Oct. 12, 1954

E. RIVOCHE

2,691,509

METHOD AND APPARATUS FOR SUPPLYING FUEL

Filed March 31, 1950

4 Sheets-Sheet 1

Fig. 1

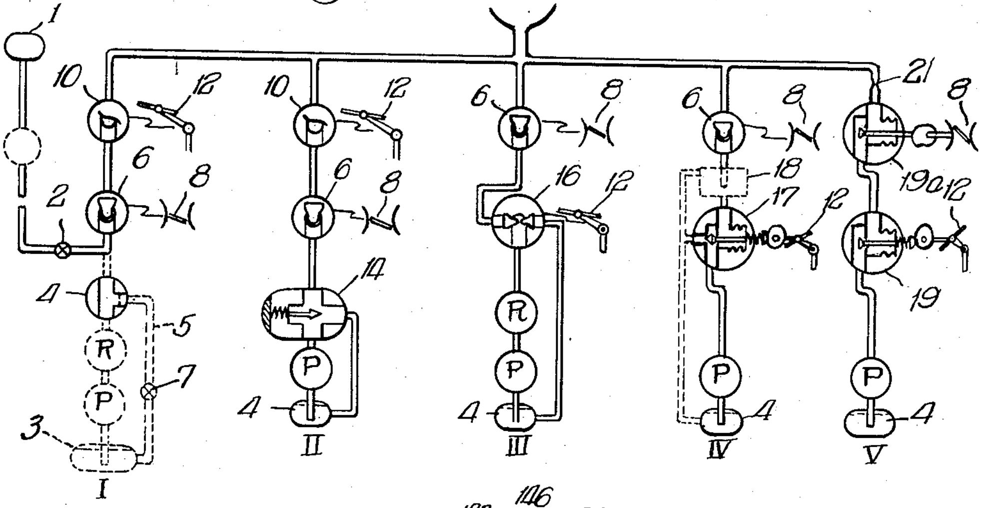


Fig. 4

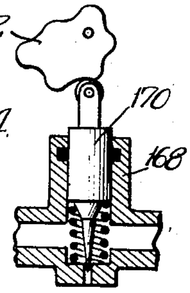


Fig. 2

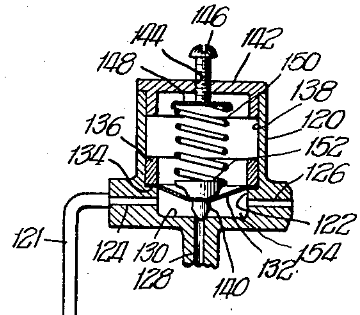
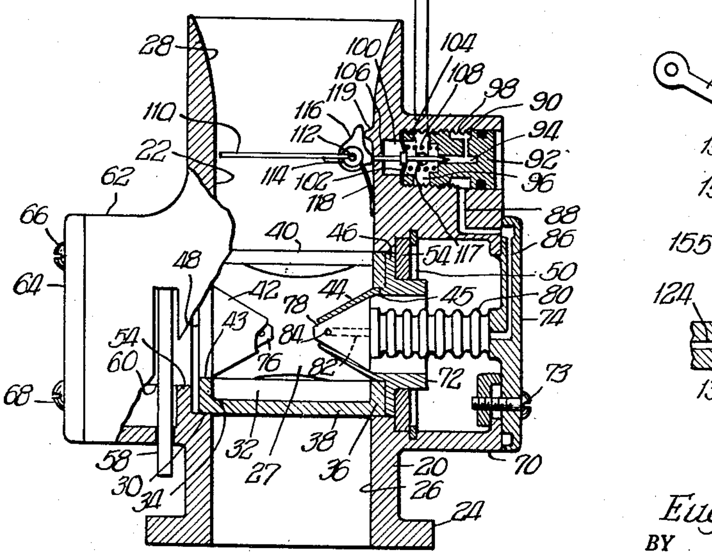
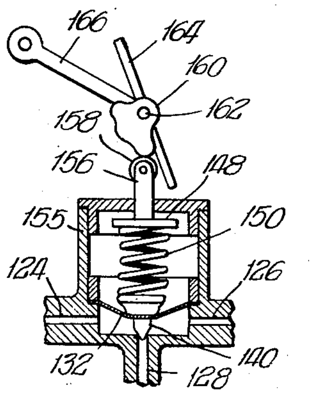



Fig. 3



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4 Sheets-Sheet 2

Fig. 5

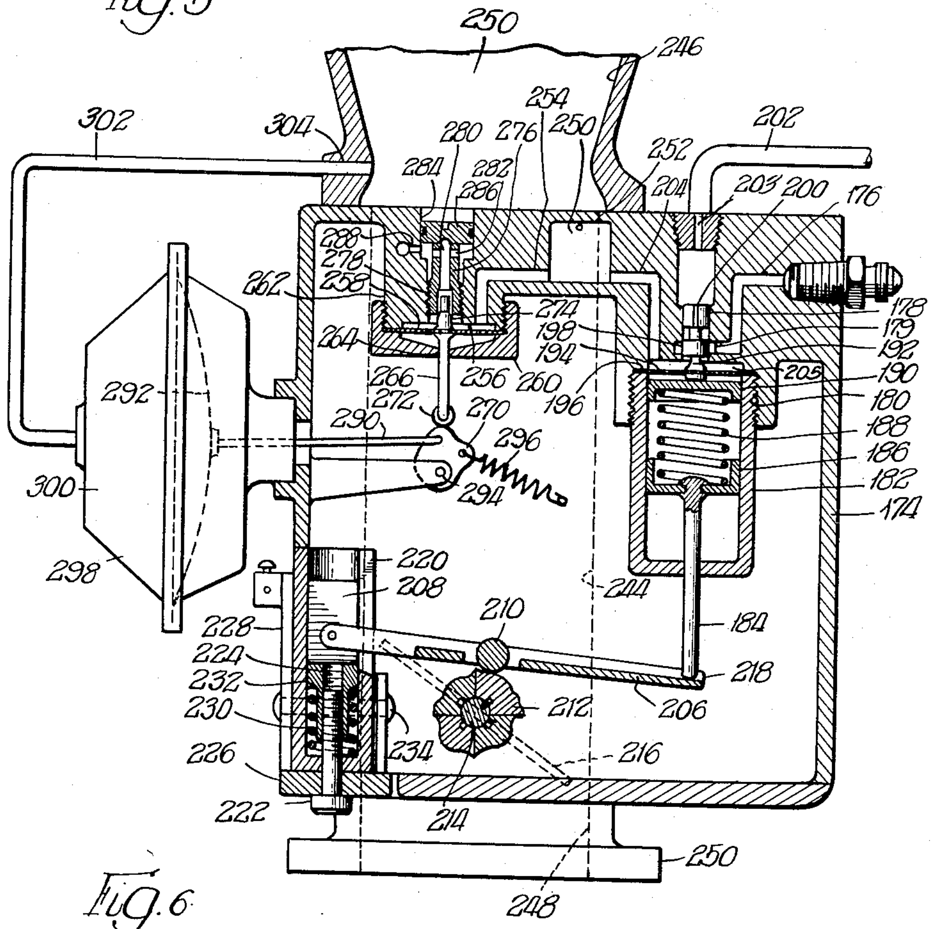

Fig. 6

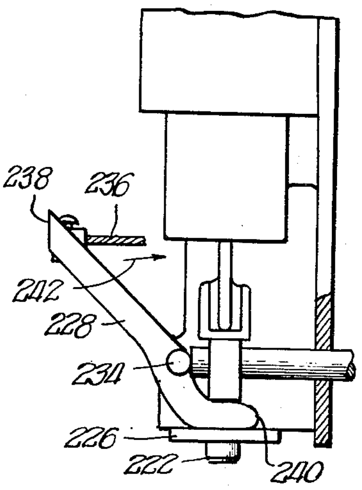

Fig. 7

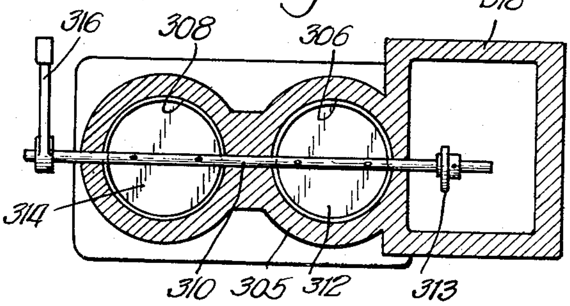

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Fig. 8

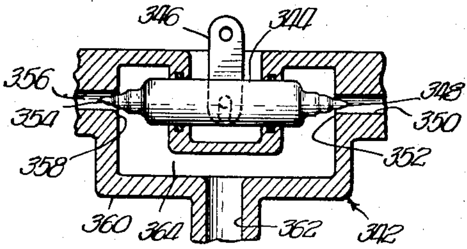

Fig. 9

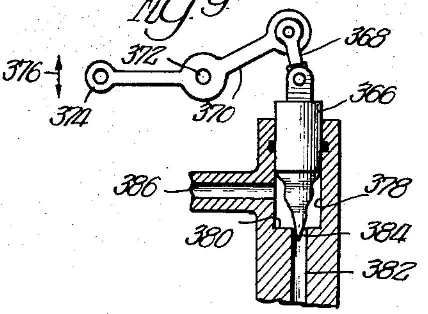

Fig. 11

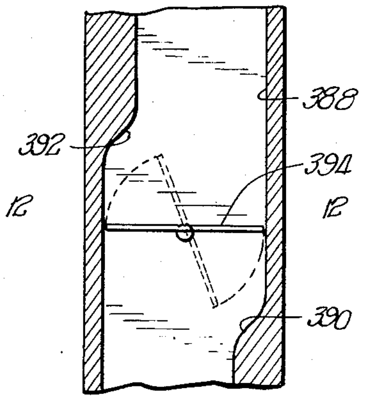

Fig. 13

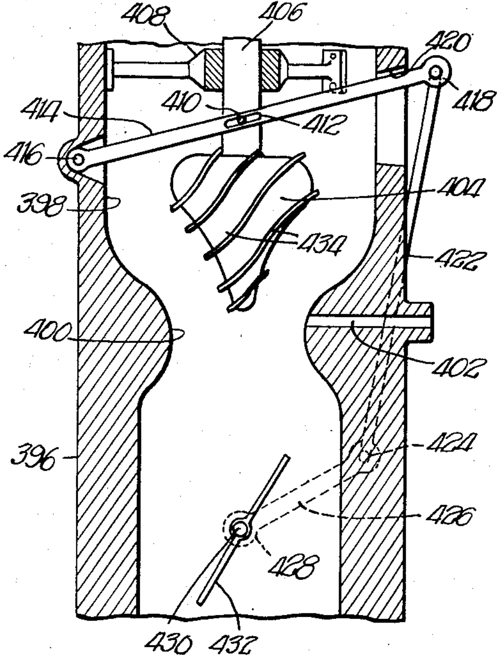

Fig. 12

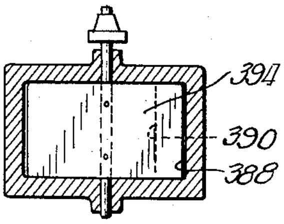

Fig. 10

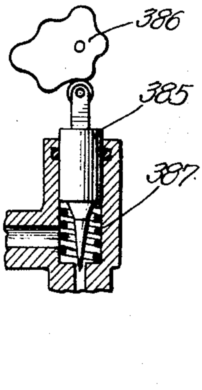

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Fig. 14.

