United States Patent

[11] 3,547,415

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[54] **CARBURETOR FOR GASOLINE ENGINES**
10 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** **261/50**
[51] **Int. Cl.** **F02m 9/08, F02m 7/22**
[50] **Field of Search** 261/44.2, 50, 51, 41.2

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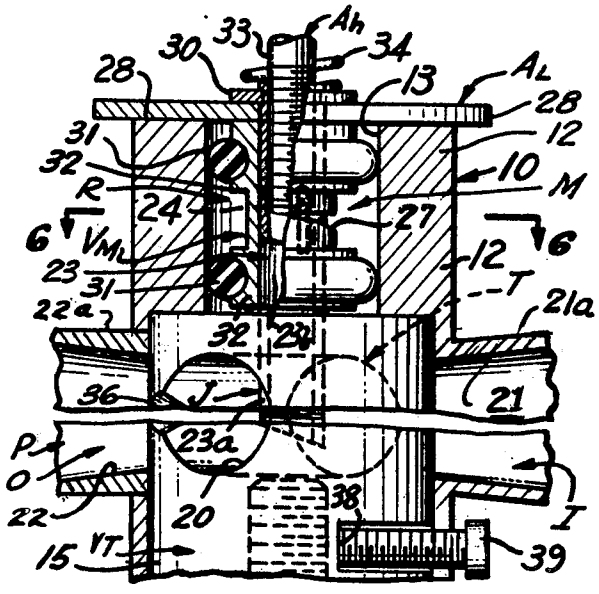
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ABSTRACT: A carburetor for gasoline engines, particularly small displacement two-cycle engines such as model engines and small motor driven cycle engines. The carburetor has a throttle valve which regulates the relative areas of the air venturi inlet and exit in such a way as to effect fuel induction through the carburetor jet by venturi action at high engine speeds and by engine crankcase depression or intake vacuum at low engine speeds. Interconnected with the throttle valve is a fuel metering valve characterized by a novel fuel metering orifice of clog-resistant single boundary edge configuration. The metering valve is adjusted in unison with the throttle valve to meter fuel to the fuel jet in accordance with a preselected function of throttle valve setting which yields an optimum fuel-air mixture at each throttle setting from idling to full speed. The metering valve embodies low and high-speed mixing adjustments, a visible scale for indicating the normal range of the low-speed mixing adjustment, and a fuel reservoir for blocking passage of air bubbles in the fuel to the fuel jet and containing starting fuel for the engine.



