients.

The venturi initially helping to get sufficient fuel at full load low speed, is also useful throughout the remainder of the full load speed range because of its making available ample depression for causing fuel flow duly metered by the venturi in accordance with the air velocity for producing a full power mixture ratio, and the primary air opening to the fuel conduit can be adjusted so that either the whole or a part of available depression that is used for producing fuel delivery can be utilized to cause a desired fuel flow throughout the full load speed range.

The primary air inlet into the fuel conduit is preferably located below the fuel level. The fuel metering orifice is also preferably so located that it is submerged a material distance below the fuel level in the float chamber. With this arrangement, and with submergence of the inlet from the primary air conduit to the fuel conduit to about the same extent as the fuel metering orifice is submerged, at times of minimum or substantially minimum depression, the fuel will rise in the fuel conduit, and by submerging the communication from the primary air passage to the fuel conduit will block up or shut off the access of primary air, whereupon the fuel flow through the conduit takes place with this hydrostatic effect in just the same way as if the primary air passage had been closed off by a valve or like arrangement, so that at full load, low speed, or at a given depression sufficiently low at other throttle positions, the full depression is used for supplying fuel. As soon, however, as the depression rises, as for example, by increase of speed, this hydrostatic valving effect ceases and the admission of air is allowed. The depression at which the primary air passage dumps may vary with different engines and depends on the amount of submergence thereof. For example, in certain embodiments of the invention the primary air passage may be made to dump at 1" of H_2O more or less.

The delivery of fuel at low depressions in the venturi when the admission of primary air is closed off hydrostatically is also enhanced in the downdraft carburetor of the type herein disclosed by a syphoning action. This is effected in a downdraft carburetor by the provision of a substantially inverted U-shaped fuel passage having the shorter arm thereof extending upwardly above the fuel level from a point below, and the longer arm extending downwardly into the venturi at a point below the fuel level. This syphoning effect is controlled by the hydrostatic action above described, and is effective when the supply of primary air is closed off from the syphon passage at low speeds characterized by the low depressions above specified. Hence, ample fuel flow is insured at low speeds, without entire reliance or weak pressure reduction in the venturi, and very low minimum speeds can be obtained without stalling of the engine. This syphoning action is interrupted by access of air when the primary air passage dumps at higher depressions. When the engine stops, and the throttle being closed, the metering valve closes the fuel passage. As hereinafter described, the intensity of syphoning effect is also controlled by provision of an idling jet or other controllable air inlet communicating with the syphon line at a point above the fuel level. The combined hydrostatic and syphoning action is also effective in promoting fuel flow at fractional loads low speed. Under such conditions the fuel metering orifice areas are more restricted and subject to frictional coefficients at low speed due to the low pressure differential thereon, and the maximum pressure differential available should be utilized supplemental by the syphoning effect to increase the fuel flow and prevent tailing off.

The introduction of air into the fuel over the metering orifice not only contributes in the control of fuel flow, but also is of advantage for breaking up of the fuel, and thus assisting in the obtaining of homogeneous mixtures of air and fuel. I may also, if desired, admit additional air into the fuel conduit adjacent to the discharge point thereof into the intake. This is accomplished so as not to interfere with the syphon action and in a manner to promote such breaking up effect and ready delivery of fuel to the discharge point, and so as not to materially affect or change the rate of fuel flow through the metering orifice. This is done by introducing air by an air nozzle of the required size in injective relation to fuel flow, or in the same direction as the direction of the fuel flow.

While the venturi has a material modifying effect on depression at the fuel nozzle at full load operation, this Venturi effect need not be relied on at fractional loads that are characterized by higher intake depressions ample for effecting the needed fuel flow. At the latter stages of operation, the primary air is operative to reduce the proportion of depression utilized at the fuel metering orifice for producing fuel flow. At low depressions for low speeds, the Venturi action, preferably augment by the syphon effect as above described, is effective in causing adequate fuel flow without attenuation by primary air introductions.

In the accompanying drawing:

The figure is a composite sectional view of the carburetor.

