Dec. 21, 1965 M. A. ARPAIA 3,224,425

FUEL SUPPLY SYSTEM, CARBURETOR AND METHOD

Filed Feb. 20, 1962 3 Sheets-Sheet 1

FIG. 1.

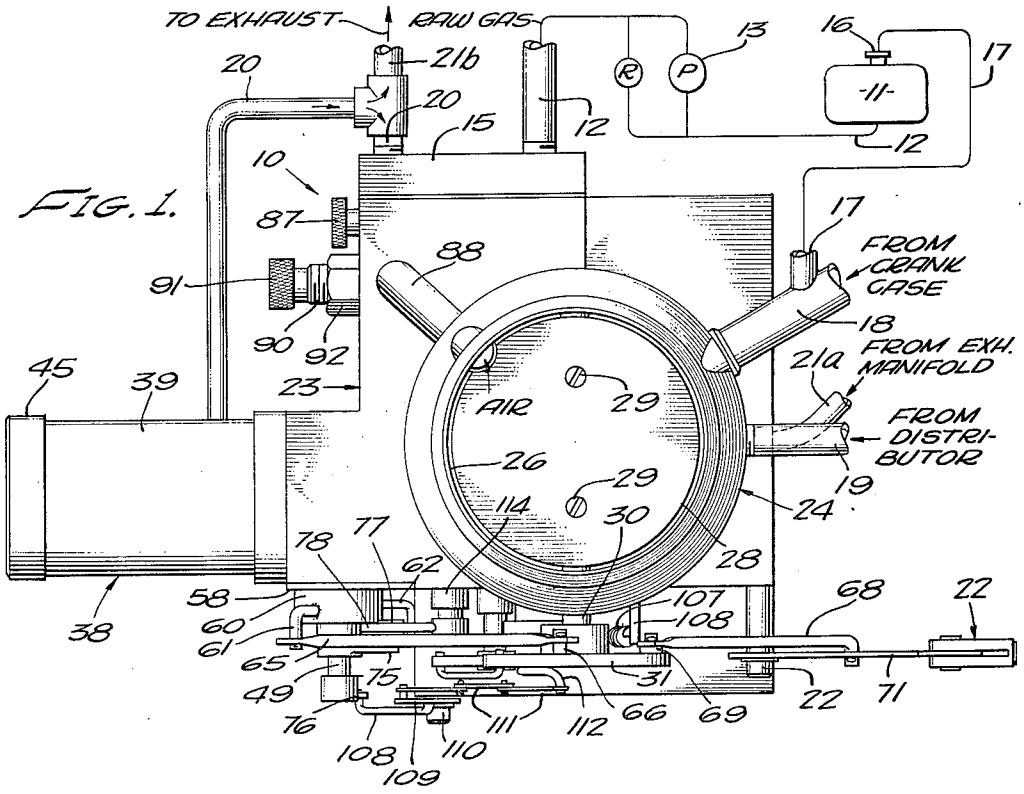
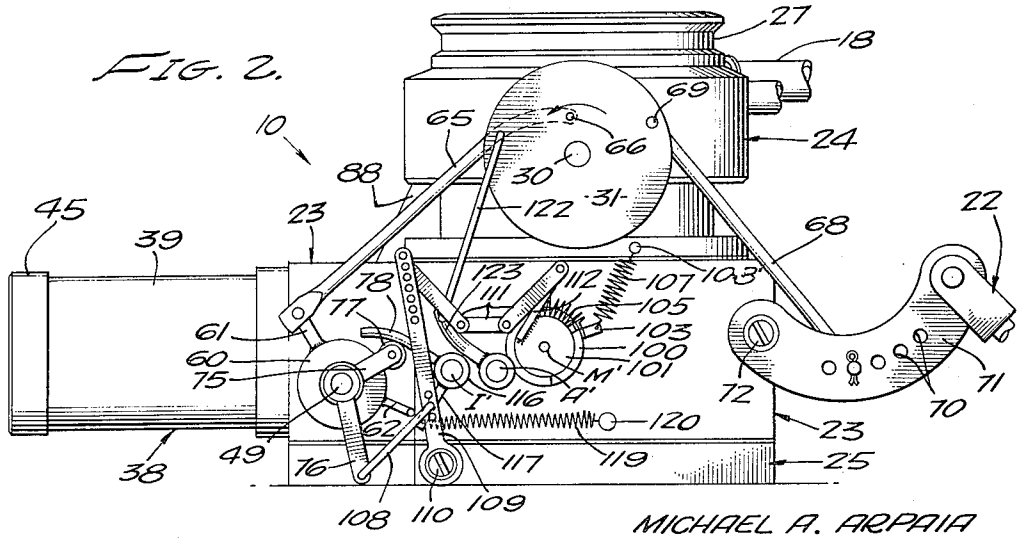


FIG. 2.