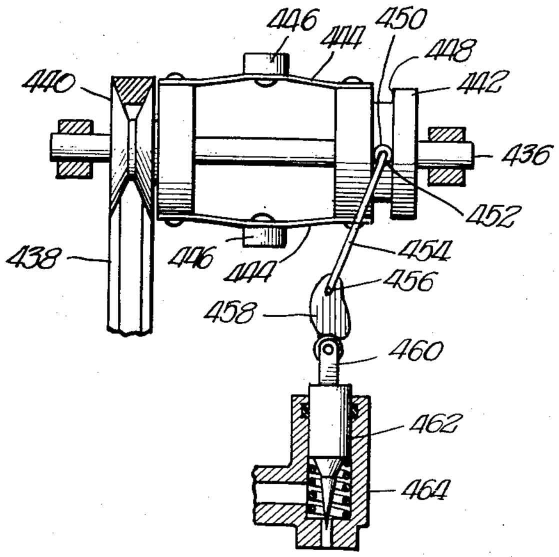
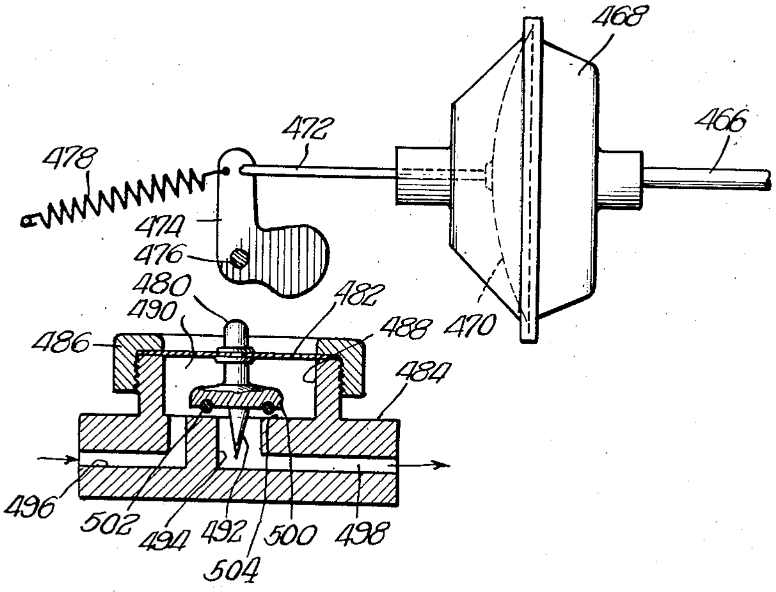


Fig. 15



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Patented Oct. 12, 1954

2,691,509

UNITED STATES PATENT OFFICE

2,691,509

METHOD AND APPARATUS FOR SUPPLYING FUEL

Eugene Rivoche, Washington, D. C.

Application March 31, 1950, Serial No. 153,162

4 Claims. (Cl. 261—36)

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This invention relates to a method and apparatus for supplying a metered quantity of fuel-air mixture to internal combustion engines and the like, and is a continuation in part of my copending application, Serial No. 109,787, filed August 11, 1949, now Patent No. 2,630,304, issued March 3, 1953.

More particularly, it relates to a method and apparatus of the character described which comprises an air throttle member for controlling the supply of air to the engine and a plurality of fuel flow control members disposed in a series arrangement, at least one of which is activated by the air throttle member, and at least one of which is activated by variations in the engine speed or the rate of flow of air thereto.

The function of the fuel flow control member which is activated either by variations in the engine speed or the rate of flow of air to the engine, is to maintain the flow of fuel within the limits of the maximum power fuel-air ratio. The function of the fuel flow control member which is actuated by the air throttle member, on the other hand, is to superimpose on this limitation just mentioned a further limitation to the flow of fuel, which limitation is consistent with the power demands on the engine. In this way a completely smooth change in the rate of fuel flow from that required for maximum power to that required for maximum economy can be obtained.

A much greater flexibility in the pattern of operation of these fuel flow control members than would be the case if movement of these members were necessarily proportional to the movements of the throttle or an air flow sensing member is provided by interposing an intermediate mechanism between this latter power source and each fuel flow control member. This flexibility which is achieved in this fashion is one of the important and novel aspects of this invention. This flexibility permits such members to be operated in synchronism with the movement of the air throttle, or an air flow sensing member, for example, but also permits the disposition of an element, such as a cam or other contoured member, in the intermediate mechanism, which element will determine the actual amount of variation in the setting of the fuel flow control member that is produced by any predetermined amount of variation in position of the air throttle or air flow sensing member. Obviously, the same arrangement could be utilized with a fuel flow control member which is operated in synchronism with the variation of the engine speed.

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Obviously, accurate control of the fuel flow to the engine can be maintained by the fuel flow control members only if the pressure on the fuel supplied to these control members is accurately controlled. For example, variations in pressure of the fuel supplied to such fuel flow control members, one of which is actuated by the air throttle member and one of which is actuated by an air flow sensing member, in turn will cause variations in the rate of flow of the fuel through these metering devices, and therefore a particular metering pattern cannot be maintained successfully.

An additional component of the fuel supply system, which is the subject matter of this invention, therefore is a pressure control member which is capable of automatically maintaining a substantially constant fuel pressure for any particular setting thereof, regardless of variations in pressure of the fuel supplied thereto or in the quantity of flow of fuel therefrom through the fuel flow control members. Although the maintenance of a substantially constant pressure as described would be the ideal situation, practical limitations in the construction of such a regulator permit the pressure to be maintained substantially constant only at any particular rate of flow. Some pattern of variation of pressure with changes in the flow rate will ordinarily exist but the only requirement for satisfactory metering is that this pattern be constant between the pressure which is maintained at a high rate of flow and that which is maintained at a low rate of flow. In other words, a regulator which establishes a substantially constant pressure at any particular rate of flow is sufficient. Therefore, the phrase "substantially constant" as used hereafter in this application will mean "substantially constant at each rate of flow," rather than substantially constant for all rates of flow. Such a pressure control member may be combined with one of the fuel flow control members if desired, and the resultant combination will be capable of accurately metering the flow of fuel regardless of variations in the pressure of the fuel supplied thereto, and will in addition maintain the fuel flow therefrom at a constant pressure at any setting of a second fuel flow control member through which the output of the combination device flows.

It is therefore an object of this invention to provide a fuel supply system for internal combustion engines and the like, which permits the maintenance of the most desirable fuel-air ratio at any engine speed under any load condition.

Another object of this invention is to provide a device which has unusual mechanical simplicity and yet which provides complete mixture control, varying the richness of the mixture smoothly and gradually from no-load conditions to full power conditions, which results have previously been only approximated even with complex mechanical structures.

Still another object is to provide a fuel metering system and apparatus which permits the realization of any maximum power or maximum economy curve of fuel-air mixture versus engine-air consumption.

Another object is to provide a carburetor which operates under pressures as supplied, for instance, by the usual fuel pump and not only by aspiration of the engine, and which operates relatively independently of variations in the pressure of the fuel supplied within reasonable limits.

A further object is to provide a fuel metering system and apparatus which gives an extremely smooth variation of supply since only one jet is required to achieve such variation and no lack of uniformity in the supply rate occurs as it normally does during the cutting in or out of the supplementary jets which are generally required for an aspiration type carburetor.

A further object is to provide a fuel metering system and apparatus which gives an unusually good continuity of supply of fuel, since it is injected under pressure and the supply therefore will not be affected by the position of the carburetor or by abrupt changes in the normal position thereof, as may occur in many bowl supply designs, nor will the fuel supply be cut off at exceedingly slow speeds, such as when a load is applied during closed throttle operation, since the fuel supply will continue at the idle rate although the engine-air consumption decreases due to a decrease in the R. P. M.

A further object is to provide a fuel metering system which requires no accelerator pump, and therefore is free from overloading, since excessive enrichment due to injudicious use of the throttle cannot occur during the start or low speed operation.

Another object is to provide a carburetor which does not utilize a float and thus there is no open reservoir of liquid adjacent to the engine which could be ignited accidentally.

Another object is to provide a carburetor which is positive of operation, whereby it causes the engine with which it is associated to start immediately, whether the temperature is low or not, and regardless of the aspirations of the engine.

Another object of the invention is to provide an inexpensive, easily operated, adjusted or repaired carburetor for an internal combustion engine which will operate in any position of vertical or horizontal alignment.

Another object is to provide a carburetor so constructed and arranged that it is readily interchangeable with engines of different sizes, within a reasonable range, the only requirement being one of adjustment or the proper selection of easily changed cams or other similarly contoured components.

A further object is to provide a fuel metering system which eliminates the tendency for intake manifold loading during long periods of deceleration, since no idle jet is provided below the throttle, and the fuel supply may be made completely dependent upon the metering valves, which under conditions of deceleration supply fuel at the idle rate.

A further object is to provide a fuel metering system which readily lends itself, in spite of its automatic aspects, to being provided with an alternative manual or automatic control of the enrichment of the air-fuel mixture for use during cold starting and warm-up periods.

A further object is to provide a fuel metering system which reduces very greatly the possibility of vapor formation in the carburetor and fuel supply channels, as well as lending itself to a disposition such that any vapor formed will be removed from the supply channel.

A further object is to provide a fuel metering system which, when supplied with fuel under pressure from a pump which tends to maintain pressure in the supply line after the engine stops, does not require a fuel shut-off valve.

A further object is to provide a fuel metering system which has relatively large metering holes in the various components and therefore which has less tendency to have foreign matter lodge in such holes to produce jet clogging.

A further object is to provide a fuel metering system which readily lends itself to providing a multiplicity of metering curves, any one of which may be used at the option of the operator, thereby providing the operator the possibility of selection, for instance, of the degree of compromise between high performance and economy operation, or the selection of a governing type of fuel supply curve, or the operation of the engine with fuels of varying viscosity, etc.