Influence of air flow on fuel flow

Referring to the drawing, I utilize the air flow for creating a depression that augments the static pressure reduction in the intake avail-

able to vary the fuel flow directly with the air flow without undue retardation of the air flow by intake restriction. The downwardly directed fuel nozzle or intake fuel terminal 10 is located in the downdraft portion of an angular passageway 12 in the casting 14 on the side of the air throttle 16 toward the engine cylinders and preferably at the throat of a venturi 18. The throttle 16 is located in the entrance portion of conduit 12 so that the air is angularly deflected after passing the throttle and before passing through the venturi. The air flow through venturi 18 serves to produce depression of a magnitude ample to secure fuel delivery at various speeds down to a minimum, particularly in the full load range of operation and need not be relied on when the intake depression is ample for producing fuel flow, and the same is of utility in homogenizing the charge components and metering the fuel in accordance with the air flow.

Air is also discharged through the open ended tubular nozzle 20 disposed in an opening 22 in casting 14 at the top, and extending centrally into the nozzle 10 and terminating inwardly of the discharge end thereof. Fuel is supplied to nozzle 10 from the atmospherically vented float chamber 24 through the horizontal passage 26 in the casting 14 slightly above the fuel level. Fuel is delivered to the horizontal passage 26 through a vertical passage 28 in the depending portion 30 of the casting 14, the portion 30 extending into the float chamber 24. The nozzle 20 extends downwardly through nozzle 10 below the horizontal passage 26 a distance greater than the distance that the passage 28 extends above the fuel level, the passage 28 forming the shorter arm of a syphon passage, and the annular passage 32 forming the long arm thereof for a purpose more fully hereinafter described.

The fuel previously aerated as hereinafter described passes in an annular stream from passage 32 subject to the homogenizing whirling effect of the spiral ribs 33 and upon discharge thereof from the annular passage 32 to the comminuting action of the air from nozzle 20 which is in injector relation to the fuel passage. This causes a high degree of atomization in the enlarged mixture confining projecting portion of the nozzle 10, the air nozzle 20 functioning primarily as an atomizer without appreciable effect on the rate of fuel flow, and this assisted by the venturi causes the fuel to uniformly permeate the air to insure uniform distribution to the cylinders.

The fuel is thus subject to an aerating action, to air blasting action of nozzle 20, and to pressure reduction in the intake for effecting fuel atomization and vaporization so that the fuel rapidly permeates the air entering the passage 12 and forms therewith a homogeneous mixture.

The fuel controlling means

The depending portion 30 is provided with a vertical bore 34 leading at one end into passage 12 below the air throttle 16 and at the opposite end terminating in the lower end of the part 30. A fuel metering orifice 36 is formed within the bore 34 below the fuel level. Fuel is supplied from bowl 24 past check valve 38 and through lower portion of accelerating well 40 and passage 42 to the fuel metering orifice 36, and, after being metered by valve 44, passes through the vertical passage 28 into passage 26.

The valve 44 is adjustable in metering orifice 36 and is actuated from the air throttle 16, the valve comprising a head 46 having a knife edge 48 coacting with the calibrated edge 50 of the cam 52, and having lateral centering fingers 54 engaging opposite sides of the cam 52. This arrangement reduces the tendency to wear between the head 46 and cam edge 50 and prevents dislocation of the parts during operation. The cam 52 comprises a plate preferably, although not necessary, secured directly to and centrally of the outer side of the throttle plate 16 within the passage 12. The valve 44 is maintained in engagement with the cam edge 50 by a spring 56.

The upper edge portion of the cam plate 52 is formed as a segmental gear 58 meshing with a rack 60 forming the stem of the piston 62 working in well 40 for supplying auxiliary fuel adjunctively to throttling upon acceleration, the stem 60 having a bearing 64 in casting 14.