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SHEET 1 OF 2

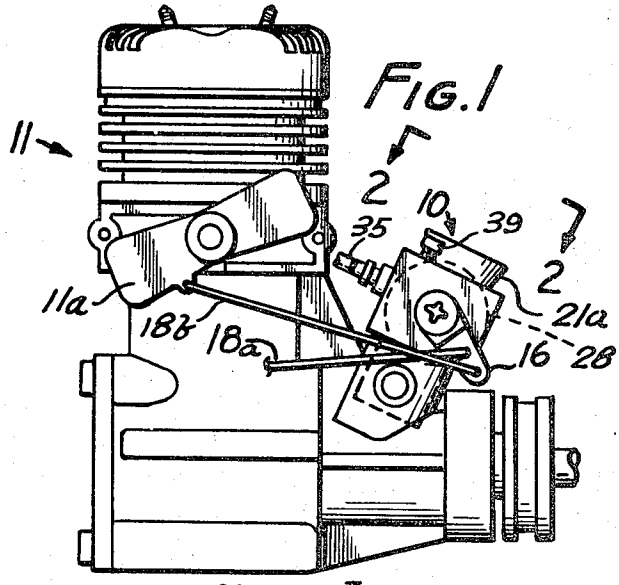


FIG. 1

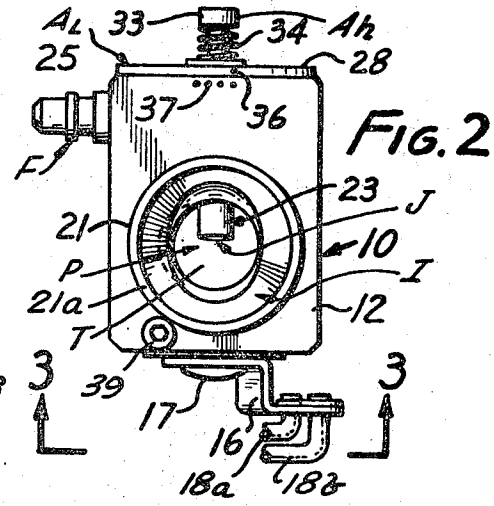


FIG. 2

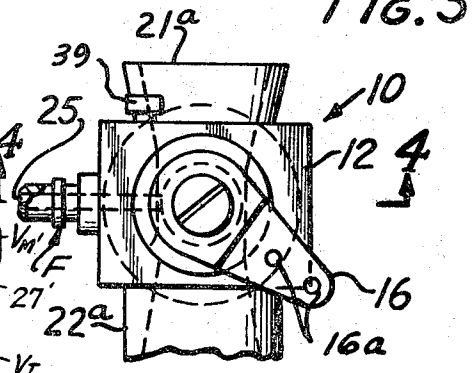


FIG. 3

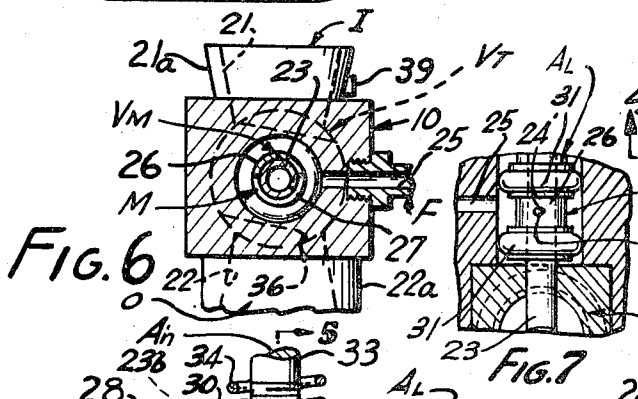


FIG. 6

FIG. 7

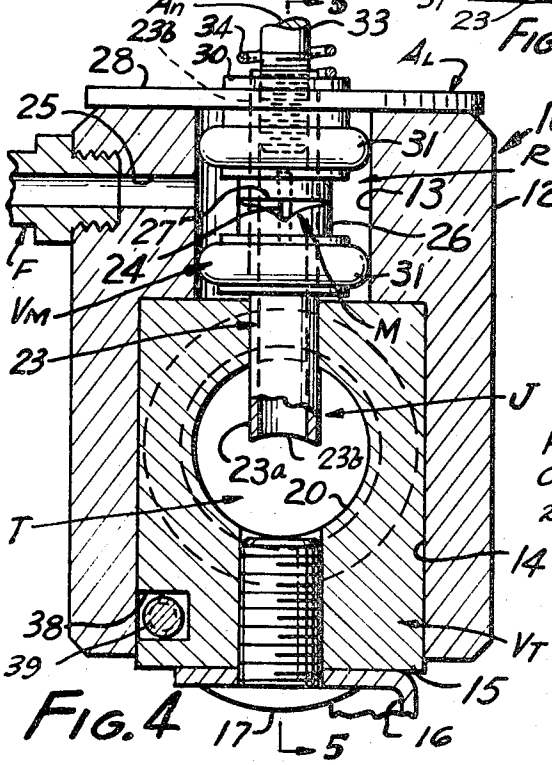


FIG. 4

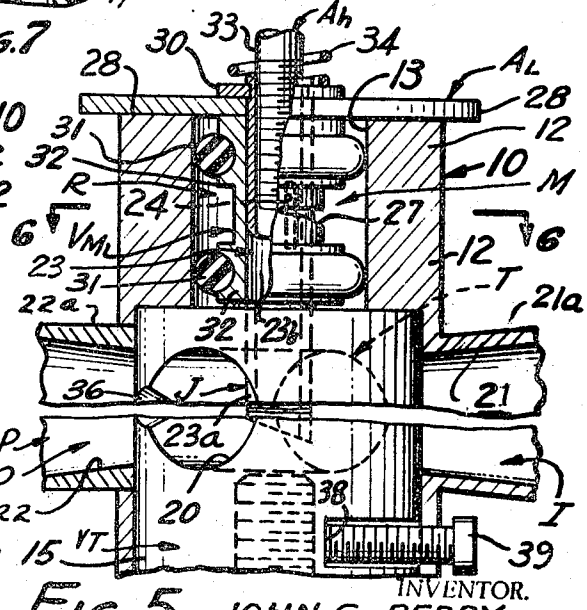


FIG. 5

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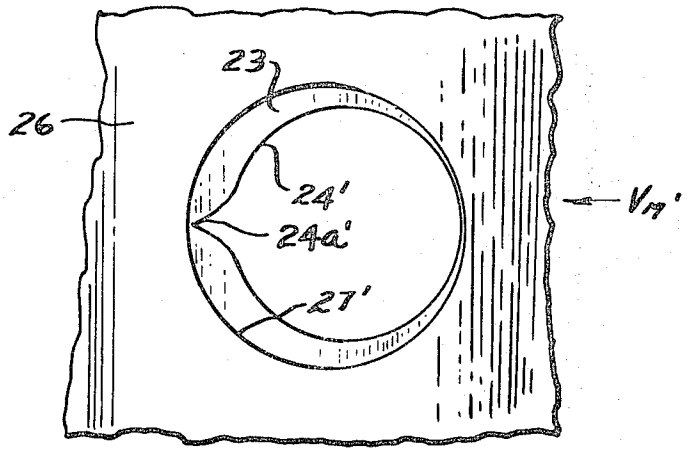


FIG 8

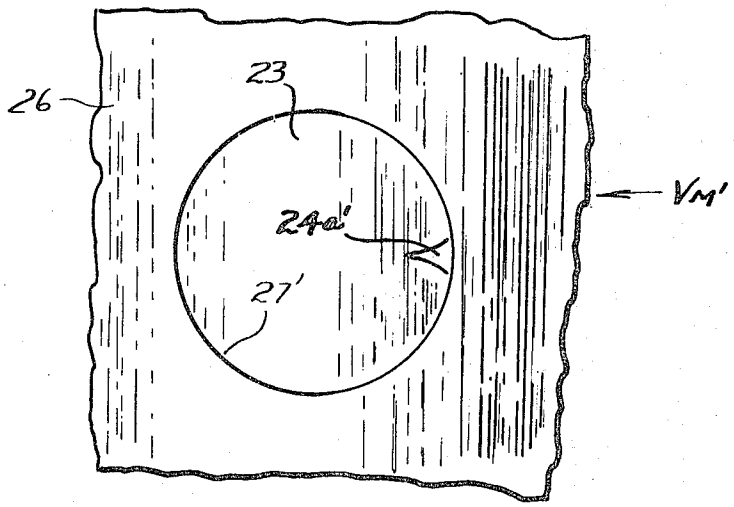


FIG 9

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CARBURETOR FOR GASOLINE ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to the field of gasoline engines and more particularly to a novel carburetor for such engines, especially relatively small displacement two-cycle engines such as model engines and small motor driven cycle engines.

2. Description of the Prior Art

According to its broader aspects, the invention provides a carburetor which may be used to advantage on a variety of gasoline engines including both two-cycle and four-cycle engines. However, the invention is primarily concerned with two-cycle engines, particularly relatively small displacement two-cycle engines, such as model engines and small motor driven cycle engines. For this reason, the invention will be disclosed in connection with a small two-cycle engine, namely, a model engine of the type used on radio-controlled model airplanes and the like.

A variety of carburetors have been devised for use on model engines of the class described. While these carburetors differ in their detailed construction, however, they are generally similar in overall design. Thus, a typical model engine carburetor is characterized by a body containing an induction air passage defining an air venturi, and a fuel jet projecting into the venturi throat in such a way that the suppression or partial vacuum created in the throat by induction airflow through the venturi produces a suction force for drawing fuel through the jet into the airstream. The magnitude of this suction force is related to the flow rate and velocity of the induction airstream. Movably mounted within the induction air passage is a throttle valve which typically comprises a rotary valve barrel having a lateral opening defining the venturi throat. Interconnected with this throttle valve for adjustment in unison therewith is a fuel metering valve whose purpose is to meter fuel to the induction airstream in such a way as to provide the correct fuel-air mixture for each throttle valve setting. The metering valve of most conventional model engine carburetors is a needle valve having a valve needle which is extended axially into the end of the fuel jet to reduce fuel flow as the throttle valve is closed and retracted axially from the jet to increase fuel flow as the throttle valve is opened.

The existing model engine carburetors of the character described have certain inherent deficiencies which the present invention seeks to overcome. One of these deficiencies resides in the tendency of a needle-type fuel metering valve to become obstructed or clogged by foreign particles in the fuel flowing through the valve. Thus, the effective fuel metering orifice of such a mixing valve is characterized by an annular shape and by two separate boundary edges. One of these edges is provided by the valve needle and defines the inner perimeter of the orifice. The other boundary edge is provided by the wall of the fuel jet and defines the outer perimeter of the orifice. The effective cross-sectional dimension or radial width of such an annular orifice of given area is relatively small in comparison to the overall cross-sectional dimension of the orifice and is substantially less, for example, than the effective cross-sectional dimension of a simple single boundary edge orifice of the same effective area. In this regard, it should be noted that the expression "single boundary edge orifice" refers to a simple orifice having a single boundary edge only which defines the outer perimeter of the orifice. Because of this particular dimensional characteristic of an annular orifice and the relatively small total effective orifice area required to properly meter fuel in a model engine carburetor, the radial width of the fuel-metering orifice in a needle-type valve employed in conventional model engine carburetors is extremely small, particularly at idling. For example, at idling, the annular fuel-metering orifice in a typical model engine carburetor may be

on the order of a few ten-thousandths of an inch in radial width.