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FUEL SUPPLY SYSTEM, CARBURETOR AND METHOD

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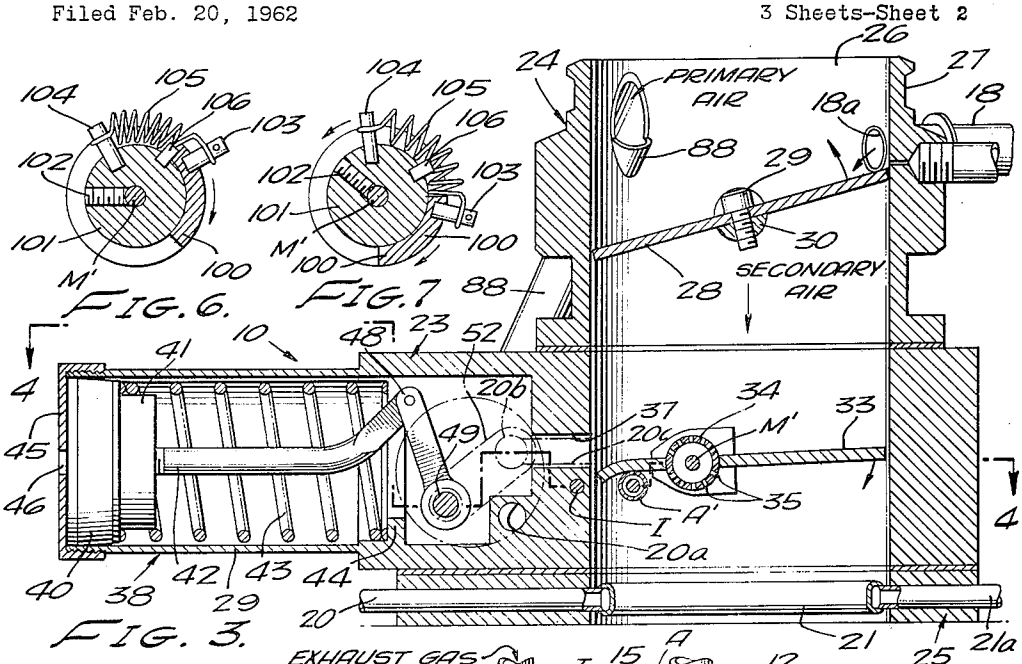

FIG. 6. FIG. 7. FIG. 3.

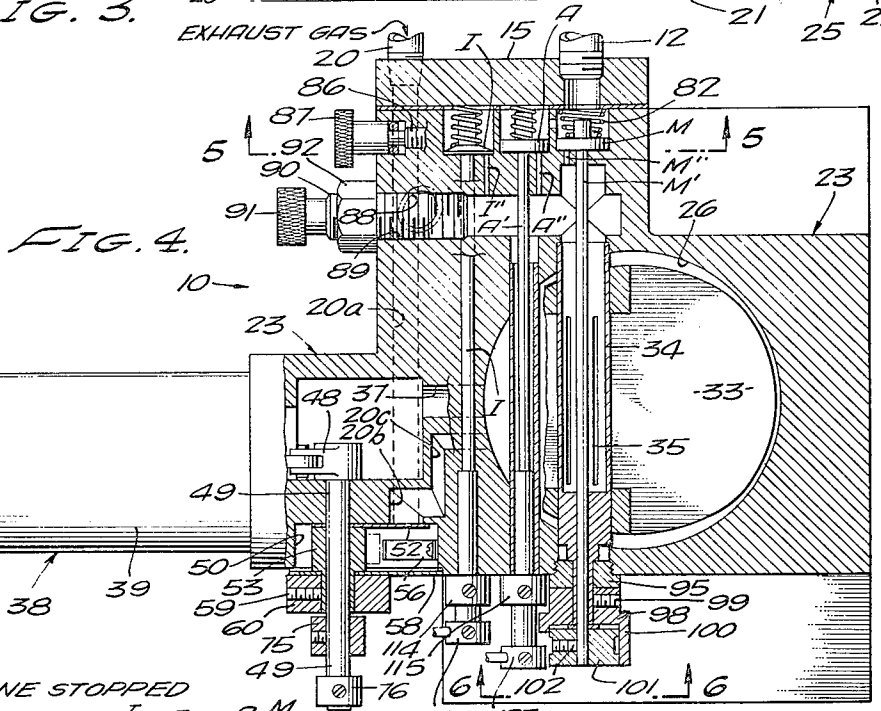

FIG. 4.

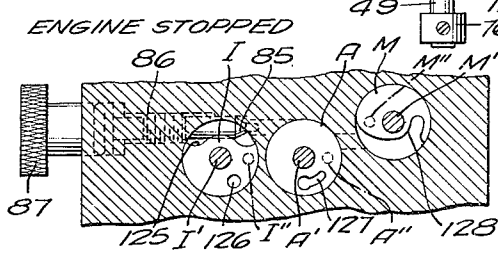

FIG. 5.