A further object is to provide a fuel metering system which lends itself particularly to use with one or more supplementary fuels or suitable additives, in any desired proportion to the principal fuel.

A further object is to provide a fuel metering system which, because of the fact that the fuel is injected under positive pressures, does not require the placement of jets in a low pressure area, which jets when so disposed are subject to having frost deposited thereon.

A further object is to provide a fuel metering system which, because it needs no idle jet disposed on the manifold side of the throttle, eliminates the common difficulty in the automotive field of ice formation during idling periods.

A further object is to provide a fuel metering system which permits the fuel supply to be substantially cut off during periods of deceleration.

A further object is to provide a fuel metering system which permits the incorporation therein of a compensating device for pressure variations produced by variations in air density.

Still another object of this invention is to provide a carburetor which utilizes only one set of fuel metering elements and yet which is capable of supplying accurately metered fuel to both sections of a dual manifold engine or to each section of a multi-manifold engine.

Further objects and advantages of this invention will become evident as the description proceeds and from an examination of the accompanying drawings which illustrate several embodiments of the invention, and in which similar numerals relate to similar parts throughout the several views.

In the drawings:

Figure 1 is a diagrammatic representation of a plurality of fuel metering systems embodying the invention;

Figure 2 is a view in elevation and partly in vertical section of one form of carburetor which may be utilized with the system embodying the invention;

Figure 3 is a view in elevation and partly in vertical section of a combined pressure regulating and metering valve;

Figure 4 is a view in elevation and partly in vertical section of a metering valve of the by-pass type;

Figure 5 is a view in elevation and partly in vertical section of another form of carburetor which may be used in a supply system which embodies the invention;

Figure 6 is an enlarged fragmentary view of the manual override mechanism for adjusting the pressure level, which mechanism is a part of the carburetor shown in Figure 5;

Figure 7 is a view in horizontal section from above of a dual carburetor incorporating the general type of unit shown in Figure 5, together with an additional air flow passage and associated throttle member;

Figure 8 is a view in elevation and partly in vertical section of a modified form of by-pass valve having a valve stem which simultaneously controls two orifices;

Figure 9 is a view in elevation and partly in vertical section of an alternative type of fuel flow control valve having a contoured valve stem;

Figure 10 is a view in elevation and partly in vertical section of a cam-operated metering valve having a straight tapered stem;

Figure 11 is a view in elevation and partly in vertical section of a manifold and a throttle member disposed therein of the butterfly type, the walls of the manifold being irregularly contoured;

Figure 12 is a view in horizontal section from above of the throttle member shown in Figure 11, the view being taken along the line 12—12 of Figure 11;

Figure 13 is a view in elevation and partly in vertical section of a contoured manifold having a Venturi block therein synchronized with the air throttle member, said Venturi block being adapted to control the velocity of the air flow past the contoured portion of the manifold;

Figure 14 is a somewhat diagrammatic view in elevation of a form of metering valve adapted to be activated by variations in the speed of the engine with which it is associated; and

Figure 15 is a view in elevation and partly in vertical section of a fuel supply cut-off valve adapted to operate during periods of deceleration.

Referring to Figure 1, a diagrammatic representation of five fuel metering systems and associated apparatus embodying the invention is contained therein. The first embodiment, indicated generally by the numeral I, comprises first of all a fuel pressure control arrangement which may take the form of a gravity feed system supplied from the main fuel supply tank 1, having the shut-off valve 2 interposed between the tank and the fuel flow control members. Obviously, a float and bowl arrangement (not shown) could also be utilized, the fuel being supplied thereto by a higher tank or a fuel pump. A conventional reducer-regulator R may be incorporated also,

which is represented by dotted lines in the conduit from the tank 1 to the shut-off valve 2.

An alternative means of fuel pressure control is shown in the dotted line portion of the first embodiment I, which comprises a fuel supply tank 3, the fuel pump P connected therewith, the reducer-regulator R and a by-pass valve 4. The by-pass valve 4 has a bleeding orifice of fixed diameter therein, which is adapted to permit a flow of fuel back to the fuel supply tank 3 through the conduit 5. The shut-off valve is not required in this alternative form of feed system since the by-pass valve 4 will normally serve to return fuel supplied under pressure after the engine has stopped, to the fuel supply tank 3, the resistance to flow being sufficiently small through the return conduit 5 to insure that the excess fuel supplied passes therethrough rather than on to the fuel flow control members. A valve 7 may be provided in the conduit 5 to permit reduction of the flow therein and therefore increase the resulting pressure on the metering valves.

Regardless of the source of the constant fuel supply pressure, the flow to the induction air is regulated by two contoured metering valves of predetermined shape. One of these valves 6 is adapted to operate in accordance with either engine speed or engine air consumption, producing any desired variation of resistance to fuel flow by suitable shaping of the parts controlling the valve opening, diagrammatically shown as a contoured needle valve moved by an air vane 8 associated therewith, which is disposed in the induction air inlet tube. The structure of this valve may take many forms, some of which are subsequently described. Valve 6 in turn is connected to valve 10, which is adapted to be operated simultaneously with throttle 12, which is diagrammatically represented and shown as being in operative association with valve 10. This latter valve produces the desired variation of resistance to fuel flow in a manner similar to valve 6, and may take many forms, some of which are described below.

In operation, the unmetered fuel is supplied to the metering valves under constant pressure. Considering first a full throttle acceleration, the throttle operated valve 10 will be at a fixed, large flow, position. The valve 6, on the other hand, being responsive to either engine speed or engine air consumption, will vary in position as the engine responds to the power demand. By suitable shaping of the elements of this valve 6, the fuel flow resulting from the imposed, constant fuel pressure and the valve resistance may be limited to that flow required for the desired maximum enrichment of the fuel-air mixture at any particular speed of the engine or at any rate of air consumption of the engine, depending on the manner of activation of the valve 6. During level road load or cruising conditions, the throttle element 10 will be partially closed and thus the throttle operated metering valve will be repositioned, and by suitable shaping of the elements of the valve 10, the fuel flow may be additionally restricted at each throttle setting, thereby reducing the richness of the mixture to the desired economy fuel-air ratio at each steady throttle position.

During part throttle acceleration, a highly desirable condition exists in that a degree of enrichment will occur which varies with the magnitude of the power demand, due to a partial reduction of the resistance to flow offered by the throttle operated valve 10 just described. When such acceleration is initially carried out by advancing the throttle and thus opening the valve 10, the fuel flow will be instantaneously increased but can never exceed the flow resulting in the maximum power fuel-air mixture, since the flow is limited to this maximum by the valve 6, which is dependent in its operation upon engine speed or air consumption rather than throttle movement.

It should be noted also that the relative positions of these two valves 6 and 10 may be interchanged in the flow circuit without changing the results in any way. It also should be mentioned that a fuel system of this general character, as indicated generally by the numeral I in Figure 1, is described in applicant's Patent No. 2,630,304 aforesaid.

As previously stated, a fuel conduit 5 is indicated by dotted lines, connecting a by-pass valve located anterior of the first metering valve to the supply tank. This bleeding system may be used, if desired, to provide a number of advantages, such as: (1) Pressure dissipation by flow via the bleeding system when the engine is shut down eliminates the necessity of a fuel shut-off device to prevent overloading of the intake manifold; (2) means for reducing the by-pass flow can be incorporated so that additional pressure may be provided to the carburetor as desired, thus permitting any necessary enrichment for cold engine starting and for power development generally; (3) increase of flow-rate from the fuel pump due to the decrease of the discharge pressure decreases the time of dwell of gasoline in the supply lines, and thus aids in delivery of cool fuel, thereby reducing vapor formation; and (4) location of the bleeder near the carburetor will permit the separation of any vapor formed in the lines from the carburetor supply.

A second embodiment of a fuel metering apparatus embodying the invention is indicated generally in Figure 1 by the numeral II. This system is adapted for use with a fuel pump, as for example the conventional automotive type, but differs from embodiment I in that the carburetor fuel supply pressure is maintained at a constant level by an automatically controlled by-pass valve 14, which performs the function of the pressure regulator and allows the excess fuel supply to flow back to the tank 4, providing the same advantages previously mentioned in connection with the bleeder system.

Another form of fuel metering apparatus embodying the invention is indicated generally in Figure 1 by the numeral III. This system provides a degree of bleeding variable with throttle setting. Obviously, it could be varied instead with the setting of the air flow sensing device. Unmetered fuel is supplied at a constant pressure to a doubly contoured two-way valve 16, which is adapted to be varied in its position by the throttle arm 12. Then, by proper contouring, the pressures existing on valve 6 may be varied as desired, as previously described, and the minimum amount of bleeding, consistent with achievement of the aforementioned bleeding advantages, can be simultaneously provided.

Still another alternative embodiment of the fuel metering apparatus embodying the invention is indicated by the numeral IV. This system achieves the same flow results in a somewhat different manner, wherein the function of the pressure regulator and the throttle operated metering valves are combined, so that the fuel pressure, and thus the fluel flow, through the engine speed, or inducted air speed operated contoured metering valve, is varied by the throttle controlled, contoured, cam-operated pressure regulator 17. This pressure regulation may be achieved by several means which will be later described.

In operation, the unmetered fuel is supplied through this system at pump pressure to the throttle operated pressure regulator 17. Under conditions of full throttle acceleration, a certain maximum pressure is maintained by the pressure regulator. This pressure is imposed on the engine speed or air consumption operated valve 6, which maintains the flow of the fuel within the limits of the maximum power requirements, throughout the speed range of the engine as previously described. During steady road-load or cruising operation, on the other hand, the throttle 12 is partially closed, and the pressure regulator therefore is repositioned. By proper contouring of the elements of the regulator, the pressure may be so reduced by this repositioning that the flow through the metering valve 6 is reduced to the desired economy fuel flow. Part throttle accelerations are achieved with a partial increase in the supply pressure and thus a partially enriched mixture will be supplied the engine.

It should be noted that a variation of this embodiment is possible, whereby the contour cam operated pressure regulator 17 may be activated by the engine speed or air consumption sensing device 8 rather than by the throttle control members, and thereby regulating the pressures to the desired level throughout the range of engine operation, while the metering in such a case is performed by a suitably contoured valve controlled by the throttle position.

In operation, during full throttle acceleration, the throttle operated metering valve is at a fixed large opening position. The flow is dependent upon the pressures imposed by the engine speed, or air consumption operated regulator, the component parts being so adapted as to produce the desired variation of pressure with a change of engine speed or air consumption, which will provide the fuel flow rate for the desired maximum power enrichment. During level road-load or cruising conditions, the throttle is partially closed, thereby reducing the flow to the desired amount under the imposed pressure conditions for the desired economy fuel flow rate.