Obviously such a narrow metering orifice is prone to obstruction by even extremely small foreign particles in the fuel. That total obstruction of the orifice will result in engine failure is obvious, of course. However, it is significant to note that even partial obstruction of the orifice will have a major adverse effect on engine performance. Thus, because of the small effective area of the metering valve orifice in a model engine carburetor, particularly at low engine speeds, partial obstruction of the orifice by even a relatively small particle in the fuel may cause a relatively large percentage reduction in the effective orifice area and hence a correspondingly large percentage change in the rate of fuel flow through the orifice to the engine. This variation in fuel flow, in turn, will have a substantial effect on a model engine because of its sensitivity to even slight changes in the fuel-air mixture, as hereinafter explained. It will be immediately appreciated by those versed in the art that this propensity of needle-type fuel metering to obstruction by foreign particles in the fuel constitutes a distinct disadvantage in the case of radio controlled model airplanes whose total cost, including radio controlled gear, may run as high as five to six hundred dollars and which generally experience total destruction in the event of engine failure.

Another deficiency of the existing model engine carburetors involves the mixing of fuel and air in the proper proportions or ratio to achieve optimum engine performance over the entire engine operating range from idling to full speed. In this regard, it is well recognized by those versed in the art that model engines are extremely sensitive to changes in the fuel-air mixture and, as a consequence, the ratio of this mixture is a critical factor in obtaining optimum engine performance. The reasons for this sensitivity of model engines to the ratio of the fuel-air mixture are twofold. First, because of their small displacement and horsepower rating, model engines consume only a relatively small amount of fuel during each cycle. As a consequence, even a relatively slight change in the rate of fuel flow to these engines has a substantial effect on engine performance. Secondly, because of their two-cycle operation, model engines are characterized by relatively inefficient exhaust-gas scavenging and, as a consequence, by a varying degree of admixture of exhaust gas with the fuel-air mixture. This varying degree of dilution of the fuel-air mixture by exhaust gas amplifies the effect on engine performance of changes in the ratio of the fuel-air mixture.

Owing to the foregoing and other factors, precise mixing of fuel with the induction air entering a model engine at every throttle valve setting is essential to optimum engine performance. As noted earlier, the existing model engine carburetors employ for this purpose a needle-type metering valve having a valve needle which is extended into and retracted from the fuel jet as the throttle valve is rotated between its idling and high speed positions. This valve needle movement is generally accomplished by mounting the throttle valve barrel so that it moves axially as it rotates and operatively connecting the valve needle to the barrel for axial movement between its idling and high-speed positions in response to axial movement of the valve barrel.

The majority of existing model engine carburetors of this type are defective in that they position the valve needle in accordance with a simple linear function of throttle valve setting while the effective area of the throttle valve opening varies according to a nonlinear function of throttle valve setting. This results in a nonlinear relationship between fuel flow rate and airflow rate which fails to yield a satisfactory air fuel mixture over the range of throttle valve settings. In this regard, it should be noted that I have determined an air fuel mixture which at least results in ideal model engine performance over the full range of throttle valve settings is obtained by maintaining a substantially constant ratio between the effective areas of the mixing valve orifice and the throttle valve opening.

Attainment of this optimum relationship between mixing orifice area and throttle opening area is extremely difficult if

not impossible to attain with a needle-type valve. This is due partly to the difficulty of designing and making a small needle valve having a nonlinear flow-metering action matching that of the throttle valve and partly to the tendency of a small needle valve to become obstructed or clogged by foreign particles in the fuel, particularly at idling. With regard to the design problem, for example, attainment of the ideal air fuel mixture with a needle-type metering valve requires relatively sophisticated valve shapes and mechanisms for translating each throttle valve position into the correct mixing valve orifice area. As a consequence, such mixing valves, even if they do exist, are quite costly and, because of their many parts, are prone to malfunction. With regard to the mixing valve obstruction problem, it will be recalled from the earlier discussion that the orifice of a needle-type mixing valve, because of its annular shape and relatively small radial width, is extremely prone to obstruction and clogging by foreign particles in the fuel, particularly at low engine speeds. Owing to this clogging propensity of a needle-type mixing valve, it is impossible to design such a valve to have ideal orifice areas in its low-speed settings for the reason that the radial orifice width would then be too small to assure reliable engine operation. In other words, in order to assure reliable engine operation, it is necessary to design such a valve to have orifice areas in its low-speed settings which are somewhat larger than the ideal, in order to provide the orifice with a satisfactory radial width, and to compensate in some way for the excess orifice area.

In the existing model engine carburetors, this compensation for excess mixing orifice area at low engine speeds involves, in part, the use of only the venturi action of the induction airstream to draw fuel through the carburetor fuel jet. It is significant to note in this regard that because of its two-cycle operation and small displacement, a model engine consumes only a relatively small volume of air during each cycle at low engine speeds. As a consequence, the flow rate and velocity of the induction air through the carburetor venturi, and hence the venturi suction available to draw fuel through the carburetor fuel jet, are also relatively small. The existing carburetors rely on this small suction force to compensate for the oversize metering valve orifice at low engine speeds and to draw fuel through the fuel jet at the correct flow rate for each low-speed throttle setting.

As best, this manner of metering fuel achieves only a rough approximation of the optimum fuel-air mixture at each throttle valve setting. For this reason, the more sophisticated model engine carburetors are equipped with air bleeds and other compensating adjustments. While these adjustments are successful, to a degree, in correcting the fuel-air mixture at each throttle setting, the carburetors embodying such adjustments are costly and difficult to tune. By way of example, most model engine carburetors are equipped with low-speed and high-speed fuel metering adjustments. These adjustments regulate fuel flow through the metering valve independently of the throttle valve and are set with the throttle valve in its idling and high-speed positions, respectively, to achieve an optimum fuel-air mixture at these throttle settings. These mixing adjustments are difficult to make, however, since their correct setting must be determined entirely by the sound of the engine.

Reliance, in the existing carburetors, on the low venturi suction at low engine speeds to meter fuel flow through the fuel jet presents distinct disadvantages in certain model engine applications, notably model airplanes. One of these disadvantages, for example, resides in the fact that even slight variation in the fuel delivery pressure or the static pressure head on the fuel, such as occur during various aerial maneuvers and as a result of fuel level changes in the fuel tank and sloshing of the fuel in the tank, has an appreciable effect upon the fuel flow rate and hence the fuel-air mixture delivered to the engine. For example, fluctuating fuel delivery pressure or static pressure head on the fuel may cause the fuel-air mixture to be excessively lean at one moment and excessively rich the next, with the result that the engine may cut out. Another disadvantage is that the existing carburetors are incapable of drawing fuel against any substantial opposing static pressure head in the fuel. For example, the maximum static pressure head which most if not all existing model engine carburetors will withstand without engine failure is on the order of 2 to 3 inches of fuel.