The well 40 communicates through passage 42 both with the passage 34 past metering orifice 36 and valve 44 and with a vertical passage 66 having communication with the pipe 68 which terminates in an open hook-shaped end portion directed downwardly into the nozzle 20 and subject to the suction therein and providing for the introduction of accelerating fuel into the intake through the air nozzle 20. The open end 70 of the pipe 68 is so situated with respect to the entrance end of the nozzle 20 that, with the throttle closed, the suction at 70 is sufficient to maintain the line 68 primed nearly up to the discharge end thereof so that fuel is forced immediately into the nozzle 20 upon actuation of the piston 62, and is drawn with the nozzle air into the intake. At the same time, a part of the fuel forced out of the well 40 passes into the fuel passage 28 past valve 44 to provide another path for supplying accelerating fuel into the intake as hereinafter more fully described. Upon descent of the piston 62, valve 38 closes to prevent fuel from being forced back into the float chamber. To prevent excessive discharge of fuel at this stage, the stem 60 is provided with an axial passage 72 opening into well 40 at its lower end and terminating at its opposite end in an angularly arranged outlet passage 74 sealed in the upper position of the pump by a portion of the bearing 64. Upon a given downward movement of the piston 62, the passage 72—74 opens to allow a part of the fuel to be forced therethrough and discharged into the space above the piston, thereby reducing the quantity of fuel being discharged into the intake.

I obtain fuel flow to accord with air flow by causing the cam controlled fuel valve 44 to give an opening 36 for each air-throttle opening of a size to pass the needed fuel in response to the depression effective on the fuel orifice which, as will be seen later, I keep less than the depression in the intake at the fuel nozzle, except at certain low intake depressions, the intake depression being also augmented by air flow at full load operation. To obtain the predetermined openings of the fuel orifice 36, the cam edge contour 50 is given a predetermined configuration productive of metering orifice change to give proper fuel flow, which will be referred to in further detail hereafter. I take care of the fuel needs changing with engine speeds for each fuel valve position by suitable variation of the pressure differential acting on the fuel, as hereafter described under another heading.

While the fuel valve 44 can be arranged to supply fuel for idling, I prefer to handle the idling fuel through a separate idling arrange-

ment 76 productive of constant fuel flow such as described in my copending applications above mentioned and in my copending application Serial No. 599,420, filed March 17, 1932. The idling arrangement 76 includes adjustable provision at 78 for the admission of air, which is preferably taken from the float chamber, and discharges through a highly constricted orifice 80 into the passage 26 at a point above the fuel level during normal engine operation. Fuel is supplied to the idler through passage 82 from the float chamber 24, fuel being delivered through a stabilizing metering jet 84. In view of the separate idling arrangement I bring the main fuel valve 44 to a substantially closed position during engine idling, thereby avoiding adjustment of the fuel valve 44 for regulating of idling fuel. Air for engine idling is supplied through the several aerating passages, the nozzle 20 and, if necessary, through the small balanced idling holes 86 in the air throttle 16.

Calibration

The internal combustion engine, such as employed for example in motor vehicles is controlled by means of the throttle to compensate for load or to vary the speed. At each throttle position the speed varies inversely with the load, the maximum speed becoming greater as the throttle opening increases. The fuel required for operation at minimum speeds varies, in general directly with the throttle opening. It also varies directly with the speed at each throttle position. For economical operation the mixture ratio is varied as the conditions of operation vary, the mixture being made richer for certain conditions of operation and leaner for other conditions of operation. In my invention I control or adjust, as hereinafter described, the pressure differential range effective for causing fuel flow at the various throttle positions, and then produce for each throttle position through cam 52 the particular fuel metering orifice individually determined for allowing under the adjusted pressure differential as the speed varies, a fuel flow in suitable ratio to the air supplied.

To determine the contour 50 of a key or cam 52 so as to properly control the opening of fuel valve 44 for any particular type of engine, I operate the carburetor in a flow bench in the usual manner, causing the air to flow therethrough in varying quantities indicative of the various conditions of engine operation and adjusting the metering orifice so that the proper mixture ratio is obtained at each throttle position at all speeds. From the data thus obtained, a cam of the proper contour can be made.

The calibration determination of the cam contour is made with the primary air passage 88 operating to decrease the pressure difference on the fuel orifice 36 as hereinafter described. The calibration is also made under other conditions of engine operation, such as with the air nozzle 20 and the idling fuel jet 76 in operation to supply air. The calibration being made under such conditions, in actual operation of the engine, proper fuel-to-air ratios may be obtained for maximum torque, maximum horse power and maximum economy, each independent of the other.