To remove undesirable vapor formed in the supply line and to eliminate the necessity for a shut-off valve, it should be noted that a bleeder orifice and return line may be used anterior to the pressure regulator in this embodiment also. In addition, a chamber 18 (shown in dotted lines) may be placed posterior to the regulator, wherein vapor formed due to the pressure decrease may collect and be removed through a small bleeding orifice and returned to the tank or to the carburetor.

It should be noted that a variant of this last described system exists which may provide satisfactory metering for certain purposes although the designer does not have complete control of the variation of fuel flow during maximum power acceleration. Such a system would replace the engine speed operated pressure regulator with a suitable engine driven pump which will provide an output varying as some function of engine speed. Properly designed or selected, a system might be devised which would provide a flow variation with engine speed during full throttle acceleration, which variation may conform to the ideal variation within required practical limits. Of course, the level load flow rate, being controlled by a suitably contoured throttle operated valve, may be designed to provide any desired economy mixture at each level load condition.

A final alternative embodiment is indicated in Figure 1 by the numeral V. This system provides for fuel flow control entirely by controlled variation of the fuel supply pressure on a fixed sized orifice. Unmetered fuel is supplied to an adjustable pressure regulator **19**, adapted to be varied in its pressure setting as any desired function of the position of the throttle **12**. The fuel is then supplied to a second pressure regulator **19***a*, which device is adapted to be varied in its pressure setting as any desired function of the rate of consumption of air by the engine. This arrangement is symbolically illustrated by the air vane **8**, which is operatively connected to the pressure regulator through a cam arrangement. The fuel is thus metered to provide a certain pressure level on a fixed sized orifice, the flow therethrough being directed into the flow of inducted air in a suitable manner.

In operation of this embodiment, consider first a full throttle acceleration from a low speed. During this period, the throttle operated pressure regulator **19** will be at some high pressure setting. By properly contouring the parts controlling the setting of the pressure regulator at each position of the air speed sensing device **8**, the pressure may be reduced to that required for producing the necessary fuel flow via the fixed orifice at each condition of air consumption as the engine responds to the power demand; for example, the maximum power fuel air mixture.

During steady throttle, level load conditions, the setting of the pressure regulator controlled by the air speed sensitive unit will be such that the fuel pressure at the orifice **21** would normally provide the above described power mixture. However, due to the repositioning of the throttle operated pressure regulator setting mechanism **19**, the pressure of the fuel being supplied to the pressure regulator **19***a* may be reduced to that pressure which will produce the flow via the orifice **21** required for producing the maximum economy fuel-air mixture at each level load speed and throttle setting. This latter pressure, produced by the setting of the regulator **19**, is less than the pressure to which the flow would be normally limited by the regulator **19***a*.

During part throttle acceleration, the highly desirable condition of an enriched mixture will be provided, the degree of enrichment increasing with the magnitude of the power demand; the upper limit being the maximum power fuel-air mixture which occurs at full throttle.

Obviously, the relative position of the regulators in the series may be freely interchanged without affecting the operation as above described, inasmuch as the regulator having the lesser pressure setting is the controlling element, regardless of its position.

Of course, an engine speed operated pressure control mechanism could be utilized in place of the air speed sensitive pressure control mechanism in a substantially similar manner.

As previously stated, all of these embodiments enable the attainment of any desired ratio of fuel to air, so that the desired maximum economy mixtures are obtained at any steady speed, constant throttle setting while, at the same time, any curve of desired maximum power fuel-air mixture against engine air consumption or engine speed are achieved under conditions of full or maximum power demand.

By way of summarizing the general features of these various embodiments, it should be pointed out that there are four basic components in all of these systems, although some of them may be combined in such a way as to appear to be only a single component.

First of all, a pressure control means is utilized which may take many forms. Gravity feed systems may be used where low constant pressures is satisfactory. As previously stated, this type of supply system may incorporate a reservoir having a float type shut-off valve which receives its supply from a higher supply tank or a fuel pump. This method has a disadvantage of requiring a shut-off valve **7** to prevent the flow in non-operative periods. Alternatively, a conventional reducer-regulator system may be used to reduce and control the pressures developed by a fuel pump so that the desired supply of pressure is attained, regardless of reasonable fluctuations of pump performance. Also, as previously stated, a fuel pump which is inherently self-regulating, may be used, thereby replacing the pressure regulator. In addition, a by-pass pressure control system may be utilized, which system has many advantages, as mentioned above. Lastly, an engine driven variable delivery fuel pump also may be utilized.

A choke is unnecessary for creating the initial flow of fuel for easy starting in a fuel supply system embodying this invention because the fuel is injected under pressures developed by a positive action fuel pressure device and not by the usual sucking action. For warm-up, however, a choke mechanism may be provided to permit the creation of a higher effective pressure on the fuel supply as desired. It may be more desirable, however, to increase the fuel supply pressure during warm-up automatically by using a thermal sensitive spring on the pressure regulating device. Manual enrichment may also be accomplished by providing override on the pressure controller, means for manually advancing the relative positions of either metering valve, or by adding a restriction in the by-pass line.

Altitude compensation may be made possible by the addition of an atmospheric pressure sensitive device, such as bellows, to automatically decrease the fuel pressure.

The second basic component is the throttle operated fuel flow control valve, which device may take many forms, either as an element in itself or as a portion of a combination element. For example, it may take the form of a straight, tapered needle valve which may be moved to the desired position with respect to the valve seat by means of an irregularly contoured cam rotating with the throttle shaft (such as shown in Figure 10). Then at any given angular position of the throttle, the cam may force the needle to the position creating the desired resistance. The same effect may be obtained by direct linkage to a needle valve of an irregular geometrical shape (such as shown in Figure 9), where the cross-section of the needle which obstructs the orifice is of such dimensions as to create the desired resistance during that particular throttle setting.

A combination of cam and contoured valve is also obviously possible if special considerations of manufacture and use should warrant it.

As shown in Figure 2, the valve may also consist of two cones, the inner surface of one forming a fuel tight seal against the outer surface of the inner cone. The inner cone remains stationary while the outer cone revolves with the throttle. The fuel supply hole located on the surface of the inner cone may be uncovered any desired amount at any given throttle setting if portions of the apex of the outer cone are suitably cut away. Thus an irregular contour may be developed on the edge of the outer cone which will create the desired resistance to fuel flow at any given throttle setting. This type of valve is disclosed in detail in applicant's copending application identified above.

Other embodiments using rotating cylinders or movable contoured plates are possible, within the principles of the above described embodiment. For example, the valve could consist of two hollow cylinders disposed one within the other, rather than the cones just described, the stationary inner cylinder being provided with a fuel supply hole adapted to cooperate with a contoured opening in the rotatable outer cylinder.

Still other means of obtaining a throttle controlled fuel flow are shown in Figures 3 and 5. These devices function in one element as combined fuel flow controls and pressure regulators, being adapted to provide varying pressure with changing throttle positions.

The third basic component is the engine speed operated, or air flow sensing device operated, fuel control valve which may also be formed as an independent element, or may be combined with other elements to form a suitable combination. For example, it may take many of the forms of the second component just described. The method of activating this third component may be chosen from a variety of means. Vacuum driven diaphragm motors activated by pressures developed in the carburetor air inlet passage, and pressure operated vanes activated by the air flow into the carburetor, are two examples of means of controlling such devices by variation of engine air consumption. Variations in the fuel flow control members with respect to engine speed may be accomplished by a number of other devices, such as engine driven centrifugal governors for example (such as shown in Figure 14), or electrically operated devices, such as voltage sensitive units excited by the output of an engine driven generator.

Figure 5 shows a method involving the use of the vacuum developed in a venturi, which vacuum, varying as a function of engine air consumption, positions the contoured cam variously as a function of the engine air consumption.

The fourth component may take the form of a conventional butterfly valve. It may be useful, however, to use a throttle in the form of two or more unmatched surfaces, at least one of which is of an irregular geometrical shape. For example, a barrel type throttle, similar to that shown in Figure 2, may be utilized, which differs from the typical in that the air hole in the cylinder may be contoured to provide an air opening rate disproportional to the throttle arm movement, as described in applicant's Patent No. 2,630,304 aforesaid. A second example might be a butterfly type of throttle rotating in an air flow passage which is contoured to provide an air opening rate disproportional to the throttle arm movement, as shown in Figure 11. This feature may be useful for special speed governing problems.

Turning now to Figure 2, the embodiment shown here is of the type diagrammatically represented as embodiment II in Figure 1, and is very similar to the type of carburetor disclosed in applicant's Patent No. 2,630,304, as mentioned above, but has a by-pass valve added thereto. This embodiment includes a stationary casing **20** having a bore **22** extending therethrough and a flange **24** adapted to be connected to the inlet manifold of the internal combustion engine.

Casing **20** also is provided with the mixture outlet passage **26** adapted to conduct the mixed air and fuel from the mixing chamber **27** to the inlet manifold. Bore **22** also communicates through intake passage **28** to the atmosphere and a suitable air filter (not shown). Bore **22** and passages **26** and **28** are preferably substantially cylindrical, the axes thereof being coextensive, i. e., if a section is taken through either passage in a plane normal to the axis, it is circular. Casing **20** also is provided with the cylindrical bore **30**, in which the generally cylindrical air control valve **32** is rotatably mounted, the axis of said bore and air valve being normal to the axis of bore **22**. The main portion of the body of the generally cylindrical valve **32** is cut away, leaving the circular end webs **34** and **36** joined together by the shutter **38** which extends therebetween and is in the form of a longitudinal section of a cylinder, and which, with the bore **22**, acts as a valve for controlling the air flow through that bore. The narrow web or strut **40** may also be provided for additional strength, extending between the end webs **34** and **36** and disposed diametrically opposite to the web **38**.

The circular end webs **34** and **36** are adapted to receive respectively the outer nozzle members **42** and **44** in the center openings **43** and **45** formed therein, the nozzle members in turn being each formed with the annular flanges **46** and **48**, respectively. These flanges **46** and **48** are in turn secured to the circular webs **34** and **36**, respectively, by suitable holding means. The annular holding member **50** is adapted to bear against the annular bearing member **52** and to thus maintain the air control valve **32** rotatably secured within the bore **30**, since the opposite end of the valve **32** bears against the flange **48**, which in turn bears against the annular flange **54** at the opposite end of the bore **30**. Because of this construction, the ends of the substantially frusto-conical outer injection or nozzle members **42** and **44** project within the mixing chamber **27** and terminate in spaced relation to each other, both outer nozzle members being freely rotatable with the valve **32**. A control arm **58** may be secured to either of the outer nozzle members, and is here shown as secured to the outer portion **60** of the nozzle member **42**, the arm **58** projecting through a suitable slot opening in the projecting portion **62** of the casing **20**, which houses the outer end **60** of the nozzle member **42**. This projecting portion **62** of the casing **20** has a closure web **64** secured thereto by the fastening members **66** and **68**. Pivotal movement of the arm **58** will thus cause rotation of both the outer nozzle members **42** and **44** and the cylindrical throttle valve **32**.