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FUEL SUPPLY SYSTEM, CARBURETOR AND METHOD

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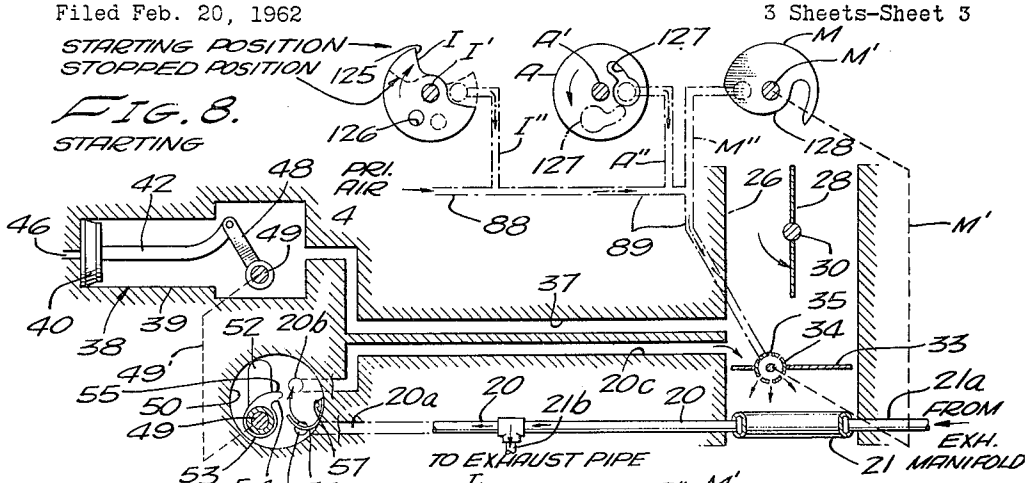

FIG. 8.
STARTING

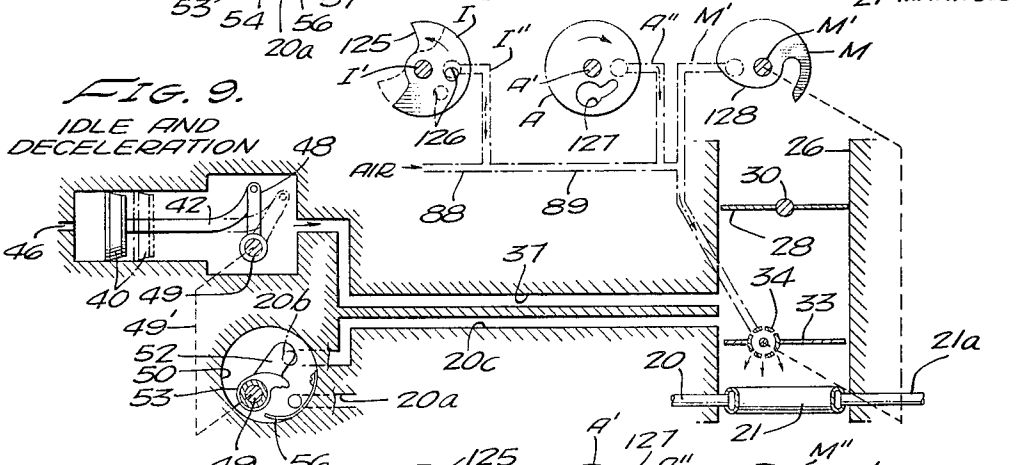

FIG. 9.

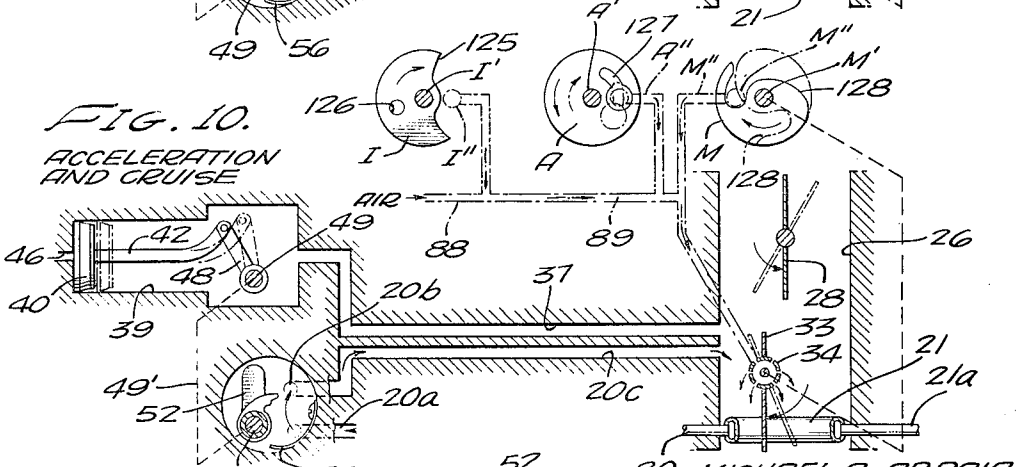

FIG. 10.

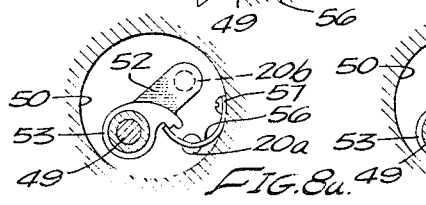

FIG. 8a.

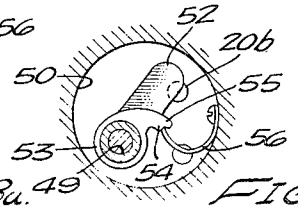

FIG. 8b.