The cam will vary in contour for different applications depending on the characteristics of the engine to which the carburetor is applied. For example, as shown and described, in my above identified copending application Serial No. 525,992, in passing from engine idling the rate of change in fuel orifice area is very slight for the first few degrees of throttle opening, the pressure differential then being high and the idler 76 then also supplying fuel. This stage represents the takeout period from idling into fractional load operation. As the intake depression decreases with further throttle opening, the rate of change is at a more rapid rate, the rate of change in orifice area varying with throttle opening at increased rates as the opening progresses. At these stages of operation, the throttle openings are such as to supply maximum air for certain low speeds and ample metering orifices are required, the fuel orifice area approaching maximum. During final opening movement of the throttle to wide open position, there is little or no variation in fuel orifice area. The increase in air passage area per increment of throttle movement at this stage of operation is slight, and only enables the obtaining of the higher speeds without requiring fuel metering orifice enlargement.

The maximum opening of the fuel orifice 36 is relatively small, for example, in one type of carburetor this area was of the order of .0069 sq. inches, the passages 26 and 28 at the discharge side of the orifice 36 being substantially larger than such orifice when of maximum area to facilitate as hereinafter described the passage of fuel and air therethrough.

With my carburetor, as more fully described hereinafter, the fuel metering orifice area and the pressure differential on said orifice may be readily controlled to obtain mixture ratios approximating the theoretical for the various conditions of engine operation. The mixture ratio curve for full load, for example, is substantially horizontal except at the low speed end (minimum air) when it tails up. The mixture ratio curve for fractional loads is more economical, being substantially horizontal except at the minimum air end (low speed) where it tails up and at the maximum air end where it tails up and merges with the full load curve.

I have found in modulating the fuel flow in some types of engines through a metering orifice 36 employing the well known tapered or conical metering pin, forming an annular orifice, that the fuel flow at certain light engine loads is erratic, the fuel flow tending to lean out or fall off. I have discovered that this decrease in fuel flow is due to frictional coefficients inherent in the use of a variable annular orifice for fuel metering subject to high pressure differences.

When metering fuel with an annular orifice, say at 10° of throttle opening, even when employing aeration for reducing the pressure differential on the orifice, the clearance must be, for example, of the order of .00125 inches so as to prevent excessive fuel flow at the high intake depression existing at such throttle position. An annular orifice of such size is so small that light hardly passes through the same. Fuel passing through such highly restricted orifice is therefore subjected to considerable frictional retardation, the action being cumulative and gradually reducing fluel flow. That the disturbing effect of the coefficients of friction is serious with an annular orifice is evidenced by the fact that the fuel flow has been found to vary to a considerable extent in a short period of time. Upon movement of the metering pin the original fluel flow is reestablished but again rapidly falls off as the metering orifice remains fixed. In actual engine operation, the tendency of the fuel to lean out

upsets the mixture ratio and causes the pressure differential to vary, which in turn also affects fuel flow detrimentally disturbing the engine operation.

I overcome the disturbing effects of frictional coefficients by the provision of a variable orifice 36 having a cross-section which is lumped or concentrated, approximating in shape a round hole instead of an annulus so that the wall surface of the orifice frictionally retarding the fuel flow is minimum and the minimum dimension thereof is substantially greater than the minimum dimension of an annular orifice.

In order to form the variable lumped orifice 36, the lower end 90 of the valve 44 is made cylindrical with one side thereof cut or slabbed off at an angle to form a frustrum. The angle of the plane cut at 90 is such as to allow variation in the area of the fuel orifice throughout the relatively small range of movement of the pin 44, and is so coordinated with the cam contour 50 that an orifice of the desired fuel passage area is obtained at each throttle position.

In the position of the valve 44 for engine idling the completely cylindrical portion of the pin 54 substantially closes the orifice 36 to preclude the passage of fuel therethrough. As the valve 44 moves with opening movement of the throttle the fuel orifice area at 36 increases, the orifices of increasing area being substantially segmental in shape. The frustrum type of metering valve may be more readily manufactured and installed than the conical type of valve, a greater range of tolerance being allowable.

The frustrum type of metering valve, when carburetor cost is a factor, can be advantageously utilized for controlling the fuel orifice 36 to supply fuel for engine idling as well as at other stages of engine operation, the relatively low coefficients of friction characteristic of the lumped type of metering orifice when employed with the fuel aeration or primary air introduction at the metering orifice being productive of steadier fuel flow at engine idling. I prefer however, where cost is not material, to utilize for supplying idling fuel the idling means 76 because such means are substantially immune to fluctuations in intake depression at engine idling.