As noted earlier and explained in detail presently, the present carburetor avoids the problems just discussed by utilizing engine crankcase depression or intake vacuum to draw fuel at low engine speeds. The existing carburetors cannot do this owing to the fact that excessive fuel flow would then occur through the oversize metering valve orifice and cause flooding of the engine. It is for this reason that the throttle valve barrels of the existing carburetors are designed to maintain precisely equal venturi inlet and exit areas in all throttle valve settings in order to avoid any effect of crankcase depression or engine intake vacuum on fuel flow rate.

Another problem which is frequently encountered in the operation of model engines, particularly those used on radio-controlled model airplanes, is engine misfire or failure due to air bubbles in the fuel. This often occurs, for example, when a model airplane is taxied along a runway and the brakes are applied. Application of the brakes throws the fuel in the fuel tank forwardly, thereby permitting air to enter the fuel line and flow through the line to the carburetor. Engine failure from this cause often occurs at the end of the runway following landing and is quite annoying to the skilled radio control pilot.

SUMMARY OF THE INVENTION

The present invention provides an improved carburetor which avoids the above noted and other deficiencies of the existing model engine carburetors. In this regard, it is significant to recall that while the present carburetor is particularly suited for use on model engines, it may be used to advantage on other gasoline engines as well, including both two-cycle and four-cycle engines.

The carburetor of the invention has a body containing an induction air passage defining a venturi having an air inlet and exit. Mounted within this passage is a throttle valve for regulating induction airflow through the passage. Projecting into the venturi throat is a fuel jet having its exit orifice situated near the central axis of the throat. Also mounted on the carburetor body is a fuel metering valve for metering or regulating fuel flow from a fuel inlet on the body to the fuel jet. This mixing valve is interconnected with the throttle valve for adjustment in unison with the latter valve between idling and high-speed positions.

One important feature of the invention resides in the novel construction of the metering valve, whereby this valve is relatively immune to obstruction by foreign particles in the fuel. According to this feature, the valve is equipped with a pair of valve members which define a fuel-metering orifice of clog-resistant, single boundary edge configuration, and the members are adjusted relative to one another in unison with adjustment of the throttle valve to vary the effective orifice area. It is significant to recall that a single boundary edge orifice is a nonannular orifice having a single outer boundary edge, only, and that this type of orifice is relatively immune to obstruction by foreign particles in the fuel because of its comparatively large cross-sectional dimensions. In the particular inventive embodiment selected for illustration in this disclosure, for example, the valve comprises a pair of interfitting, relatively rotatable valve sleeves with intersecting openings whose region of intersection defines the single boundary edge fuel-metering orifice.

According to another important feature of the invention, the metering valve is arranged to meter fuel to the carburetor fuel jet in accordance with a function of throttle valve setting which is selected to attain an optimum fuel-air mixture and ratio at each throttle valve setting over the entire range of throttle valve adjustment from idling to full speed. The present

ideal relationship between airflow rate and fuel flow rate, over the entire range of throttle valve adjustment, is accomplished with maximum simplicity and minimum cost and is permitted primarily because of the clog-resistant configuration of the metering valve orifice; that is to say, the effective area of the mixing valve orifice can be made sufficiently small to provide the optimum fuel flow rate in every throttle valve setting from idling to full speed without danger of clogging and hence adverse effect on engine reliability. In the particular inventive embodiment illustrated in this disclosure, the metering valve is provided with the desired fuel-metering action by shaping the metering openings in the mixing valve sleeves in such a way as to maintain a substantially constant ratio between the effective areas of the metering valve orifice and the throttle valve opening over the full range of throttle valve settings.

The metering valve embodies low- and high-speed mixing adjustments for regulating fuel flow independently of the throttle valve. These low- and high-speed mixing adjustments are made with the throttle valve in its idling and full speed positions, respectively. According to an important feature of the invention, the low-speed or idling adjustment is equipped with a visible scale for indicating the normal idle adjustment range. This scale greatly facilitates proper idling adjustment of the carburetor.

The improved fuel-metering action of the present mixing valve, particularly at low engine speeds, permits attainment of another important feature of the invention. According to this latter feature, the throttle valve is arranged to regulate the relative effective inlet and exit areas of the carburetor venturi in such a way that the exit area exceeds the inlet area at low engine speeds. Under these conditions, the engine crankcase depression or intake vacuum is effective to draw fuel to the carburetor at low engine speeds. At high engine speeds, the fuel is drawn through the carburetor by the venturi action of the induction airstream. This feature of the invention renders the fuel-air ratio of the fuel-air mixture delivered by the carburetor relatively immune to fluctuation as a result of varying fuel delivery pressure or varying static pressure head on the fuel and permits the carburetor to draw fuel against the opposing action of a relatively large static pressure head on the fuel.

Yet another feature of the invention resides in the provision of a fuel reservoir about the mixing valve. This reservoir serves a dual function of preventing passage of air bubbles to the carburetor fuel jet and containing a supply of starting fuel for the engine.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of a carburetor according to the invention installed on a model gasoline engine;

FIG. 2 is an enlarged end view of the carburetor looking in the direction of the arrows on line 2–2 in FIG. 1;

FIG. 3 is a side view of the carburetor looking in the direction of the arrows on line 3–3 in FIG. 2;

FIG. 4 is an enlarged section taken on line 4–4 in FIG. 3;

FIG. 5 is a section taken on line 5–5 in FIG. 4 with the throttle valve rotated slightly;

FIG. 6 is a section, on reduced scale, taken on line 6–6 in FIG. 5;

FIG. 7 illustrates a modified fuel-metering valve according to the invention;

FIG. 8 illustrates the valve of FIG. 7 on enlarged scale in its high-speed position; and

FIG. 9 illustrates the valve in idling position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to these drawings, there is illustrated a carburetor 10 according to the invention mounted on a gasoline engine 11. In this instance, the engine is a small two-cycle gasoline engine of the type used on radio-controlled model airplanes, boats, and the like. Carburetor 10 has a body 12 through which extends an induction air passage P defining a venturi having an inlet I, an outlet O, and an intervening throat T. Mounted within the passage P is a throttle valve V_t which is movable between idling and high-speed positions to regulate induction airflow through the passage. Also mounted on the carburetor body 12 is a fuel jet J which projects into the carburetor venturi throat T. Fuel jet J communicates to a fuel inlet F on the body through a fuel-metering valve V_m. This valve has a variable area fuel-metering orifice M through which fuel flows from the inlet to the jet. The throttle valve V_t and the metering valve V_m are interconnected for adjustment of these valves in unison to regulate the effective area of the metering orifice M concurrently with regulation of induction airflow through the carburetor venturi. Embodied in the valve V_m is a low-speed adjustment A_L and a high speed adjustment A_h. These adjustments regulate fuel flow to the fuel jet J independently of the throttle valve V_t and, as will be explained presently, are set with the throttle valve in its idling and high-speed positions, respectively, to attain optimum fuel-air mixtures at these settings. About the fuel-metering valve V_m is a fuel reservoir R. This reservoir communicates the fuel inlet F to the valve orifice M.