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United States Patent Office 3,224,425 Patented Dec. 21, 1965

3,224,425

FUEL SUPPLY SYSTEM, CARBURETOR AND METHOD

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Filed Feb. 20, 1962, Ser. No. 174,608
48 Claims. (Cl. 123—122)

This invention relates to fuel supply systems for internal combustion engines and more particularly to an improved apparatus and method of forming and controlling the supply of a combustible fuel mixture in accordance with the actual fuel needs of the engine and for discontinuing the supply of all fuel when not actually required to meet power or idling requirements.

The present invention is related to and represents improvements with respect to certain novel concepts outlined in my United States Patent 2,864,597, granted December 16, 1958, and in my copending application for Letters Patent Serial No. 837,993, filed September 3, 1959 and now Patent No. 3,053,242, granted Sept. 11, 1962. Each of the referred to prior fuel systems makes use of certain auxiliaries designed to be inserted between generally conventional carburetor devices and the engine intake manifold and have as one of their principal objectives the provision of automatically controlled means for discontniuing the supply of fuel to the engine under such certain conditions, particularly during coasting and deceleration.

The present invention incorporates these same capabilities but these are obtainable as an incident to the operation of a specially constructed carburetor assembly differing in numerous respects both structurally and functionally from prior carburetor designs. For example, it has long been common practice to utilize carburetors having float chambers to control the fuel level and having suction responsive fuel jets supplied from the float chambers and discharging into the throat of a venturi forming an essential part of the carburetor. Such jets have calibrated throats effective to supply fuel at a rate depending on the pressure differential acting on the opposite ends of the jets, and varied by varying the pressure at the venturi throat. While this arrangement has been widely used and possesses certain advantages, it is recognized as subject to certain serious disadvantages sought to be avoided by the present invention. One of the manifest limitations on such prior systems is the fact that the efficient functioning of the carburetor is adversely affected under nonlevel operating condition, such carburetors being unsuitable for use under widely varying altitude conditions or where the engine is required to operate in widely differing angular positions. Also certain operating and design characteristics of carburetors using nozzle jets are subject to the supply of excess and unnecessary quantities of fuel to the engine during coasting and deceleration operation. Moreover, since the combustion air supply is virtually cutoff at such times, the fuel and mixture which does flow to the cylinders is too rich for proper or complete combustion with the result that partially burned hydrocarbons issue from the exhaust system to pollute the atmosphere to leave unmentioned the losses in engine effiicency and cost of operation.

A further and particularly serious objection to prior systems is the fact that the engine performance is deficient in numerous respects evidenced by sluggishness, power loss and inability to respond quickly to changes in loading conditions. For example, the supply of fuel into the air stream is dependent upon rotation of the engine for a sufficient period to produce sufficient lowering of the air pressure in the venturi to activate the fuel jets.

To minimize this highly objectionable delay, it has been customary to provide supplementary devices in the form of accelerator pumps effective to supply an initial quantity of fuel into the combustion air stream. Such supplementary devices are rendered operative in a number of ways as by the operator depressing the accelerator pedal. However, an operation of this type varies widely between individuals and is most difficult to control, particularly in the hands of unskilled and inadequately informed engine operators with the result that the engine is easily flooded or, at best, is supplied with a fuel mixture which is too lean or too rich.

Another shortcoming of prior carburetion systems is the fact that engine performance, particularly in the case of higher compression engines, is dependent on the use of fuels within a limited octane range. Attempts to use fuels outside this range result in seriously inferior engine performance, severe knocking and risk of damage to the engine.

Another shortcoming of prior carburetors is the lack of satisfactory and efficient means for obtaining a proper fuel and air ratio over a wide range of engine operating conditions.

The foregoing and other serious shortcomings of prior fuel supply systems for internal combustion engines are overcome by the present fuel system and method of regulating and controlling the supply of combustible mixture to an engine. Among the important distinguishing characteristics of the present carburetor is the absence of both a float bowl and suction activated metering jets of any character. Likewise lacking is the conventional venturi passage and the functions performed thereby.

Instead the present carburetion system makes use of any suitable fuel pump operable to supply fuel under predetermined pressure directly to the inlet side of the fuel metering valves so long as the engine is rotating. The flow of fuel from this pressurized supply to the intake manifold occurs past metering valves arranged to be regulated and adjusted by various functionally interrelated auxiliaries forming important components of the present invention.

The fuel metering valves include a main valve, an acceleration valve and an idling valve, each discharging into a common primary air passage maintained sufficiently warm to vaporize substantially all fuel before the resulting rich mixture of vapor and air is discharged into a main stream of secondary air. The briefly described flow of fuel and air into the manifold occurs substantially immediately that the operator presses the accelerator to start the engine and without the delay inherent in typical prior carburetion systems. Furthermore, the mixture of fuel vapor and primary air is introduced into the secondary air through a plurality of wide thin jets thereby greatly facilitating faster and complete admixture of the very rich mixture with the secondary air.

Preheating and vaporization of the fuel is accomplished through use of hot exhaust gases bled from the exhaust system and conducted through heat exchange passages traversing the carburetor housing. Regulated portions of such exhaust gases in semicooled condition are discharged into the intake manifold along with the combustible mixture and are found to be highly effective in slowing the combustion rate within the engine cylinders. By proper regulation of the quantity of exhaust gases supplied to the cylinders along with the combustible mixture, it is found that fuels having a wide range of octane ratings can be used in the same engine to provide high performance operation wtihout need for adjusting the carburetor.