Control of fuel flow by primary air

To suitably vary the fuel flow upon speed changes at each throttle position and the corresponding fuel valve position, and to lessen the high depression at the exit side of the fuel valve port 36, the vertically extending passage 88 is provided having communication at a point well above the fuel level with atmosphere and leading to the fuel conduit at a point 92 immediately at the discharge side of orifice 36 below the fuel level, both orifices 36 and 92 being submerged a substantial distance below the fuel level for a purpose hereinafter more fully described. The passage 88 has therein a metering orifice 94 which is adjusted in size by the valve 96.

By air moving through passage 88 the action of depression is divided to be effective on both air coming in at 92 and on the fuel coming in at 36, or otherwise stated, the pressure differential on the fuel is reduced. The size of the metering orifice 94 is adjusted in accordance with the characteristics of the engine on which the carburetor is employed, and is preferably made large to enable the use of fuel metering orifices of maximum area to reduce the effects of frictional coefficients without causing the fuel to run too rich, the primary air orifice 94 in practice preferably not being larger than that which would cause an undesirable idling engine speed, such as one of the order of .02761 sq. inches.

The reduction of pressure differences across the fuel gate 36 by the admission of air through the passage 88 enables the use at periods of high intake depression of a fuel orifice opening at 36 larger than the small opening that would have to be used to hold the fuel back against the full intake depression, with resulting elimination of the irregularity of flow that would be incidental to use of such smaller opening subject to greater depression.

At fractional load operation, say up to 40° of throttle opening, the fuel orifice 36 is adjusted to give for the practical maximum of primary air a desired fuel flow for each throttle position, and the attenuated pressure differential effective on the orifice is such as to prevent undue increase in fuel flow with increase of speed and intake depression at each throttle position. At such throttle positions however as the speed decreases to minimum, as under a suddenly acquired load, resulting in a decided drop of the pressure differential effective in promoting fuel flow, I find that the frictional coefficients inherent in the fuel metering orifice of the areas required to restrict the flow of fuel at high depressions even with ample primary air, tend to cause the fuel to unduly tail-off or lean out. Under such conditions of part load operations, I include provision for opposing tendency to tail-off, other than by merely opening the throttle wider. By submerging the primary air entrance 92 well below the fuel level, at a given minimum of depression, say an 1" H_2O, depending on the distance of submergence of the entrance 92, the admission of primary air is cut off hydrostatically by the fuel, thereby rendering available the maximum depression in the venturi for forcing fuel through the restricted metering orifice 36. The closing off, by fuel sealing, of the passage 88 also renders available the syphoning effect above mentioned which promotes fuel flow under such low speed conditions without entire dependence upon the pressure differential on the fuel.

At fractional load I introduce the maximum quantity of primary air to enable the use of larger fuel metering orifices but of sufficient restriction to supply economical fuel at the higher intake depressions, and compensate at low depression for unavoidable fuel orifice constriction by increasing the pressure differential thereon and supplementing this by the syphon effect. This reduces the tendency to tail off at low speeds which might cause the engine to stall.

At full load or nearly full load operation, the fuel orifice area is fixed at maximum, the frictional coefficients thereof even at low speeds cease to be troublesome. At this stage of operation the variation in fuel inducing effect of the pressure reduction, and this is then lower, must be relied on for inducing fuel flow upon increasing the speed, further opening movement of the air throttle 16 not affecting the area of the orifice 36. At full load the fuel rate of flow is greater and richer mixture ratios are necessary.

At low speeds full load when the intake pressure reduction available for causing fuel introduction is least, and a relatively rich mixture is required for engine lugging, the air passage 88 again closes off hydrostatically, the maximum pressure differential available being required for effecting fuel introduction through orifice 36, and

the syphon effect being available. As the speed increases, the pressure reduction in the intake increases, and particularly the kinetic effect of the venturi, until, in the absence of fuel flow controlling primary air, there would be a tendency for the fuel to run too rich. I then cause the air passage or well 88 to dump hydrostatically to inaugurate the flow of primary air and reduce the pressure differential on the fuel.