The projecting portion **70** on the opposite side of the casing **20** serves to house the outer end **72** of the nozzle member **44**, and this projecting portion **70** is likewise provided with a closure web **74** similar to the web **64** which is secured by suitable fastening members, such as the bolt 73.

The nozzle members 42 and 44 have the inner stationary nozzle members 76 and 78 disposed respectively therein, each such nozzle member being brought into close fitting abutment with the inner surface of its associate outer nozzle member by an expansion spring member, such as the bellows 80, which is secured at one end to the inner nozzle member 78 and at the opposite end to the closure web 74. Each of the inner nozzle members is provided with a longitudinal passage such as the passage 82 in the inner nozzle member 78, and a fuel outlet passage such as the outlet 84 in the inner nozzle member 78.

A fuel passage 86 may be provided in the closure web 74, as shown, which in turn may communicate with the passage 88 in the projecting portion 70 of the housing 20. The closure web 64 may be provided with a similar passage which may communicate with a passage similar to passage 88 in the projecting portion 62 of the casing 20. Such a construction readily permits the inner nozzle member 76 to be connected to the same fuel flow control member that is connected to inner nozzle 78, or an entirely separate source of fuel may be utilized for nozzle 76. This construction also permits the ready use of nozzle 76 for introducing supplementary fuels or additives of various kinds, if desired.

Returning now to passage 88 in the projecting portion 70 of housing 20, this passage may be in communication with the annular passage 90 in the valve seat 92. This passage 90 is connected to the centrally located longitudinal passage 94 in the valve seat 92, and this passage 94, in turn, opens into the chamber 96 formed by the threaded bore 98 and the inner end of the valve seat 92. As indicated, the valve seat 92 may be provided with suitable threads on its outer surface so that it may be engaged with the threaded wall of the bore 98. The bore 98 terminates in a similar unthreaded bore 100, and the flexible diaphragm 102 is normally held by the threaded annular member 104 against the shoulder formed between the bores 98 and 100. A needle valve 106 is centrally mounted on the diaphragm 102 so that it projects therethrough into association with the valve seat 92 and the fuel passage 94 therein. A spring member 108 is disposed between the inner end of the valve seat 92 and the diaphragm 102, which normally urges the diaphrgam 102, and therefore the needle valve 106, away from the valve seat 92.

An air vane 110 is pivotally mounted on the shaft 112 in the passage 28, and is normally held in the closed position shown in Figure 2 by the pin 114 on the cam member 116, which is fixedly mounted on the rotatable shaft 112. The cam member 116 is in turn normally urged to rotate in a clockwise direction by the spring 118, as shown in Figure 2, and when no force is applied to the pin 114, the cam is adapted to abut the stop 119 on the wall of the passage 28, as shown. The cam member 116 is also normally in abutting relation with the inner end of the needle valve stem 106. The position of the needle valve stem 106 therefore is normally determined by the position of the air vane 110 and the position and contour of the cam 116. The position of the air vane 110 and the cam 116 in turn depend upon the rate of the air flow through the casing 20. Obviously, the rate of the air flow is controlled by both the adjustment of the cylindrical valve 32 and the speed of the internal combustion engine, to which the casing 20 is secured. The needle valve stem 106 and the valve seat 92 therefore in combination form a fuel flow control member for controlling the flow of fuel to the nozzle member 78. Although it is not shown, a similar control may be exerted by this combination over the flow of fuel to the nozzle member 76, since fuel passages comparable to the passages 86 and 88 may communicate with the spring bellows (not shown), which is adapted to normally urge the nozzle member 76 toward the outer nozzle member 42.

As previously mentioned, the inner nozzle member 76 may be connected to a source of supplementary fuel or a source of suitable additive, such as, for example, a water and alcohol mixture. For some purposes it will be desirable to utilize the fuel flow control member made up of the throttle operated outer nozzle member 42 and the inner nozzle member 76 as the sole means of controlling the amounts of such supplementary fluids which are introduced. For example, if it is desired to add an anti-detonant, such an arrangement as just mentioned can be utilized to great advantage, since during periods of greatly increased demand the fuel flow control member will permit an increased flow of the anti-detonant. At the same time the flow of primary fuel will not be greatly increased initially due to the control exerted by the vane operated control valve in series therewith, so that the end result will be that the percentage of anti-detonant in the fuel mixture will be greatly increased. This percentage will gradually decrease as the flow of primary fuel is increased as the engine responds to the demand and the flow of anti-detonant remains the same. In other words, if the engine in question is of the automotive type and the vehicle starts up a steep incline at a relatively low rate of speed, the throttle will be simultaneously opened by the operator of the vehicle to meet the increased demand on the engine. This opening of the throttle will simultaneously open the valve formed of nozzles 42 and 76 and thus increase the flow of anti-detonant, whereas the flow of fuel out of the inner nozzle member 78 will still be limited by the fuel flow control member operated by the vane 110. The percentage of anti-detonant in the fuel mixture will therefore initially be rather high, but as the flow of fuel from inner nozzle member 78 increases, the percentage of anti-detonant will rapidly decrease. This arrangement has the advantage of supplying the anti-detonant, or the like, in the greatest quantities at the most desirable periods.

On the other hand, it may be desirable when adding supplementary fuels to regulate the flow thereof in substantially the same fashion as the flow of the primary fuel is regulated. An additional set of metering devices can be utilized, for example, to control the supplementary fuel flow, although with proper construction of the control devices the flow of supplementary fuel need not be proportional to the flow of the primary fuel if such is not desired.

The chamber 96 is provided with the fuel inlet 117, which inlet is connected to the by-pass regulator valve member 120 by the fuel line 121. The by-pass regulator valve member 120 has a cylindrical bore 122 therein. The cylindrical bore 122 is connected to the fuel line 121 by the passage 124, and also has a second oppositely disposed passage 126 leading therefrom, together with a third passage 128 in communication with and centrally located in the base 130 of the bore 122. The diaphragm 132 is mounted in the bore 122, being secured against the shoulder 134 by the annular member 136, the shoulder 134 being formed between the bore 138 and the bore 122, the latter being somewhat smaller in diameter than the former. A needle valve stem 140 is centrally disposed on and carried by the diaphragm 132, and is adapted to be received in the passage 128, which, together with the base 130 of the bore 122, forms a valve seat. The by-pass valve 120 is provided with a closure member 142 having a threaded opening 144 centrally disposed therein, which opening is adapted to receive the screw member 146. The latter is in turn adapted to bear against the bearing plate 148 carried by the spring 150, which is normally disposed in compressed relation between the bearing plate 152, which is secured to the needle valve 140.

The pressure on the needle valve stem 140 can therefore be adjusted by suitable positioning of the threaded screw member 146. Therefore, if the passage 126 is connected to a source of fuel supplied under pressure, the chamber 154, which is formed by the bore 122 and the diaphragm 132, will normally be filled with fuel supplied at a pressure dependent on the characteristics of the pump, or the like, which is utilized to furnish the fuel supply. Variations in this pressure will obviously be reflected in the position of the diaphragm 132, which in turn controls the position of the needle valve 140. The amount of variation in the position of the diaphragm 132 will be controlled by the pressure exerted by the spring 150. As previously stated, this latter pressure can be adjusted within certain limits by variation in the position of the screw member 146.

In actual operation, therefore, a flow of unmetered fuel is supplied to the passage 126 under a pressure, for example, of four pounds per square inch. The screw member 146 may be adjusted in such a way as to permit sufficient fuel to pass into the passage 128 to cause the pressure in the passage 124 to be reduced to three pounds per square inch, for example. The passage 128 may be connected to the reservoir of fuel from which the fuel supply is taken, and consequently only a selected portion of the fuel supply is passed on to the engine. Because of the fact that the needle valve stem 140 is carried by the diaphragm 132 under a selected amount of pressure exerted by the spring 150, if a constant fuel pressure is maintained, the diaphragm 132 will remain substantially stationary. However, if the fuel supply pressure is increased, the pressure on the side of the diaphragm 132 which is adjacent to the chamber 154 will also be increased. The equilibrium between the pressure exerted by the spring 150 and the pressure exerted by the fuel supply on the diaphragm 132 therefore will be destroyed, and the diaphragm will tend to move in a direction which will bring these two opposing forces back into equilibrium. Therefore, if the fuel supply pressure rises, the diaphragm 132 will move in a direction which will cause the spring 150 to be compressed until the pressure exerted thereby is substantially equal to the pressure exerted by the fuel supply. Such a movement of the diaphragm 132 will in turn cause the needle valve stem 140 to move away from the base 130 of the chamber 154, thus increasing the flow of fuel into the by-pass passage 128. If the components making up the by-pass valve 120 are

properly designed, the increase in the flow of fuel through the passage 128 will be sufficient to take care of the increased pressure in the fuel supply, and both the amount of fuel flowing through the passage 124 and the pressure of the fuel therein will be maintained substantially constant.

It is, therefore, obvious that the by-pass valve 120 is a convenient means of regulating the fuel pressure at a selected, substantially constant, value.

Turning now to Figure 3, a form of by-pass regulator valve and fuel flow control valve, in combination, is disclosed therein, the construction of the valve 155 being substantially identical to the by-pass regulator valve 120 shown in Figure 2, except that the screw member 146 has been replaced with a plunger 156 having a roller 158 journalled in the outer extremity thereof. The roller 158 is adapted, in turn, to bear against the cam 160 mounted on the shaft 162. A somewhat diagrammatic representation of a throttle member 164 is shown mounted on the shaft 162, the latter in turn being rotatable by movement of the lever 166. Rotation of this cam may also be caused by engine speed, or an engine air comsumption sensing device. It can be seen that by such an arrangement the pressure level maintained by the by-pass valve is no longer constant, as in the case of the by-pass regulator valve 120, where by suitable adjustment of the screw member 146 a particular pressure level could be selected at will. In the embodiment shown in Figure 3, the level of pressure selected to be maintained by operation of the by-pass regulator valve 155 is determined by the position and configuration of the cam member 160. The position of this element is in turn dependent upon the position of the shaft 162, the latter being controlled by the lever 166, as stated, which lever may also be controlled by an air flow sensing device, of course. Since under normal operation the position of the lever 166 will be dependent on the desired position of the throttle member 164, it can be readily seen that the pressure maintained by the by-pass regulator valve 155 at any particular moment will be a function of the setting of the throttle member 164, but because of the configuration of the cam, the pressure maintained by the by-pass regulator valve need not be proportional to the movements of the throttle member.