Another important feature of the invention is the provision of sensitive pressure responsive means responsive

to pressure conditions within the intake manifold and operable to supplement the accelerator pedal in controlling the positions of the several valves including the valve regulating the supply of exhaust gases to the intake manifold. The pressure responsive control performs many operations at different times including cutting off all fuel flow to the engine when the engine is stopped as well as during deceleration and coasting operation. For example during deceleration or coasting, air throttle valve is fully closed causing a marked reduction in pressure in the manifold with the result that the pressure responsive device acts to close all fuel flow to the engine until the engine approaches idling speed or the operator opens the throttle valve to resume speed. In either case the increase in the manifold pressure characterizing slowing of the engine to the idling seped is utilized to reopen the idling fuel valve whereupon the rotating engine resumes idling operation in a normal manner and without the operator realizing that the engine actually has not been running on fuel supplied to it. Other functions of the pressure responsive device include that of enriching or leaning the fuel mixture automatically as is desirable under certain engine operating conditions thereby increasing engine performance, economy and efficiency.

Another feature involves the use of a flow responsive vane positioned downstream from the air throttle valve to the rate of the flow to adjust the main fuel metering valve to provide a desired fuel-air ratio and supplementing the main throttle valve in regulating the quantity of the air admitted to the intake manifold. These functions are highly important and are performed by the present invention in highly effacious and positive manner.

Accordingly, it is a primary object of the present invention to provide an improved fuel supply and carbureting system and method for an internal combustion engine having numerous advantages over prior systems and methods.

Another object of the invention is the provision of an improved carbureting device for internal combustion engines which operates with uniform efficiency independently of gravity forces and the position of the carburetor relative to the horizontal and operating in conjunction with a pressurized source of liquid fuel.

Another object of the invention is the provision of a carbureting method and system for supplying a premixed stream of primary air and vaporized fuel into a main stream of secondary air and including in addition means for preheating the initial mixture as well as for slowing down burning of the combustion mixture in the engine cylinders thereby avoiding knocking, pinging and the like characteristic of too rapid combustion.

Still another object of the invention is the provision of a fuel system wherein pressurized liquid fuel is supplied directly into a preehated air system for vaporization therein prior to the introduction of this rich mixture into a main stream of secondary air flowing into the intake manifold.

Another object of the invention is the provision of automatic means responsive to subatmospheric pressure conditions in the engine intake manifold and operable to close off all supply fuel to the engine during certain conditions, as for example, during deceleration and coasting of the engine, and capable of sensing slowing of the engine virtually to idling speed before resuming idling fuel supply.

Another object of the invention is the provision of a carbureting system incorporating manifold pressure sensing means operating to control and regulate the bleeding of hot exhaust products into the carburetor as well as for supplying controlled quantities of hot products of combustion into the combustible fuel mixture for the purpose of slowing down and regulating the burning rate of the mixture in the cylinders.

Another object of the invention is the provision of a fuel supply and carbureting system for an internal

combustion engine having a manually controlled throttle and associated linkage mechanism for selectively operating metering valves controlling flow of pressurized liquid fuel through discharge ports opening directly into an air flow passage of the carburetor and so arranged that fuel is admitted into the air stream prior to or simultaneously with starting rotation of the engine.

Another object of the invention is the provision of an improved carbureting system for engines subjected to wide variations in loading and to speeds ranging between idling and full speed and characterized by highly efficient combustion throughout the operating range, the negligible production of oxides of nitrogen and the presence of substantially no unburned hydrocarbons.

Another object of the invention is the provision of automatic means activated as an incident to engine starting actuation of the accelerator pedal and effective to operate the engine at faster than normal idling while the engine is warming and thereafter effective to slow the engine to normal idling speed.

Another object of the invention is the provision of a fuel supply system for an engine incorporating means for purging both the fuel tank and the crank case of hydrocarbons and to admixture these with fuel and air flowing to the engine intake manifold.

These and other more specific objects will appear upon reading the following specification and claims and upon considering therewith the attached drawings to which they relate.

Referring now to the drawings in which preferred embodiments of the invention are illustrated.

FIGURE 1 is a top plan view of a preferred embodiment of the carburetor per se incorporating features of the present invention, the view being taken looking into the air inlet of the carburetor proper and showing schematically certain other auxiliaries of the fuel system;

FIGURE 2 is a side elevational view of the carburetor proper looking upwardly from the bottom of FIGURE 1 and showing the position of parts when the engine is stopped;

FIGURE 3 is a broken line sectional view taken longitudinally through the pressure sensing device and through the main air flow passage, the position of the parts being those occupied when the engine is stopped;

FIGURE 4 is a broken sectional view taken along the broken line **4—4** on FIGURE 3 showing the position of components of the fuel metering valves;

FIGURE 5 is a fragmentary sectional view taken along line **5—5** on FIGURE 4 and showing the positions of the three fuel metering valves and the ports controlled thereby when the engine is stopped;