In my invention, a varying pressure differential, at times attenuated by primary air introduction, is maintained on the metering orifice 36 irrespective of the cross-sectional area, i. e. at all throttle positions and at all speeds. The proper areas for orifice 36 having been determined for the throttle range, the correct mixture ratios are obtained by the variations in pressure differential under all conditions of engine operation, the mixture ratio being made to tail up at low speeds in accordance with the theoretical mixture ratio curves.

The well 88 also serves as an auxiliary reservoir from which fuel is supplied to the intake to facilitate speeding up from low speeds, the fuel dumping from well 88 faster than it can pass through the more restricted orifice 36. The well 88 also functions as a reservoir for receiving fuel upon acceleration, the fuel being forced into the well by the plunger 62. The well 88 is of sufficient elevation or length to prevent fuel from being forced out at the top when the accelerating pump is operated. When the plunger descends fuel is in part forced directly into passage 28 and 66 for delivery into the intake and in part into well 88 from which it gradually drains out following the accelerating moment, thereby insuring the supplying of auxiliary fuel over a portion of the speeding up period.

The admission of air at 92 with the metered fuel coming in at 36 produces an air-fuel mixture in the conduit 26—28 which, on passing to nozzle 10, is more effectively broken up than solid liquid fuel by blasting and/or delivery into partial vacuum. As the fuel has already been metered at 36 prior to admixture with the air, the correct air-to-fuel proportioning can be obtained.

At engine idling, air passage 88 is open i. e. drained of fuel, and fuel valve port 36 is substantially closed so that the conduit 88—28—26 conveys air only, and such air serves as a carrier for the idling fuel mixture supplied at 76 and delivered to the fuel nozzle 10.

With a cam 52 of predetermined contour and a metering valve 44 of a predetermined cut at 90, the mixture ratio for the entire range of engine operation can be made leaner by enlarging the primary air passage at 94 and richer by reducing the air passage at 94, the correction being made equally effectively for the entire range of engine operation so that it is impossble, although the adjustment is simple, to obtain faulty operation at any stage of engine operation, the adjustment when made to supply the required fuel economically for full load high speed operation being satisfactory for the entire range.

Regulation of fuel flow for various engine speeds

If the engine speed is increased with the air throttle wide open, the air flow increases rapidly, necessitating a correspondingly considerable increase in fuel supply. A typical case is increase from 65 cc. per min. at substantially minimum speed to 500 cc. per min. at substantially maximum engine speed, both at wide open throttle. As has been seen, the fuel metering orifice 36 is of maximum area when the throttle is wide open. Venturi 18 is chosen of such throat size that the depression on the fuel nozzle 10 located at the throat thereof rises in response to air flow increase resulting from engine speed increase at wide open throttle so as to cause delivery of the required fuel, the primary air introduction at 88 being controlled hydrostatically as above described to control the ratio of fuel to air in accordance with the speed or lugging conditions.

If the throttle be closed somewhat from wide open position, as, for instance, to 50°, while this makes substantially no difference in air flow and fuel flow at low engine speeds, there is a material reduction in air flow at the higher speeds, with resulting reduction in need for fuel. At such times, however, the intake depression is higher, but the primary air passage 88 is then effective in reducing the pressure reduction across fuel orifice 36, the fuel flow being correspondingly decreased, and the requirements for economical operation satisfied. Upon passing to the lower part fractional load operation, the intake depression is further increased by the further closing of the throttle and the fuel metering orifice area correspondingly reduced in consonance with reduction of throttle opening, and thus automatic compensation by primary air introduction becomes increasingly effective.

At intake depressions above a predetermined value I reduce the effects thereof on fuel flow by air introduction at 88, and at lower intake depressions augment the fuel flow inducing effects thereof by air flow through a venturi, the latter being particularly valuable at low speeds full load, and the primary air then being closed off to allow utilization of the maximum pressure differential available for promoting fuel flow augmented by syphon effect. The pressure differential on the fuel is thus kept within range to cause, upon fuel metering orifice adjustment, a flow of fuel in suitable ratio to the air throughout the speed range at each of the throttle positions.