The carburetor 10 is installed on the engine 11 by coupling the carburetor O to the engine air intake. During engine operation, induction air flow to the engine occurs through the carburetor venturi. Fuel flow occurs from the carburetor fuel inlet F, through the metering valve V_m, to the fuel jet J from which the fuel is discharged into the venturi throat T to mix with the induction air. The throttle V_t and the valve V_m are adjustable in unison to concurrently regulate induction airflow and fuel flow through the carburetor. The low-speed adjustment A_L and high-speed adjustment A_h are set with the throttle valve V_t in its idling position and its high-speed position, respectively, to attain optimum fuel air mixtures at these throttle settings. As noted earlier and hereinafter explained in greater detail, the primary features of the invention reside in the novel clog-resistant, single boundary edge configuration of the metering valve orifice M, the optimum fuel-metering action of the metering valve V_m, the configuration of the throttle V_t whereby crankcase depression or intake vacuum is utilized to draw fuel through the carburetor at low engine speeds, the reservoir R for inhibiting passage of air bubbles in the fuel to the fuel jet and containing engine starting fuel, and the visually indicated adjustment range of the low-speed adjustment A_L.

Referring now in greater detail to the drawings, the body 12 of the carburetor 10 which has been selected for illustration has a generally blocklike configuration and may be machined or injection molded from plastic or metal. Extending centrally through the body is a bore 13, one end of which is counterbored at 14. Rotatably fitted within the counterbore 14 is a valve barrel 15 which constitutes the throttle valve V_t. Valve barrel 15 has an outer end face substantially flush with the adjacent end face of the carburetor housing 12. Seating against this end face of the valve barrel is a throttle arm 16. Throttle arm 16 is firmly clamped to the valve barrel 15 by a screw 17, whereby the barrel may be rotated by the application of a force to the outer end of the arm. Extending through the outer end of the throttle arm 16 are a pair of holes 16*a* for receiving operating links 18*a*, 18*b*. These links will be referred to again presently.

Extending diametrically through the throttle valve barrel 15 is a bore 20 communicating a pair of diametrically opposed openings 21 and 22 at opposite sides of the carburetor body 12. Bore 20 and openings 21, 22 collectively define the carburetor venturi and individually define, respectively, the venturi throat T, inlet I, and exit O. The inlet and exit openings 21, 22 have inwardly convergent tapers and diameters at heir inner ends which are substantially equal to the diameter of the valve barrel throat bore 20. In the particular embodiment of the invention illustrated, the carburetor body 12 is injection molded in one piece, preferably from plastic, and the inlet opening 21 has a conically tapered wall 21*a* which is molded integrally with the body. The exit opening 22 has an externally cylindrical wall 22*a* formed by a sleeve which is fabricated separately from the carburetor body and is pressed fitted in or otherwise secured to the body.

The carburetor fuel jet J is provided by a tube or sleeve **23** which extends concentrically through and is firmly secured to the inner end of the throttle valve barrel **15**. One end **23***a* of this sleeve projects into and to the approximate center of the valve barrel bore **20** to form the fuel jet proper. This end of the sleeve has an opening **23***b* which forms a fuel exit orifice through which fuel emerges from the jet into the induction airstream flowing through the carburetor.

The opposite end **23***b* of the sleeve **23** extends centrally through the carburetor body bore **13** and forms one fuel-metering member of the fuel-metering valve V_m. Opening through the wall of this latter sleeve end is a narrow fuel port or slot **24** which is elongated in the axial direction of the sleeve. Slot **24** communicates the interior fuel passage in the sleeve to the fuel inlet passage **25** of the carburetor fuel inlet F. Metering valve V_m has a second flow metering member in the form of a valve sleeve **26** which is rotatable on and disposed in fluid sealing relation with the outer end **23***b* of the sleeve **23**. Outer sleeve **26** contains a fuel port or slot **27** which is elongated and tapered circumferentially of the sleeve. Slots **24**, **27** are disposed in intersecting relation in such a way that their region of intersection defines the mixing valve orifice M. As will appear from the later description, the sleeves **23**, **26** function as valve sleeves and, for this reason, will hereinafter be referred to as valve sleeves.

The low-speed adjustment A_L of the valve V_m comprises a peripherally serrated disc **28** which is rigidly secured to the outer end of the outer mixing valve sleeve **26**. This disc projects edgewise between two opposite side faces of the carburetor body **12**, as shown in FIG. **5**, to permit rotation of the disc by hand to turn the outer valve sleeve **26** relative to the inner valve sleeve **23**. The inner face of the disc seats slidably against the adjacent end face of the carburetor body. The outer end of the inner valve sleeve **23** projects a small distance beyond the outer face of the disc and is externally circumferentially grooved to receive a snap ring **30**.

It will now be understood that the throttle valve barrel **15**, mixing valve sleeves **23**, **26**, and the low-speed adjustment disc **28** are positioned axially relative to the carburetor body **12** by virtue of seating contact of the inner end of the barrel with the annular shoulder at the juncture of the carburetor body bore **13** and counterbore **14** and seating contact of the adjustment disc with the adjacent end face of the body. While these parts are restrained against axial movement relative to the carburetor body, the parts are free to turn relative to the body.

Surrounding the outer valve sleeve **26** of the metering valve V_m are a pair of O rings **31**. These O rings are contained within circumferential grooves in a pair of radially enlarged axially spaced shoulders **32** which are integrally formed on the outer valve sleeve. O rings **31** are located at opposite sides of both the mixing valve orifice M and the fuel inlet passage **25** and bear against the wall of the carburetor body bore **13** to define with this wall and the outer valve sleeve **26** the fuel reservoir R. This reservoir thus surrounds the valve V_m in the region of its orifice M and provides communication between the orifice and the fuel inlet passage **25**.

The high-speed adjustment A_h of the fuel-metering valve V_m comprises a screw **33** which is threaded into the outer end of the inner mixing valve sleeve **23**. The inner end of this adjustment screw is located adjacent the fuel-metering slot **24** in the inner valve sleeve **23**. Surrounding the screw between its head and the low-speed adjustment disc **28** is a compression spring **34**. This spring exerts axial pressure on the adjustment screw to effect frictional retention of the screw in its current setting.

Referring now to FIG. **1**, it will be observed that the present carburetor **10** is mounted on the engine **11** in the same way as the conventional model engine carburetor. Thus, the carburetor outlet sleeve **22***a* is coupled to the engine air intake so that induction air flow to the engine occurs through the carburetor venturi passage P. The carburetor throttle arm **16** is connected to a throttle actuator, such as a servoactuator, through the link **18***a*. Link **18***b* connects the throttle arm to the usual pivoted exhaust shutter **11***a* on the engine **11** for adjustment of the shutter and the carburetor throttle valve V_t in unison. The carburetor fuel inlet F is connected to a fuel tank (not shown) through a fuel line **35**.