FIGURES 6 and 7 are fragmentary sectional views on an enlarged scale taken along line **6—6** on FIGURE 4 and showing details of certain of the components of the main fuel valve used to control leaning and enriching the fuel mixture during cruising operation; FIGURE 6 showing the positions of the parts during normal conditions without leaning of the mixture and FIGURE 7 showing the positions of the parts while the mixture is being leaned;

FIGURE 8 is a schematic representation of the more important passages of the carburetor, together with the several valves, and indicating in full lines the positions of these valves immediately following depression of the accelerator pedal and before actual starting of the engine;

FIGURES 8*a* and 8*b* are fragmentary views of the thermostatic compensator respectively, showing the position of the immediately associated components when the engine is stationary, cold and before depression of the accelerator in the first of these views, and second view showing the position of the parts under fast idling immediately following starting and prior to engine warmup.

FIGURE 9 is a schematic view similar to FIGURE 8

and showing in full lines the positions of the same parts after starting and during engine idling operation, the dotted line position of the parts being the positions occupied during coasting and deceleration; and,

FIGURE 10 is a view similar to FIGURES 8 and 9 but showing in full lines the positions of the several parts during acceleration, and by dot and dash lines, the slightly different positions during cruising operation.

Construction in general

Referring more particularly to FIGURE 1, there is shown a preferred embodiment of a fuel supply and carbureting system incorporating the present invention and designated generally **10**. Components of the usual operating environment forming no part of the present invention and well understood by those skilled in the art have not been illustrated or have been indicated only schematically. For example, the engine fuel tank **11** has a fuel line **12** leading into a conventional fuel pump **13** understood as driven by the engine and supplying fuel under a predetermined pressure determined by the setting of the high pressure relief valve R. By this means liquid fuel under constant pressure is supplied to a manifold extending horizontally along one side of the carburetor housing and normally closed by a removable cover plate **15**. Fuel tank **11** is normally sealed by a removable filling cap **16**, the usual breather opening of which has seated therein a pipe **17** opening into the carburetor main air passage by way of a conduit **18**. Conduit **18** will be understood as having its inlet end connected into the engine crankcase. It will therefore be recognized that unburned or incompletely burned hydrocarbon vapors derived from the top of the sealed fuel supply tank **11** as well as from the engine crankcase are bled into the carburetor intake and are admixed with the combustible mixture flowing to the engine.

Other auxiliaries of the fuel system shown in FIGURE 1 include a conduit **19** leading into the carburetor main air passage from the right hand side thereof and communicating with the engine distributor housing for use in known manner to control the advance and retardation of the ignition system in the usual manner. An exhaust gas conduit **20** enters the side of the main carburetor housing by way of the fuel manifold cover **15**, its inlet end being in communication with the engine exhaust manifold or conduit and serves to bleed hot products of the combustion therefrom into the carburetor. These hot gases are used to preheat the fuel and primary air as well as for admixture with the combustible mixture to control the rate of combustion, the manner in which this is done and controlled being explained in detail below. Another and highly important auxiliary is the manually operated linkage **22** having its unshown end arranged to be controlled by the operator, as through the usual accelerator pedal of a motor vehicle. Suitable spring means not shown act to urge linkage **22** toward the right thereby normally urging the throttle valve and other parts linked thereto to the positions indicated in FIGURES 1 to 5 and representing non-operation of the engine.

The carburetor assembly proper includes a main housing best shown in FIGURES 1, 2 and 3 as having a main casting **23** interposed and suitably rigidly secured to a tubular inlet coupling **24** and a mounting plate **25** by which the assembly is secured to the inlet opening (not shown) of the engine intake manifold. These three members are connected together through conventional sealing gaskets and the several central openings axially aligned to provide a main air passage **26** lacking a venturi throat and here shown as being of the same diameter throughout. The upper end of this passage will be understood as connected in normal use to the discharge of a suitable air filter mounted thereover and clamped to passage **26** by clamp means seating within groove **27**. The lower end of main air passage **26** will be understood as mounted in airtight registry with the inlet of the engine intake manifold, not shown.

Flow through main air passage **26** is controlled primarily by a throttle valve **28** secured by screws **29** to a shaft **30** journaled transversely of the upper or inlet end of main passage **26**. One end of shaft **30** extends through the wall of tubular member **24** and has firmly fixed to its outer end a disc **31** (FIGURES 1 and 2) forming part of the accelerator pedal control linkage to be described in more detail presently. Located downstream from throttle valve **28** in main air passage **26** is an air flow responsive vane **33** secured to the slotted fuel and primary distributing tube **34**. Tube **34** lies parallel to shaft **30** and is suitably journaled in the main housing. The portion of tube **34** exposed within passage **26** is provided with a plurality of elongated narrow slots **35** discharging a rich mixture of fuel and air to either side of vane **33**. Of importance is the fact that slotted tube **34** is offset to one side of the center of air passage **26**. In consequence, a considerably greater surface area of vane **33** is located on one side of tube **34** than on the other. Furthermore, and unlike throttle valve **28**, vane **33** has sufficient spacing from the side wall of passage **26** when pivoted to lie crosswise of air passage **26** to pass sufficient air and fuel emanating from slotted tube **34** to satisfy engine idling requirements. Throttle valve **28** however differs from throttle valves commonly used in carburetors in that it is designed to have a close and substantially sealed fit with the passage side walls when occupying its closed position as illustrated in FIGURE 3. Under these conditions substantially all air flowing into the intake manifold must enter by way of slots **35** in tube **34** or by way of the exhaust gas passage as will be described presently.