In my invention primary air introduced at 88 is effective in controlling the pressure differential on the fuel metering orifice 36 to vary or control the fuel flow, and at the same time, the primary air serves to pick up the fuel at orifice 36 and facilitate the delivery thereof through passages of ample size into atomizing relation to the air nozzle 20, without appreciable frictional retardation. The metering orifice 36 is below the fuel level, and the weight of the fuel in the chamber 24 augmented by the atmospheric pressure thereon serves to push the fuel through such orifice 36 where it is swept through passage 26—30 by the air stream therein. In other words, I provide, particularly at high speeds, a high velocity air flow through passages 26—28 effective on a submerged metering orifice 36 for effecting delivery of fuel to a higher elevation, this level being slightly above the normal level of the fuel. The idling fuel air jet 76 also facilitates by aeration at a point above the fuel level delivery of fuel into atomizing relation to the blast nozzle 20. At low speeds or low depressions when the passage 88 is liquid sealed the fuel is forced into the intake by the action of the passages 28, 26 and 32 forming a syphon. A steady flow of fuel into the intake is thus insured when the pressure differentials are extremely low, and this is accomplished without the syphon being vented by the air from the idling jet, the entrance therefrom to the syphon passage being extremely small,

and apparently sealed by a fuel film at such stage of operation.

The fuel, or fuel and air mixture, entering nozzle 10 is formed into an annular stream, and is then subjected to the blasting action of the nozzle 20 effective in further aerating the fuel, and obtaining a high degree of fuel atomization or comminution. The fuel or mixture thus aerated is swept through the passage of ample cross-section in nozzle 10 directly into the venturi 18 where it admixes with the main air supply. The fuel before delivery into the venturi 18 is subjected to a series of aerations, the first being primarily effective in controlling fuel flow by variation of the pressure differential on the metering orifice 36 below the fuel level, and the second being primarily effective in causing fuel atomization without frictional retardation. This facilitates the introduction of fuel into the intake, and the several aerations place the fuel in condition to be thoroughly vaporized and to form a homogeneous charge mixture.

The shape of the intake passage 12, in the downdraft carburetor, as above described, is such as to counteract tendency of the air to stratify due to passage of the air past the air throttle 16, prior to admixture of the fuel therewith.

In conventional carburetors of the posterior throttle type, the fuel admixes with the air prior to passing the throttle, and stratification effects are not as detrimental.

When air only passes the throttle one side of the throttle blade forms in effect a Venturi mouth, while the passage at the opposite side of the throttle blade sets up frictional retardation to air flow, the air flow through the passage becoming what is termed herein as stratified or a one sided air flow. If this condition exists at the time the fuel is introduced the charge mixture will not be homogeneous, and faulty distribution results.

In the downdraft carburetor I obviate air stratification by deflecting the air at right angles into the venturi 18, the latter assisting in smoothing out the air stream. In taking the right angle bend the air is rendered uniform in cross-section so that the fuel when introduced permeates an air stream of uniform cross-section. Other expedients, such as the spirals 33, may be resorted to to insure homogeneous admixture of the fuel and air at venturi 18 for promoting uniform distribution to the cylinders. The symmetrizing of the air stream is effected without resorting to expedients unduly restricting the air passage, the result being obtained by deflection of the air stream between the air throttle and the venturi and prior to fuel introduction.

The carburetors embodying my invention, both in the updraft or downdraft type, are very compact, occupying the minimum space required for the parts. The float chamber 24 is located in the angle of the intake passage portion so that the horizontal and vertical portions of the intake passage hug the top and one side of the float chamber. This compactness is rendered possible by arranging the fuel passage 26 horizontally to discharge into the nozzle 10 substantially on a line with the juncture of the float chamber and the horizontal portion of the intake. This arrangement also facilitates actuation of the fuel valve 44 and pump 62 from the throttle.

In the present invention, I dispense with interconnecting mechanisms for the control of the movement of the metering pin 44, thereby preventing back lash, distortion and the like, detrimental to precise metering, and positive motion of the accelerating plunger 62 is obtained by the meshing gears 58—60 between the throttle 16 and plunger 62.

By my invention, the pressure differential on the fuel orifice and the fuel orifice area are coordinated so that the fuel is supplied smoothly in suitable ratio to the air substantially throughout the range of operation of the engine without being impeded by frictional effects, notwithstanding that the intake depression varying at times in inverse relation to the fuel requirements, tends to cause either too much fuel flow or not enough. At low depressions at low speeds tailing off of the fuel flow is prevented by the combined hydrostatic and syphon effects, and upon acceleration additional fuel is rendered instantly available for discharge into the intake.