From the description thus far, it is evident that the throttle valve barrel **15** and the inner valve sleeve **23** rotate in unison. During such unified rotation of the valve barrel and inner valve sleeve, the outer valve sleeve **26** remains stationary because of the frictional contact between its O rings **31** and the wall of the carburetor body bore **13**. As a consequence, rotation of the valve barrel **15** rotates the fuel-metering slot **24** in the inner valve sleeve **23** laterally along the fuel-metering slot **27** in the outer valve sleeve **26**. The outer metering slot **27** is longitudinally tapered so that lateral movement of the inner metering slot **24** along the outer slot varies the effective area of the intersection region of these slots. As already noted, this region defines the valve orifice M. Accordingly, rotation of the throttle valve barrel regulates the effective area of the valve orifice.

The effective area of the metering valve orifice M can also be regulated, independently of the throttle valve V_t, by rotating the low-speed adjustment disc **28**. This disc rotation rotates the outer valve sleeve **26** relative to the inner valve sleeve **23** and thereby rotates the outer metering slot **27** lengthwise relative to the inner metering slot **24**.

As clearly shown in the drawings, the metering valve orifice M is a simple, single boundary edge orifice of the kind discussed earlier. It will be recalled that an orifice of this type is characterized by relatively high immunity to obstruction and clogging by foreign particles in the fuel. This clog-resistant configuration of the valve orifice constitutes an important feature of the invention. Another important feature resides in the configuration of the metering slot **27** in the outer mixing valve sleeve **26**. As noted above, this slot is longitudinally tapered so that relative rotation of the mixing valve sleeves **23**, **26** regulates the effective area of the valve orifice M. However, the metering slot **27** is more than just tapered; it is tapered in a manner which yields the proper fuel-air mixture in every setting of the throttle barrel **15**. In the case of a model engine, the ideal mixture is at least closely approximated by maintaining a constant ratio between the effective area of the mixing valve orifice and the throttle valve opening. The metering slot **27** is tapered in a manner which maintains such a constant area ratio. In this regard, it is evident that the effective throttle valve opening is equal to the overlap area of throttle barrel bore **20** and carburetor body openings **21**, **22** and that this effective valve opening varies according to a nonlinear function of throttle barrel position or rotation. For this reason, the metering slot **27** is tapered to provide a selected nonlinear relationship between the mixing orifice area and the angular position of the throttle barrel **15**. Thus, the lower edge of each half of the metering slot **27** in FIG. **4** curves away from the upper slot edge as these edges approach the center of the slot in such a way that the increase in orifice area occasioned by given incremental rotation of the slots increases along the tapered slot according to a nonlinear function of valve sleeve rotation. This function is selected to yield a substantially constant ratio between orifice area and throttle opening. It should be noted at this point that the metering action of the valve V_m utilizes only one-half of the outer tapered metering slot **27**. The double-ended configuration of the illustrated metering slot is merely for manufacturing convenience.

The throttle valve V_t is arranged in such a way that in its full open or high-speed setting, the throttle valve barrel **15** occupies its position of FIG. **4**. In this position, the venturi throat bore **20** in the barrel and the venturi inlet and outlet openings **21**, **22** in the carburetor body **12** are coaxially aligned. The valve V_m is arranged so that in this high-speed setting of the throttle valve, the metering slot **24** in the inner valve sleeve **23** registers with the wide end of the tapered metering slot **27** in the outer valve sleeve **26**, as shown in FIG. **4**. Under these conditions, induction airflow through the carburetor venturi passage P produces a partial vacuum within the venturi throat T which draws fuel into the carburetor through the fuel inlet F, the metering orifice M, and the fuel jet J.

Rotation of the throttle valve barrel **15** from its high speed position of FIG. **4** to its idling position of FIG. **5** rotates the venturi throat bore **20** in the barrel out of alignment with the venturi inlet and outlet openings **21**, **22** and thereby reduces the effective areas of these openings. This reduction of the venturi inlet and outlet areas reduces induction air flow through the venturi passage P. Rotation of the valve barrel **15** from its high-speed position also rotates the inner valve sleeve **23** relative to the outer valve sleeve **26** in a direction to reduce the effective area of the metering valve orifice M. It will be understood from the earlier discussion of this orifice that this rotation of the throttle valve barrel reduces the effective area of the mixing valve orifice according to a nonlinear function of throttle valve setting; that is to say, the change in the orifice area occasioned by given incremental rotation of the throttle valve progressively diminishes according to a nonlinear function of throttle valve setting as the idling position is approached. The reverse is true, obviously, when the throttle valve barrel **15** is rotated from idling position toward high-speed position. In this case, the increase in the effective area of the mixing valve orifice M occasioned by given incremental rotation of the throttle barrel **15** progressively increases according to a nonlinear function of throttle valve setting as the high-speed position is approached. This function, which is determined by the curvature of the lower edge of the outer fuel-metering slot **27**, is selected to yield the desired fuel-air mixture at every throttle setting.

As noted earlier, this ability of the metering valve V_m to meter fuel properly over the entire range of throttle valve adjustment from idling to full speed results, in large part, from the relatively high immunity of the valve orifice M to obstruction by foreign particles in the fuel. Thus, such high immunity of the orifice to obstruction permits the orifice to be closed sufficiently to meter the fuel properly at idling without adversely affecting engine reliability.

As noted earlier, the efficient metering action of the metering valve V_m over the entire range of throttle valve adjustment provides another important advantage in the present carburetor. This advantage is the ability to utilize engine crankcase depression or intake vacuum to draw fuel through the carburetor at low-speed throttle settings. To this end, the throttle valve V_t is designed to regulate induction airflow through the carburetor venturi passage P by regulating the relative effective areas of the venturi air inlet I and exit O in such a way that the exit area exceeds the inlet area at low-speed throttle settings. Under these conditions, the engine crankcase depression or intake vacuum is effectively transmitted to the venturi throat T at low-speed throttle valve settings to aid, if not entirely effect, fuel induction through the fuel jet J. In this regard, it is significant to recall that the induction airflow rate through the carburetor venturi, and hence the venturi suction force produced by the induction airflow, are relatively small at low-engine speeds. This venturi suction force, by itself, is sufficient merely to overcome a static pressure head on the fuel equivalent to only 1 or 2 inches of fuel.

Regulation of the venturi inlet and exit areas in the manner just mentioned is accomplished, in the illustrated carburetor, by providing the bore **20** in the throttle valve barrel **15** and the inner ends of the venturi inlet and exit openings **21**, **22** with equal diameters and notching the edge of the outlet end of the valve barrel bore at **36**. This notch is located at the trailing side of the bore relative to the direction of valve barrel rotation from high-speed to idling position.

It will now be understood that in any position of the throttle valve barrel **15**, the venturi inlet I has an effective area equal to the overlap area of the venturi inlet opening **21** and the adjacent inlet end of the valve barrel bore **20**. The venturi exit O has an effective area equal to the overlap area of the venturi exit opening **22** and the adjacent exit end of the barrel bore. Rotation of the valve barrel **15** toward full open or high-speed position increases these effective areas, while rotation of the barrel toward idling position reduces the effective areas. As the valve barrel approaches its idling position, the effective venturi exit area exceeds the effective venturi inlet area by an amount equal to the cross-sectional area of the valve barrel notch **36**. The engine crankcase depression or intake vacuum is effective, under these conditions, to draw fuel through the carburetor at low-speed throttle settings. This differential area may be attained in other ways, of course, as by tapering the bore **20** to make the inlet **21** slightly larger than the outlet **22**.