The pressure sensing device

The pressure sensing device designated generally **38** forms an important part of the carburetor unit and comprises a cylindrical outer housing **39** formed integral with housing **23** and projecting laterally from one side wall of the latter. Although structurally simplified sensing device **38** is generally similar in purpose and function, although structurally much simpler than to the pressure sensing devices shown in my Patent 2,864,597 and in my aforementioned application for Letters Patent. The interior end of cylinder **39** communicates through a large bore **37** with main air passage **26** in an area opposite vane **33**. Reciprocally supported interiorly of cylinder **39** is a piston comprising a shallow cup-shape resilient self-sealing piston **40** of suitable material such as Teflon. This piston has outwardly flaring side walls terminating in a thin edged lip having a close sealing contact with the interior of the cylinder. This piston is securely supported centrally of its bottom by a rigid main body **41** mounted on the end of piston rod **42**. A compression spring **43** surrounds this rod with one end bearing against piston body **41** and the other end bearing against a shoulder **44** projecting inwardly from cylinder **39**. The outer end of cylinder **39** is closed by a threaded end cap **45** having a vent **46** opening to the atmosphere.

As best appears in FIGURES 3 and 4, the inner end of piston rod **42** is bent upwardly and pivotally connected by a pivot pin to a crank **48** fixed to a shaft **49** journaled crosswise of cylinder **39** and extending outwardly through the wall of carburetor housing **23**. Shaft **49** extends into a shallow cylindrical cavity **50** opening through the outer face of housing **23** and enclosing a valve for regulating the supply of warm exhaust gases into the combustible mixture flowing to the engine. It is pointed out that, as schematically illustrated in FIGURES 8 to 10, shaft **49** is shown in two sections offset from one another solely for convenience in illustrating the components. The fact that the two parts of the shaft are one and the same is indicated by the broken dash line **49'** in FIGURE 8.

The exhaust gas regulating valve located within cavity **50** comprises a thin strip of flexible metal **52** such as

phosphorus bronze brazed or otherwise secured to a hub **53** (FIGURE 4) freely rotatable on shaft **49**. The free end of valve **52** bears slightly against the bottom wall of cavity **50** and its movement under the action of decelerator linkage **22** includes different degrees of closure across outlet port **20***b* (FIGURE 8) of the exhaust gas passage **20***c* opening into main air passage **26** opposite the flow responsive vane **33**. The hot exhaust gases derived from the exhaust system by way of conduit **20** enter cavity **50** after passing along the carburetor preheating passage **20***a* (FIGURE 4).

Hub **53** to which valve strip **52** is fixed is formed with a stop **54** having a guard finger **55** (FIGURES 8 and 9). Stop **54** is positioned to be engaged during engine starting by the free end of a bimetal thermostat **56** having its other end anchored to the side wall of cavity **50**, as by a screw **57**. When thermostat **56** is cold its free end curls upwardly to lie against the radial side wall of stop **54**, whereas when warm, thermostat **56** uncurls and flexes downwardly away from stop **54**. In other words, as the engine cools after a period of operation, bimetal **56** cools and curls upwardly until its free end comes to rest against the lower generally radial side of stop **54**. In consequence, the bimetal is stressed and in readiness to curl upwardly still further as soon as hub **53** is rotated counterclockwise as viewed in FIGURE 8 as an incident to engine starting. The free end of the bimetal then moves into the position to abut stop **54** as the engine starts thereby holding the idling valve excessively open initially to assure fast engine idling during warm up. Guard finger **55** safeguards against the possibility of bimetal **56** flexing upwardly past stop **54**. As will be explained more fully below, bimetal **56** also provides a limiting stop urging valve **52** to rotate counterclockwise on but independently of shaft **49** to control the quantity of exhaust gases flowing into exhaust port **20***b* and through passage **20***c* into the fuel mixture in main air passage **26** as well as the supply of fast idling fuel during starting and engine warm up. It will therefore be recognized that thermostat **56** is a temperature compensating device superimposed on the other regulating controls for valve **52** and is effective to further control the supply of fast idling fuel and the flow of hot exhaust gases allowed to enter the heat exchange passage **20***a* and to mix with the fuel mixture. To be pointed out is the fact that the location of cavity **50** and valve **52** on the remote face of the carburetor housing from supply pipe **20** allows much of the heat in the gases to be absorbed by heat exchange with the carburetor housing and with the fuel and air present in mixing passages **89** (FIGURE 4). Hence, the gas entering cavity **50** is appreciably cooler than when entering passage **20***a* and does not warp or overheat valve **52**.