An alternative form of by-pass fuel flow control valve 168 is shown in Figure 4, which valve does not utilize a diaphragm, and therefore is not capable of reacting to variations in the fuel supply pressure, or variations in the flow rate through the metering valves, but is merely responsive to changes in the position of the needle valve 170, which position is in turn controlled by the position and configuration of the cam 172. This valve can be operated either by the throttle member or an engine speed activated member, and can be used as a metering valve as well as a by-pass valve. It could be substituted for both the by-pass valve 4 and one of the metering valves in the embodiment shown in Figure 1, embodiment I, for example.

An alternative type of carburetor is shown in Figure 5, which embodiment incorporates as a part thereof a combined pressure regulator and fuel flow control member. This carburetor is provided with a housing 174 having a passage 176 therein which is in communication with a suitable fuel supply (not shown). The passage 176 in turn connects with the bore 178, terminating in the annular groove 179 therein. The bore 178 is in communication with, and also axially aligned with, the threaded bore 180. This bore 180 is provided with an externally threaded cap member 182, which has a plunger 184 slidably mounted therein so that it is adapted to move substantially along the longitudinal axis thereof. A pressure plate 186 is mounted on the upper end of the plunger 184, and is adapted to bear against the spring member 188 disposed within the cap member 182. The opposite end of the spring 188 bears against a bearing plate 190, which is secured to one end of the valve stem member 192.

The valve stem member 192 is mounted for longitudinal movement in the bore 178 on the diaphragm 194, which diaphragm is secured at its peripheral edge between the cap member 182 and the shoulder 196 formed in the base of the bore 180. The valve stem member 192 is provided with an area of enlarged diameter 198, which area is normally disposed substantially in alignment with the annular groove 179 in the bore 178. The upper end 200 of the valve stem member 192 may be utilized as a bearing surface which is adapted to maintain the valve stem 192 in alignment with the bore 178. This end 200 of the valve stem 192 may be fluted, as shown, so that fuel may freely pass from one side of the fluted area of the stem 192 to the other. The end of the bore 178 which is associated with the end 200 of the valve stem 192 is in communication with a conduit 202 through the orifice 203, which conduit in turn communicates with the fuel supply tank. The diaphragm 194 and the base of the bore 180 form a chamber 205 into which the bore 178 opens. The passage 204 leads from this chamber also.

It thus may be seen that fuel flowing into the casing 174 through the passage 176 enters the bore 178 and, depending upon the longitudinal position of the valve stem 192, is normally passed through the annular groove 179 both into the portion of the bore 178 associated with the fluted end 200 of the valve stem 192 and into the chamber 205. The position of the valve stem 192, and therefore of the area of enlarged diameter 198 thereon, is determined by the position of the diaphragm 194. The differential pressure exerted on this diaphragm 194, which is responsive to pressure applied to either side thereof, is the force which controls the position of the diaphragm. The pressure applied to the side of the chamber 205 is that of a fuel flowing therein. The pressure affecting the opposite side of the diaphragm 194 on the other hand, is that which is applied thereto by the spring 188 operating through the pressure plate 190.

In actual operation, when the valve stem 192 is moved in the direction of the conduit 202, the amount of fuel flowing through that conduit is greatly decreased, since the annular passage formed between the upper edge of the area of enlarged diameter 198 and the upper edge of the annular groove 179 is restricted when the valve stem 192 is moved in this direction. Likewise, when the valve stem 192 is moved in the opposite direction toward the chamber 205, the annular passage just mentioned is increased in area. In the same fashion, the annular passage formed between the lower edge of the area of enlarged diameter 198 on the valve stem 192 and the lower edge of the annular groove 179 is restricted when the valve stem 192 is moved in the direction

of the chamber 205, and is enlarged when the valve stem is moved in the opposite direction.

Such a by-pass valve is generally similar to the type of valve shown in Figure 3, but differs therefrom in that as one of the outlet orifices is restricted, the other outlet orifice is enlarged. By way of contrast, in the by-pass valve shown in Figure 3, the size of only one of the outlet orifices can be controlled.

The pressure applied to the plunger 184 is dependent upon the setting of the lever 206, which is pivotally attached to the slotted piston member 208. The lever 206 has the roller 210 rotatably mounted thereon substantially midway between its two ends, which roller is adapted to bear against the cam member 212. The cam 212 is in turn mounted on the throttle shaft 214, upon which the throttle 216 is mounted. This cam 212 may be capable of being mounted in a plurality of positions, the particular one shown being divided into four parts, for example, so that one of the quadrants thereof may be selected to bear against the roller 210 as desired. These quadrants may each have different configurations to provide a selection of four different patterns of operation.

The free end 218 of the lever 206 is adapted to bear against the plunger 184 and to communicate variations in the positions of the lever to the bearing plate 186, and thus vary the pressure applied to the diaphragm 194 in accordance with the rotation of the cam 212, which in turn is rotated in synchronism with the throttle member 216.

To provide a further adjustment of the pressure applied to the diaphragm 194 by the spring 188, a means of adjusting the position of the slotted piston 208 is provided. The piston 208 is slidably disposed in the housing 220, and has a screw member 222 threadedly received in the threaded bore 224 formed therein. The head of the screw 222 normally abuts the washer 226, which in turn normally abuts the base of the housing 220. The screw 222 is mounted for sliding movement in both the housing 220 and the washer 226, and may be moved downwardly from the position shown in Figure 5 by appropriate movement of the lever arm 228. A spring 230 is provided between the base of the housing 220 and the shoulder 232 on the piston 208, which spring normally urges the piston 208 away from the base of the housing 220.

As best shown in Figure 6, the arm 228 is adapted to be pivoted about the shaft 234 by a longitudinal pull exerted on the flexible cable 236 secured to the end 238 of the arm 228. Such pivotal movement of the arm 228 causes the position of the opposite end 240 of the arm 228 to vary, and to thus control the position of the washer 226. Since the piston 208 is normally urged in an upward direction, as shown in Figure 5, and since the screw 222 is secured thereto, the washer 226 will normally also be urged in an upward direction and will bear against the end 240 of the arm 228. Because of this construction, a longitudinal pull exerted on the cable 236 in the direction of the arrow 242, in Figure 6, will cause the end 240 of the arm 228 to move in a downward direction, which in turn will cause the piston 208 to also move downwardly, the end result being that the end 218 of the lever 206 is raised. This shift in position of the end 218 of the lever 206 will compress the spring 188 and increase the normal pressure applied by this spring to the diaphragm

194. A manual enrichment control may be provided in this fashion.

The housing **174** is also provided with an air passage **244** similar to passage **22** in the carburetor shown in Figure 2. An inlet passage **246** also is provided which is similar to the inlet passage **28** of the carburetor shown in Figure 2, together with an outlet passage **248**. The flange **250** is provided on the housing **174** adjacent the outer end of the outlet passage **248** to permit the housing to be secured to the inlet manifold of the engine with which the carburetor is to be used.

A chamber **250**, with which the passage **264** communicates at the base thereof, is also provided in the housing **174** to aid in the removal of vapor which may be formed in the fuel supply lines. The chamber is provided with a minute outlet port **252**, which is in communication with the air passage **244**. A much larger outlet port is provided to the passage **254**, which passage communicates with the chamber **256** formed between the diaphragm **258** and the housing **174**.

If vapor is introduced into the chamber **250** it will tend to rise to the top thereof. The port **252** is of such a size as to be able to pass such vapor freely into the air passage **244** but to pass the liquid fuel only with difficulty. Any fuel which does pass into the passage **244** will be in insignificant amounts.

The diaphragm **258** is held in position by the cap member **260** which is adapted to be threaded onto the circular projecting portion **262** of the housing **174**. The cap **260** is provided with a central opening **264** therein in which the plunger **266** is slidably mounted. One end of the plunger **266** is secured to the diaphragm **258**, whereas the opposite end is adapted to bear against the cam **270**, this end being provided with a suitable roller **272**.

The valve stem **274** is also carried by the diaphragm **258** in the chamber **256**, and is adapted to extend into association with the externally threaded valve seat **276**, which is adapted, in turn, to be threadedly received in the threaded bore **278**. The valve seat **276** is provided with a central, longitudinal bore **280** which is in communication with a lateral bore **282** in the valve seat **276**. This lateral bore **282** is in turn in communication with the bore **284** in the housing **174**. The bore **284** is closed by the sealing member **286**, and has in communication therewith a bore **288** which in turn communicates with the air passage **244**. This bore provides the means for directing the flow of fuel into the air flow in passage **244**. The manner in which this bore **288** terminates in the passage **244** may take any convenient form which is designed to aid in the thorough dispersion of the fuel in the air flow. It may also be desirable to provide a suitable cup-like receptacle (not shown) in the engine manifold at a point where any excess fuel which might enter the air passage **244** after the engine has stopped, for example, could collect. The structure of the receptacle could be such that the collected fuel would be removed therefrom by the air flow only after the flow reached a particular intensity.

The diaphragm **258** is sufficiently flexible to be moved by pressure applied to the plunger **266** by the cam **270**, the fuel pressure normally urging the plunger into contact with the cam. The position of the cam **270** is controlled by the arm **290**, one end of which is mounted on the diaphragm **292** and the other end of which is pivotally secured to the cam **270**. The cam is pivotally mounted on the arm **294** projecting from the housing **174**, and is normally urged to rotate in a clockwise direction, as shown in Figure 5, by the spring **296**.

The diaphragm **292** is mounted in a housing **298** and forms one wall of the pressure chamber **300**. The pressure chamber **300** is in communication, through the conduit **302** and the passage **304**, with the air inlet passage **246** of the housing **174**, and the pressure therein is therefore responsive to pressure changes in the flow of air into the passage **244**. Variations in pressure within the chamber **300** in turn cause the diaphragm **292** to expand or contract, working through the arm **290** with or against the spring **296**, which normally urges the cam member **270** to rotate as previously described. Therefore, the position of the valve stem **274** will be a function of the air pressure within the air inlet passage **246**.

The form of carburetor just described, therefore, incorporates a combined fuel pressure control member and fuel flow control member, together with a second fuel flow control member in series therewith, the former being activated by variations in the position of the throttle member, and the latter being activated by variations in the air flow to the engine. This embodiment is a specific illustration of the type of fuel supply system generally disclosed as embodiment IV in Figure 1.

Additional metering valves could of course be provided in tandem arrangement with those shown in Figure 5. Such valves could be used to regulate the flow of supplementary fuels or additives, and could be of substantially the same form as the metering valves just described, shown in Figure 5, or the valves shown in Figures 9 and 10. Valves of these latter types could be utilized in the manner previously described in connection with the inner nozzle member **76** shown in Figure 2.