This utilization of engine crankcase depression or intake vacuum to draw fuel at low-speed throttle settings results in two distinct benefits. First, the suction force produced in the fuel jet J by the crankcase depression is quite large, substantially larger, for example, than the venturi suction force produced by induction airflow through the carburetor. This larger, crankcase depression induced suction force is capable of drawing fuel through the carburetor against the action of a relatively large static pressure head on the fuel. The maximum static pressure head which the present carburetor will sustain without engine failure, for example, may be equivalent to 8 to 10 inches of fuel or more. Secondly, variations in the fuel delivery pressure or static pressure head on the head have little if any effect on the ratio of the fuel-air mixture delivered to the engine. Also, variations in the fuel level in the fuel tank do not affect the mixture. Thus, a model airplane equipped with a present carburetor may execute the aerial maneuvers referred to earlier without fear of engine failure.

Threaded in the carburetor body **12** and projecting into a slot **38** in the wall of the throttle valve barrel **15** is an adjustable stop screw **39**. This stop screw limits rotation of the valve barrel and is adjustable to regulate and fix the effective throttle valve opening in idling position.

It will be recalled that the metering valve V_m has high-and low-speed adjustments A_h, A_L. The low-speed adjustment A_L is made with the throttle valve barrel **15** in its idling position by rotating the low-speed adjustment disc **28**. Rotation of this disc rotates the outer valve sleeve **26** relative to the inner valve sleeve **23** to regulate the effective area of the valve orifice M. This adjustment is set to obtain the optimum fuel air mixture at idling. A feature of the invention resides in a reference mark **36** on the low-speed adjustment disc **28** which cooperates with scale markings **37** on the carburetor body **12**, to indicate the normal range of the low-speed adjustment. This greatly facilitates proper setting of the adjustment.

The high-speed adjustment A_h is made with the throttle valve barrel **15** in its full open or high-speed setting by rotating the high-speed adjustment screw **33** into or from the inner mixing valve sleeve **23**. This adjustment moves the inner end of the screw along the inner valve sleeve metering slot **24** to cover or uncover the slot, depending upon the direction of screw adjustment, thereby to vary the effective area of the mixing valve orifice M. The high-speed mixing adjustment is set to obtain the optimum fuel air mixture at full throttle position. As noted earlier, the spring **34** aids retention of the high-speed adjustment screw in its adjusted setting. Of significance is the fact that adjustment of the high-speed mixing adjustment screw **33** does not alter the effective area of the mixing valve orifice M in its idling position. This is because of the wall thickness of the inner valve sleeve **23** which permits fuel to flow, at idling, along the inner sleeve slot **23**, between the outer sleeve **26** and the inner adjustment screw **33**.

As noted earlier, the metering valve V_m is surrounded by the fuel reservoir R. This reservoir serves a two-fold function. First, it contains a supply of starting fuel for the engine **11**. This starting fuel supply is located in close proximity to the engine and thus facilitates starting of the engine. Secondly, the reservoir inhibits passage of large air bubbles in the fuel which would cause engine failure. Thus, any air which enters the reservoir in the fuel mixes in small amounts with the fuel leaving the reservoir through the mixing orifice M and is therefore absorbed by the engine in such small amounts as to not affect engine operation.

The operation of the present carburetor **10** is now obvious. Thus, with the carburetor mounted on the engine **11** in the manner illustrated in FIG. **1** and with the throttle valve V_t in

its full open position, induction air flow to the engine occurs through the carburetor venturi passage P. This induction airflow creates a venturi suction force which draws fuel into the carburetor through the fuel jet J to mix with the induction air. The high speed adjustment A_h is set to obtain the optimum fuel-air mixture at this full throttle position.

Rotation of the throttle valve V_t from its high-speed or full open position to its idling position progressively reduces the effective areas of the venturi inlet I and exit O. This adjustment of the throttle valve also adjusts the metering valve V_m to progressively reduce the area of the valve orifice M and thereby progressively reduce fuel flow to the engine. The low speed adjustment A_L is set to obtain the optimum fuel air mixture with the throttle valve in its idling position. The reverse action occurs when the throttle valve is rotated from idling position to full open or high-speed position. The valve V_m is effective to regulate or meter fuel flow through the carburetor in accordance with a nonlinear function of throttle valve setting which yields an optimum fuel-air mixture at every throttle valve setting.

Rotation of the throttle valve V_t toward its idling position reduces the induction airflow through the carburetor venturi passage P and thereby the venturi suction for pulling the fuel through the carburetor. As the throttle valve approaches its idling position, the effective area of the venturi exit O exceeds the effective area of the venturi inlet I. The engine crankcase depression or intake vacuum then becomes effective to draw fuel through the carburetor. The engine exhaust shutter **11***a* is positioned simultaneously with adjustment of the throttle valve in such a way that the exhaust port of the engine is covered by the shutter as the throttle valve approaches its idling position to effect dilution, by exhaust gas, of the fuel-air mixture entering the engine.

As noted earlier, the circumferential slot **27** of the fuel metering valve V_m is tapered in such a way as to provide a constant ratio between the effective area of the valve orifice M and the effective opening of the throttle valve V_t, since this constant ratio has been found to yield a satisfactory if not ideal fuel-air mixture for model engines over the entire range of throttle valve settings. In larger engines, some other relationship between orifice area and throttle opening may be better. Obviously, the metering valve illustrated can be designed to provide virtually any relationship desired by appropriate shaping of the tapered slot **27** and/or the longitudinal slot **24**.

Moreover, a constant ratio between the effective metering orifice area and the effective throttle opening may be attained in other ways. FIG. **7** illustrates an alternative metering valve V_m' for this purpose. In this case the fuel ports or slots **24, 27** of the valve V_m are replaced by fuel ports **24', 27'** of the same shape as the throttle valve openings **20, 21, 22**. In the particular embodiment illustrated, the fuel ports **24', 27'** are round to match the round shape of the throttle valve openings. It is evident that if the fuel ports are properly dimensioned and oriented in the same relative angular positions as the throttle valve openings **20, 21, 22**, adjustment of metering valve and throttle valve in unison will maintain a constant predetermined ratio between metering orifice area and throttle opening area. It is further evident that the metering valve ports or openings and the throttle valve openings may have any matching shapes which may yield either a nonlinear or linear relation between the effective orifice and valve opening areas and throttle valve position.