With my system of fuel control the pressure reduction at the engine side of the throttle is made available for the discharge of the fuel directly thereinto so that the fuel, by discharge into a region of reduced pressure, is more easily vaporized, and the charge mixture has free passage to the cylinders without being impeded by the throttle.

Fuel atomization and vaporization are also assisted by the aerating action of the pressure differential controlling primary air means and by discharge of air centrally through the annular stream of previously aerated fuel, so that the fuel assumes under the action of the several aerating or vaporizing influences, a thoroughly homogeneous state in suspension in the air, the carburetor being adapted for metering either volatile fuels, or fuels of low volatility, such as fuel oils, alcohol, etc.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. The process of supplying charges for internal combustion engines which consists in introducing primary air into the intake at the engine side of the throttle together with fuel introduced into the primary air through a metering orifice subjected to a pressure differential reduced by said primary air relative to the intake depression available, and at low depressions corresponding to power operation at low speed closing off the primary air and introducing the fuel by a siphoning action to form a power mixture ratio.

2. Process in accordance with claim 1 in which the closing off of the primary air is effected hydrostatically by the fuel.

3. Process of supplying charges for internal combustion engines, comprising introducing primary air into the intake at the engine side of the throttle together with fuel introduced through a submerged metering orifice into the primary air, the primary air being introduced in a quantity to reduce the pressure differential on the metering orifice sufficiently to allow the use of relatively large orifice areas reducing frictional effects therein, modulating the fuel metering orifice to give for each throttle position the orifice area predetermined to be required for said throttle position, and at low depressions closing off the primary air to render more of the depression available effective in promoting fuel flow.

4. Process as in claim 3 in which at low depression fuel flow is augmented by a syphon action.

5. Process as in claim 3 in which the primary air is closed off at low depression by the fuel hydrostatically.

6. Process of supplying charges for internal

combustion engines, comprising delivering primary air into the intake at the engine side of the throttle together with fuel introduced into the primary air through a submerged metering orifice subjected to a pressure differential reduced by the introduction of primary air over the metering orifice, producing for each throttle position a predetermined orifice area to supply the fuel in suitable ratio to the air, the reduction in pressure differential produced by the primary air being made to approach a maximum to allow the use of metering orifice areas having frictional coefficients approaching the minimum, and at low depressions closing off the primary air by the fuel hydrostatically to effect fuel delivery through the metering orifice under a greater pressure differential.

7. Process in accordance with claim 6 in which the fuel is delivered downwardly into the intake by a syphoning action when the primary air is closed off.

8. In apparatus for supplying and proportioning charges for internal combustion engines comprising an intake, a throttle therein, a float chamber, means partially submerged in the float chamber fuel for conducting primary air into the intake at the engine side of the throttle, said submerged portion filling with fuel to close off the primary air at low depression, a fuel metering orifice opening into the submerged portion of said primary air conducting means, and having a variable pressure differential thereon attenuated by the primary air, cam means operated adjunctively to throttling for producing at various throttle positions metering orifice areas coordinated with the pressure differential effective on the orifice for producing desired mixture ratios, said orifice areas being proportional to the amount of primary air admitted for reducing frictional coefficients in the orifice.

9. In apparatus for supplying and proportioning charges for internal combustion engines comprising an intake, a throttle therein, means for conducting fuel into the intake at the engine side of the throttle, an air tube extending into the intake in atomizing relation to the discharge end of said fuel conducting means, a bypass from the fuel conducting means to the entrance portion of said air tube, and substantially primed with fuel at higher depressions, and a fuel pump for forcing fuel from said bypass into said tube upon acceleration.

10. In apparatus for supplying and proportioning charges for internal combustion engines comprising an intake, a throttle therein, a constant level float chamber, means for conducting fuel and controlling the flow thereof from said constant level float chamber into the intake, a fuel pump operated upon opening movement of the throttle, a by-pass extending upwardly from said fuel pump into the intake at the engine side of the throttle, and means for controlling the suction in said by-pass to retain the same substantially primed with fuel for immediate discharge of fuel into the intake upon actuation of said pump.

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