As previously stated, the type of air flow passage and fuel flow controls in Figure 5 are particularly suited for use in dual carburetor construction. A possible form of such a dual carburetor is illustrated in Figure 7, where the housing **305** is provided with the adjacent air flow passages **306** and **308**. The throttle shaft **310** has the two throttle members **312** and **314** disposed thereon which are adapted to control the flow of air through the passages **306** and **308**, respectively. The shaft **310** is provided at one end with the throttle arm **316** and the opposite end of the shaft **310** projects into the housing **318**, here shown to form an integral part of housing **305**. This housing **318** is comparable to the housing **174**, shown in Figure 5, and is adapted to contain elements similar to those shown in that figure in the housing **174**. The cam **313**, for example, on the shaft **310**, is the counterpart of the cam **212** on the shaft **214** in Figure 5.

An important characteristic of this construction is that a single set of metering valves can be utilized to control the flow of fuel to each of the air passages **306** and **308**, such as the metering valves shown in Figure 5. A passage (not shown) comparable to the passage **288** in Figure 5 will be provided in the housing **318** extending from the metering valves into the housing **305**, which passage is in communication with both air passages **306** and **308**. Under such an arrangement, the fuel fed to each air passage would be metered by the same set of control valves, and would be equally divided between the two passages **306** and **308** without difficulty, since the flow of fuel is not dependent upon any aspiration effect in the air passages **306** and **308**, but results from the fuel being supplied to the metering valves under pressure, and since the branches of the fuel passage to the air passages may be made to have equal flow resistance.

This ability to utilize the same set of metering valves for both carburetors in such a dual system is a very important aspect of the present invention, since in most carburetors, currently in use, the control devices as well as the air flow passages must be duplicated in order to form a dual carburetor. It is conceivable also, that with the present invention a separate carburetor could be provided for each cylinder using only a single set of metering valves.

Turning now to Figure 8, an alternative type of valve, indicated generally by the numeral **342**, is disclosed, in which a contoured dual valve stem **344** is provided which is adapted to be shifted longitudinally in either direction by movement of the lever **346**. This is the same as valve **16** in embodiment III of Figure 1. The end **348** of the valve stem **344** is axially aligned with the passage **350**, and the valve seat **352**, whereas the opposite end **354** of the valve stem **344** is axially aligned with the passage **356** in the valve seat **358**. The valve stem **344** is slidably mounted in the casing **360**, with which the valve seats **352** and **358** are here shown as being formed integrally. The casing **360** is also provided with the passage **362** leading from the chamber **364** with which the passages **350** and **356** are also in communication. Obviously, as the valve stem **344** is shifted in one direction, the position of one of the valve stems will be changed in a particular direction, whereas the position of the opposite valve stem will be changed in the opposite direction. If the passage **362** is the fuel input passage, the flow out through the passages **350** and **356**, respectively, can therefore be controlled by a longitudinal movement of the valve stem **344**. By proper contouring of the valve stem **344**, the minimum amount of bleeding consistent with achievement of the bleeding advantages previously mentioned can be provided.

Still another alternative type of cam operated metering valve is disclosed in Figure 9, in which a contoured valve stem **366** is provided, rather than a straight tapered needle valve. The lever **368** is pivotally secured to the upper end of the valve stem **366**, and the opposite end thereof is in turn pivotally secured to the lever **370**, which is pivoted at substantially its mid-point **372**. Movement in the direction of the arrow **376** of the end **374** by a suitable throttle arm, for example, will cause the valve stem **366** to move longitudinally in the bore **378**, and the position of the valve stem **366** with respect to the valve seat **380** will be varied accordingly. The passage **382** is centrally disposed in the valve seat **380**, and is adapted to receive the contoured end **384** of the valve stem **366** as it is moved downwardly (as shown in Figure 9). A second passage **386** is provided in communication with the bore **378**, and may be utilized as an input passage for the fuel flow in the same manner as passage **119**, shown in Figure 2.

Yet another type of control valve is illustrated in Figure 10 in which a straight tapered needle valve is shown which is otherwise generally similar to the valve just described illustrated in Figure 9. The valve stem **385** is adapted to be controlled by movement of the cam **386** and is normally urged into abutment therewith by the spring **387**.

Figures 11 and 12 disclose a type of throttle member earlier referred to, in which the air passage **388** is provided with contoured walls **390** and **392**. As the throttle member **394** is rotated, as shown by the dotted lines, the normal opening of such a butterfly throttle is altered by the fact that the side walls **390** and **392** have a configuration which is adapted to restrict the amount of opening normally obtained in a valve of this general character. In other words, the amount of opening which occurs in the initial portion of the path of the throttle **394** is disproportionate to the actual movement of the throttle member **394**.

Although the source of varying pressure utilized to operate the diaphragm **292** in Figure 5 is there shown as the passage **306** opening into the air intake passage **246** in the carburetor housing **174**, it may be desirable to have an additional means of increasing the effectiveness of a pressure pick-up passage of this general type. One method of accomplishing this is to provide a Venturi block in the air passage having a cone throttle associated therewith.

One form of such an arrangement is shown in Figure 13, wherein the housing **396** is provided with the air flow passage **398**, which passage is in turn provided with the restricted opening **400**. A pressure pick-up passage **402** is provided at the restricted opening in the housing **396** which pick-up passage is comparable to the passage **304** shown in Figure 5. A cone Venturi block **404** is centrally disposed in the air flow passage **398**, the stem **406** thereof being slidably mounted in the annular bearing member **408**, as shown. The stem **406** carries a pin **410** which is adapted to be received in the slot **412** in the arm **414**. One end of the arm **414** is pivotally mounted as at **416** in the housing **396**, and the opposite end **418** projects through a suitable slot **420** in the housing **396** and is pivotally secured to one end of the arm **422**. The opposite end of the arm **424** is in turn pivotally secured to the arm **426**. The opposite end **428** of the arm **426** is secured to the shaft **430** which carries the throttle member **432**.

The cone Venturi block **404** may also be provided with a plurality of spiral vanes **434**, which are adapted to give the air flowing through the air passage **398** a turbulent whirling flow to aid in obtaining a thorough dispersion of the fuel in the air flow. Obviously this type of vane could be provided on the inner wall of the air passage **398** if desired.

This arrangement permits the speed of the flow of air through the passage **402** to be varied not only by the throttle member **432**, but also by the Venturi block **404**, the position of these two elements being synchronously varied through operation of the interconnected arms just described. In other words, if the shaft **430** is rotated in a clockwise direction (as shown in Figure 13), the throttle member **432** will move toward a more closed position, and through operation of the arms **426**, **422** and **414**, the position of the Venturi block **404** will be simultaneously varied so that it is brought into closer association with the restricted opening of the housing **396**. Such a closing of the throttle member **432** tends to reduce the speed of the air flow in the passage **398** and through the restricted opening **400**, but the simultaneous movement of the Venturi block **404**, as just described, will have a tendency to increase the rate of flow at this point, the end results being that the flow of air through the restricted opening **400** is not decreased to the degree that it normally would be when the throttle member **432** is moved toward the closed position. Such an arrangement results in a maintenance of the desired pressure in the passage **402** even at restricted throttle openings. This insures the satisfactory operation of a diaphragm activated mechanism such as that shown in Figure 5 throughout the entire range of possible throttle positions. It should also be pointed out that the Venturi block **404** may be contoured in such a way that the movement thereof and therefore the variations of the speed of the flow of air past the pick-up passage **402**, may be made any desired function of the movement of the throttle **432**. Obviously the same result could also be attained by introducing a control arrangement between the throttle and the Venturi block which includes a contoured cam so that the movement of the Venturi block will be any desired function of the movement of the throttle. By so varying the position of the Venturi block, and therefore varying the flow of air past the pick-up passage **402**, the pressure applied to a diaphragm control mechanism (such as that shown in Fig. 5) can be varied as any desired function of the movement of the throttle **432**. This would in turn cause the setting of a metering device operably connected to and controlled by the diaphragm control mechanism to vary as any desired function of the movement of the throttle. Obviously, other mechanisms could be operated from a source of power such as the pressure pick-up passage, for example, a pressure operated distributor mechanism, or the like.

One possible arrangement for the operation of an engine speed operated metering valve is more or less diagrammatically shown in Fig. 14. The shaft **436** is adapted to be rotated by the V-belt **438** which passes over the pulley **440**, the opposite end of the V-belt **438** being driven by a similar pulley (not shown), rotated in accordance with the engine speed. The collar **442** is slidably mounted on the shaft **436** and is connected to the pulley **440** by a plurality of band spring members **444**, which bands are each provided with the weights **446**. By proper selection of these components, the collar **442** may be made to move longitudinally along the shaft **436** in accordance with the speed at which the shaft revolves, the collar moving to the left, as shown in Fig. 14, as the speed of the shaft increases.

The collar **442** has an annular groove **448** formed therein, which groove is adapted to receive the end **452** of the arm **454** having the roller **450** rotatably mounted thereon. The arm **454** has the cam surface **458** formed at the opposite end thereof, and is pivoted at **456**, as shown. This cam surface **456** is adapted to bear against the plunger **460**, which plunger is secured to the valve stem **462** in the valve **464**, which valve is of substantially the same type as that shown in Figure 10.

As the collar **442** moves along the shaft **436** in accordance with variations in the speed of the engine, these movements are communicated to the arm **454** through the pin **452**, and the position of cam **458** is thus varied in accordance with variations in the speed of the engine. Changes in the position of the cam, in turn causes variations in the position of the needle valve stem **462**, which may be utilized to control the flow of fuel to the engine.

Turning now to Figure 15, a valve arrangement is there shown which is adapted to cause the fuel supply to be cut off during periods of deceleration, when the amount of vacuum developed by the engine rises above a particular point. The conduit **466** is in communication with the air flow passage below the throttle member so that when the throttle is allowed to assume a relatively closed position, while the engine is still turning at a relatively high speed, a substantially high vacuum is created below the throttle member. This vacuum will be communicated to the chamber **468** through the conduit **466** and will in turn affect the position of the diaphragm **470**. One end of the arm **472** is centrally disposed on and is carried by the diaphragm **470**, being also pivotally secured at the opposite end to the cam **474**. This cam **474** is pivotally mounted at **476**, and is normally urged to rotate in a counterclockwise direction (as shown in Figure 15), by the spring member **478**. The valve stem **480** is centrally mounted on and carried by the diaphragm **482**, and is so disposed in relation to the cam **476** that when said cam is moved in a clockwise direction, it will be moved into engaging relation with the upper end of the valve stem **480**.