A feature of the valve configuration of FIG. **7** resides in a tapered notch **24***a'* in the wall of the inner valve port of opening **24'**. This tapered notch is located to be uncovered by the outer valve port or opening **27'** in the idling position of the mixing valve V_m' (as shown in broken lines) and permits accurate low-speed and idling regulation of the mixing orifice area by the low-speed or idle adjustment A_L'. The valve V_m' is otherwise identical to the valve V_m, as is the remainder of the carburetor. A primary advantage of the valve arrangement of FIG. **7** is its reduced cost owing to the ability of forming the valve sleeve ports by simple drilling and broaching operations.

I claim:

1. A carburetor comprising:
a body containing a bore and inlet and exit air passages at opposite sides of and opening at one end to said bore;
a throttle valve barrel rotatable in said bore between idling and high-speed positions and containing a transverse air passage having ends which overlap said ends, respectively, of said body passages in the circumferential direction of said barrel throughout the range of barrel rotation between said positions;
said passages defining an induction air venturi having an inlet and an exit formed by said inlet and exit passages, respectively, and a throat formed by said barrel passage;
the overlap area of said throat and inlet passages constituting the effective inlet area of said venturi, the overlap area of said throat and exit passage constituting the effective exit area of said venturi, and said inlet and exit areas having boundary edges on said body, and barrel which undergo relative movement to enlarge said inlet and exit areas upon rotation of said barrel in the direction of said high-speed position and reduce said inlet and exit areas upon rotation of said barrel in the direction of said idling position in a manner such that said exit area exceeds said inlet area throughout a range of low-speed positions of said barrel including said idling position;
means secured to said barrel and accessible externally of said body for rotating said barrel between said positions;
a fuel jet extending through one end of said barrel and opening to said venturi throat;
a fuel inlet on said body communicating with said fuel jet; and
a fuel-metering valve between said fuel inlet and said fuel jet including a pair of interfitting valve sleeves within said bore at said one end of said barrel and on the axis of said barrel, means securing one valve sleeve to said barrel for rotation with said barrel, means secured to the other valve sleeve and accessible externally of said body for rotating said other valve sleeve, and said valve sleeves having overlapping fuel ports through which fuel flows from said fuel inlet to said fuel jet and whose overlap area is varied to meter the fuel flow to said fuel jet by relative rotation of said valve sleeves.

2. A carburetor according to claim **1** wherein:
said bore opens through opposite sides of said body;
said barrel has an end exposed at one end of said bore and said other valve sleeve has an end exposed at the opposite end of said bore;
said barrel-rotating means comprises a throttle arm secured to said exposed barrel end and accessible at one side of said body; and
said other valve sleeve rotating means comprises a valve-sleeve-adjusting member secured to said exposed end of said other valve sleeve and accessible at the side of said body opposite said throttle arm.

3. A carburetor according to claim **1** including:
a fuel-metering screw accessible externally of said body and threaded in the inner valve sleeve for axial adjustment relative to said inner sleeve to cover and uncover the fuel port in said inner sleeve and thereby regulate fuel flow through said fuel ports independently of the relative rotation of said valve sleeves.

4. A carburetor according to claim **1** wherein:
the wall of said bore is radially spaced from the outer valve sleeve to define an annular fuel reservoir about and communicating with the fuel port in said outer sleeve; and
said fuel inlet opens to said reservoir.

5. A carburetor according to claim **4** wherein said fuel metering valve includes a pair of seal rings surrounding said outer valve sleeve at opposite sides of the fuel port in said outer sleeve and sealing said outer sleeve to the surrounding wall of said bore, and said reservoir is bounded by said outer valve sleeve, the wall of said bore, and said seal rings.

6. A carburetor according to claim **5** wherein:
said bore opens through opposite sides of said body;

said barrel has an end exposed at one end of said bore and said other valve sleeve has an end exposed at the opposite end of said bore;

said barrel-rotating means comprises a throttle arm secured to said exposed barrel end and accessible at one side of said body; and

said other valve-sleeve-rotating means comprises a valve-sleeve-adjusting member secured to said exposed end of said other valve sleeve and accessible at the side of said body opposite said throttle arm.

7. A carburetor according to claim 6 including a fuel-metering screw accessible externally of said body and threaded in the inner valve sleeve for axial adjustment relative to said inner sleeve to cover and uncover the fuel port in said inner sleeve and thereby regulate fuel flow through said fuel ports independently of the relative rotation of said valve sleeves.

8. A carburetor according to claim 7 wherein:

said inner valve sleeve is secured to said barrel and extends axially through said barrel into said throat to form said fuel jet; and

said valve-sleeve-adjusting member is secured to said outer valve sleeve, and said body and valve-sleeve-adjusting member have indicia for indicating the normal range of adjustment of said valve-sleeve-adjusting member.

9. A carburetor comprising:

a body containing a bore and inlet and exit air passages at opposite sides of and opening at one end to said bore;

a throttle valve barrel rotatable in said bore between idling and high-speed positions and containing a transverse air passage having ends which overlap said ends, respectively, of said body passages in the circumferential direction of said barrel throughout the range of barrel rotation between said positions;

said passages defining an induction air venturi having an inlet and an exit formed by said inlet and exit passages, respectively, and a throat formed by said barrel passage;

the overlap area of said throat and inlet passages constituting the effective inlet area of said venturi, the overlap area of said throat and exit passage constituting the effective exit area of said venturi, and said inlet and exit areas having boundary edges on said body and barrel which undergo relative movement to enlarge said inlet and exit areas upon rotation of said barrel in the direction of said high-speed position and reduce said inlet and exit areas upon rotation of said barrel in the direction of said idling position, means accessible externally of said body for rotating said barrel between said positions;

a fuel jet extending through one end of said barrel and opening to said venturi throat;

a fuel inlet on said body communicating with said fuel jet; and

a fuel-metering valve between said fuel inlet and said fuel jet including a pair of interfitting valve sleeves within said bore at said one end of said barrel and on the axis of said barrel, means securing one valve sleeve to said barrel for rotation with said barrel, means secured to the other valve sleeve and accessible externally of said body for rotating said other valve sleeve, said valve sleeves having overlapping fuel ports through which fuel flows from said fuel inlet to said fuel jet and whose overlap area is varied to meter the fuel flow to said fuel jet by relative rotation of said valve sleeves, the wall of said bore being radially spaced from the outer valve sleeve to define an annular fuel reservoir about and communicating with the fuel port in said outer sleeve and said fuel inlet.

10. A carburetor according to claim 9 wherein:

said bore opens through opposite sides of said body;

said barrel has an end exposed at one end of said bore and said other valve sleeve has an end exposed at the opposite end of said bore;

said barrel rotating means comprises a throttle arm secured to said exposed barrel end and accessible at one side of said body;

said other valve sleeve rotating means comprises a valve-sleeve-adjusting member secured to said exposed end of said other valve sleeve and accessible at the side of said body opposite said throttle arm; and

said fuel-metering valve includes a pair of seal rings surrounding said outer valve sleeve at opposite sides of the fuel port in said outer sleeve and sealing said outer sleeve to the surrounding wall of said bore, said fuel reservoir being bounded by said outer sleeve, the wall of said bore, and said seal rings.