The diaphragm **482** is carried by the housing **484**, being secured thereto by the threaded collar **486** which is adapted to be received by the externally threaded annular flange **488** formed on the housing **484**. The flange **488**, together with the diaphragm **482**, form the chamber **490** into which the valve stem **480** projects, the lower end **492** of the stem **480** extending downwardly and into the bore **494** in the housing **484** at the base of the chamber **490**. The inlet passage **496** is also in communication with the chamber **490** and the outlet passage **498**, and is in communication with the bore **494**. The valve stem **480** is provided with the shoulder **500** adjacent the end of **492** thereof, which shoulder has the resilient annular gasket or sealing member **502** associated therewith to form a seal with the base **504** of the chamber **490**, when the valve stem **480** is moved downwardly by the cam **474**.

In the normal operation of the valve, stem **480** is in the position shown in Figure 15, but if the amount of vacuum created in the chamber **464** rises above a particular point, the cam **474** will be moved into abutment with the upper end of the valve stem **480**, and further movement thereof will cause the stem **430** to be moved downwardly a sufficient distance to close the bore **494**. The fuel supply normally passes into the chamber **490** through the inlet passage **496** and thence into the bore **494**, and out through the outlet passage **498**. However, when the cam **474** is moved as just described and causes the chamber **494** to be sealed, the flow of fuel through the outlet passage **498** is cut off. The elements of the mechanism shown in Figure 15 can be so designed that the outlet passage **498** will be cut off only when the amount of vacuum created in that portion of the air passage with which conduit **466** is in communication reaches a point which would normally occur only if the engine is running at a relatively high rate of speed and the throttle is in a relatively closed position, such as will occur during periods of deceleration.

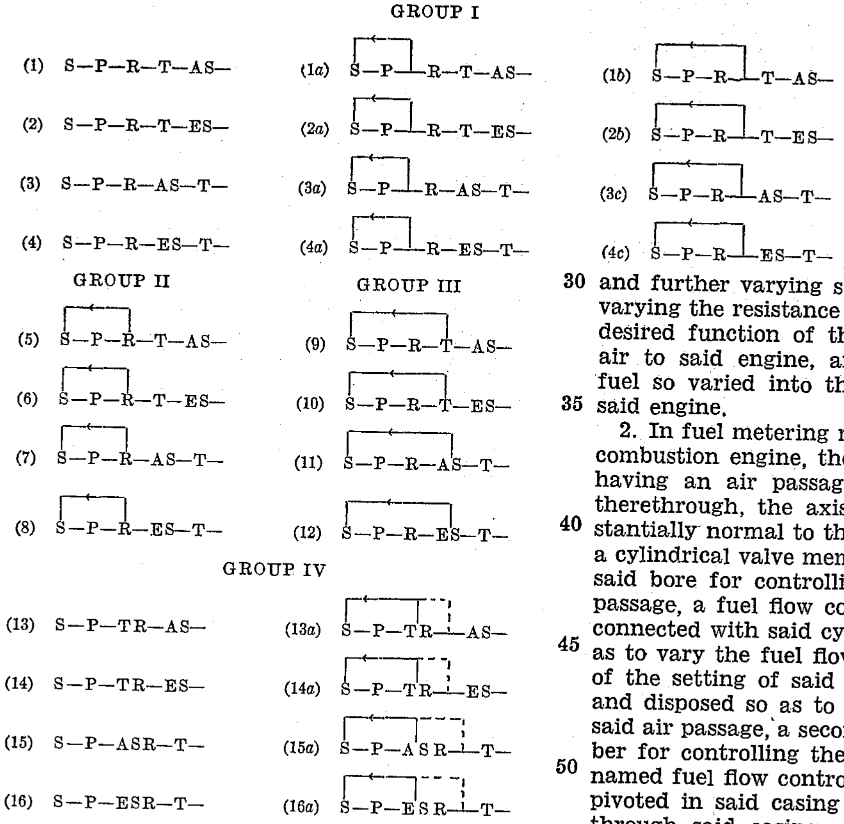
Since the fuel is supplied in the present invention to the air passage under pressure, and since there is a negligible aspiration effect in feeding the fuel into the air passage above the throttle, such a cutting off of the fuel will be possible without undesirable consequences.

To aid in conveying a better understanding of all the possible variations of the basic concept of this invention the following table has been prepared, using the following symbols:

Key

S	Supply tank
P	Pump
R	Fuel pressure regulator
T	Throttle operated metering valve
AS	Air speed operated metering valve
ES	Engine speed operated metering valve
TR	Throttle operated pressure regulator
ASR	Air speed operated pressure regulator
ESR	Engine speed operated pressure regulator
—←—	By-pass line

Table



GROUP I

(1) S—P—R—T—AS—
(1*a*) S—P—R—T—AS—
(1*b*) S—P—R—T—AS—
(2) S—P—R—T—ES—
(2*a*) S—P—R—T—ES—
(2*b*) S—P—R—T—ES—
(3) S—P—R—AS—T—
(3*a*) S—P—R—AS—T—
(3*c*) S—P—R—AS—T—
(4) S—P—R—ES—T—
(4*a*) S—P—R—ES—T—
(4*c*) S—P—R—ES—T—

GROUP II

(5) S—P—R—T—AS—
(6) S—P—R—T—ES—
(7) S—P—R—AS—T—
(8) S—P—R—ES—T—

GROUP III

(9) S—P—R—T—AS—
(10) S—P—R—T—ES—
(11) S—P—R—AS—T—
(12) S—P—R—ES—T—

GROUP IV

(13) S—P—TR—AS—
(13*a*) S—P—TR—AS—
(14) S—P—TR—ES—
(14*a*) S—P—TR—ES—
(15) S—P—ASR—T—
(15*a*) S—P—ASR—T—
(16) S—P—ESR—T—
(16*a*) S—P—ESR—T—

GROUP V

(17) S—P—TR—ASR—
(18) S—P—TR—ESR—
(19) S—P—ASR—TR—
(20) S—P—ESR—TR—

GROUP VI

(21) S—P—R—T—
(22) S—P—R—AS—
(23) S—P—R—ES—

GROUP VII

(24) S—P—TR—T—AS—
(25) S—P—TR—T—ES—
(26) S—P—TR—AS—T—
(27) S—P—TR—ES—T—
(28) S—P—ASR—T—AS—
(29) S—P—ASR—T—ES—
(30) S—P—ASR—AS—T—
(31) S—P—ASR—ES—T—
(32) S—P—ESR—T—AS—
(33) S—P—ESR—T—ES—
(34) S—P—ESR—AS—T—
(35) S—P—ESR—ES—T—

The drawings and the above discussion are not intended to represent the only possible forms of this invention, in regard to details of construction. Changes in form and in the proportion of parts, as well as the substitution of equivalents, are contemplated, as circumstances may suggest or render expedient, without departing from the spirit or scope of this invention, as further defined in the following claims.

What is claimed is:

1. The method of supplying a metered quantity of fuel-air mixture to an internal combustion engine which comprises supplying a controlled flow of air to said engine, supplying a flow of fuel under pressure from a suitable supply of fuel, by-passing a portion of the supplied fuel back to said supply of fuel, varying the flow of the fuel so by-passed by varying the resistance offered to the flow of the by-passed portion as any desired function of the resistance offered to said flow of said air to said engine, simultaneously varying a second flow of said supplied fuel as any other desired function of the resistance offered to said flow of said air to said engine and further varying said second flow of fuel by varying the resistance offered to said flow as any desired function of the velocity of the flow of air to said engine, and directing said flow of fuel so varied into the flow of air supplied to said engine.

2. In fuel metering mechanism for an internal combustion engine, the combination of a casing having an air passage and a cylindrical bore therethrough, the axis of said bore being substantially normal to the axis of said air passage, a cylindrical valve member rotatably mounted in said bore for controlling flow through said air passage, a fuel flow control member operatively connected with said cylindrical valve member so as to vary the fuel flow as any desired function of the setting of said cylindrical valve member and disposed so as to inject a flow of fuel into said air passage, a second fuel flow control member for controlling the flow of fuel to said first named fuel flow control member, and a member pivoted in said casing movable by the air flow through said casing, said last named member being provided with a contoured cam for actuating the said second named fuel flow control member so that the setting of said second named fuel flow control member is any desired function of the velocity of the air flow through said casing, and a by-pass valve adapted to pass only a selected adjustable portion of the fuel supplied under pressure thereto to said second fuel flow control member, the portion selected being controlled by and a function of the setting of said cylindrical valve member, said by-pass valve also being adapted to return the balance of said fuel to the original source of supply.

3. In fuel metering mechanism for an internal combustion engine, the combination of a casing having an air passage and a cylindrical bore therethrough, the axis of said bore being substantially normal to the axis of said air passage, a cylindrical valve member rotatably mounted in said bore for controlling flow through said air passage, at least one fuel flow control member operatively connected with said cylindrical valve member so as to vary the fuel flow as any de-

sired function of the setting of said cylindrical valve member and disposed so as to inject a flow of fuel into said air passage, a second fuel flow control member for controlling the flow of fuel to at least one of the first named fuel flow control members, and a control member pivoted in said casing movable by the air flow through said casing, means operatively connecting said control member to said second named fuel flow control member so that the setting of said second named fuel flow control member is any desired function of the velocity of the air flow through said casing, and means for maintaining said fuel pressure at a selected constant level, said means comprising a housing, a diaphragm disposed so as to close a chamber in said housing, an inlet passage in communication with said chamber, a plurality of outlet passages in communication therewith, a valve stem carried by said diaphragm disposed in close association with one of said outlet passages, a resilient member normally urging said valve stem into sealing relation with said one of said outlet passages, and means for varying the tension on said resilient member.

4. In fuel metering mechanism for an internal combustion engine, the combination of a casing having an air passage and a cylindrical bore therethrough, the axis of said bore being substantially normal to the axis of said air passage, a cylindrical valve member rotatably mounted in said bore for controlling flow through said air passage, a fuel flow control member operatively connected with said cylindrical valve member and disposed so as to inject a flow of fuel into said air passage, a second fuel flow control member for controlling the flow of fuel to said first named fuel flow control member, said control member being in the form of a contoured valve, an air pressure responsive control member in pressure transmitting communication with the air flow in said casing, said air pressure responsive control member comprising a pressure chamber, a diaphragm responsive to air pressure which is disposed so as to form a portion of the walls of said chamber, an air pressure transmitting conduit connecting said chamber with said air passage, and means for operatively connecting said diaphragm to said second fuel control member, said last named member controlling the setting of said second fuel flow control member so that the setting thereof is any desired function of the velocity of the air flow in said air passage.

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