As is made clear in FIGURES 1, 2 and 4, the outer end of shaft **49** projects beyond cavity **50** and through a cover plate **58** (FIGURES 1 and 4). This cover plate, generally rectangular in shape, lies flush against the face area of housing **23** and has an opening having a loose fit with the reduced outer end portion of shouldered hub **53**. Fixed to the outer end of hub **53**, as by set screw **59**, is a disc **60** having a pair of L-shaped arms **61**, **62** projecting radially from its periphery as is best shown in FIGURES 1 and 2. Arms **61**, **62** are spaced approximately 145 degrees apart in a clockwise direction as viewed in FIGURE 2, and the shorter leg of upper arm **61** is socketed in an opening in the end of a rigid link **65** pivoted to a pin **66** carried on the rear face of disc **31** fixed to throttle valve **28**. A second rigid link **68** is connected between pin **69** mounted in disc **31** and a selected one of openings **70** in arc lever **71** forming part of the manually controlled accelerator linkage **22** for the carburetor. The left hand end of lever **71** is pivotally supported on the carburetor casing by a shouldered screw **72**.

Referring back to disc **60**, it is pointed out that the second L-shaped arm **62** projecting from this disc has its shorter leg lying parallel to shaft **49** and underlying an arm **78** (FIGURE 2) extending from the idling fuel control mechanism and will be described in greater detail in connection with that valve. It suffices to say that at this point arm **62** is a positively operated component of the acelerator linkage and is operable thereby to open the idling fuel valve I during engine starting conditions.

Other auxiliary arms likewise rigidly secured to the acelerator controlled linkage **22** and operated thereby are best shown in FIGURES 1, 2 and 4. These auxiliaries include an arm **75** fixed to shaft **49** closely beside disc **60** and a second arm **76** fixed to the outer end of shaft **49**. Inner arm **75** pivotally supports a roller **77** against its inner face and near its outer end which roller underlies and operates in the plane of an arcuate arm **78** projecting radially from and secured to shaft I' of idling fuel valve I. Outer arm **76** forms part of the operating linkage for the fuel leaning and enriching control and will be described later following a description of fuel metering valves.

Fuel metering valves and the operating linkage therefor

The three fuel metering valves and their structural relationships to one another and to other components of the illustrated embodiment of the carburetor is best shown in FIGURES 3, 4 and 5 whereas certain of their functional relationships are more clearly illustrated schematically in FIGURES 8, 9 and 10. A description of the structure will be given first with the reference to FIGURES 3, 4 and 5. There are three fuel metering valves arranged in side-by-side relation in communicating cavities of the main housing which cavities are closed by cover plate **15** (FIGURE 4). For convenience of identification the idling valve is designated I, the accelerator valve by A, and the main metering valve by M. Each valve comprises a disc having a flat inner face having a precision rotating fit with juxtaposed bottom wall of the fuel supply cavity. Each valve is also contoured and ported in the manner best shown in FIGURES 5, and 8 to 10 and each is fixed to an associated shaft I', A', M' rotatably journaled in parallel passages extending transversely to main body **23** of the carburetor housing.

The idling and accelerating fuel valves I and A are held pressed against their respective metering orifices by light compression springs (FIGURE 4) acting between cover **15** and the outer faces of the respective valves. Main valve M is held seated by a light helical spring **82** having its larger end sealed against the packing gasket for cover **15** in an area opposite the discharge end of fuel supply conduit **12**. The fuel flows into the fuel manifold extending across the face of the fuel inlet side of each of the valves and understood as maintained sealed closed by cover **15**. As is best shown in FIGURE 5, fuel flow to the inlet side of idle fuel valve I is controlled by a needle valve **85** mounted on a threaded stem **86** having a knob **87** secured to its outer end and by which needle valve **85** can be adusted. Needle valve **85** will therefore be understood as controlling the passage of pressurized fuel from the portion of the fuel manifold behind valves A and M into the receiving chamber behind idle valve I. Valve I, in turn, is controlled automatically through means to be described to permit or to block idling fuel flow depending on engine operating conditions, the principal function of valve I being to cut off all idle fuel flow under certain engine operating conditions and to permit proper idle fuel flow at other times.

Each of valves I, A, M moves across fuel distributing passages I'', A'' and M'', respectively, of appropriate small dimensions for fuel metering purposes and the outlet end of these passages open into a relatively large bore primary air passage **89** (FIGURE 4) containing preheated primary air enroute to the engine intake manifold. As herein shown the primary air is withdrawn from the upper end of main air passage **26** through a tube **88** opening into the mixing and preheating passage **89** extend-

ing horizontally across the carburetor parallel and close to the fuel inlet manifold.

The volume of primary air permitted to enter preheating passage **89** is controlled by a threaded valve member **90** (FIGURE 4) supported in the threaded outer end of passage **89** at the juncture of this passage with tube **88**. A knob **91** on the outer end of member **90** serves to adjust the position of member **90** across the lower end of tube **88** and is locked in any adjusted position by lock nut **92**.

Preheating passage **89** is out of communication with but in heat exchange relation to the hot products of combustion flowing through passage **20***a* of the main carburetor housing. Since the housing is made of brass or other suitable high heat conducting material, it will be understood that passage **89** is maintained warm at all times the engine is operating and despite the cooling effect of the liquid fuel undergoing evaporation in passage **89**. In addition, the hot gases are effective to preheat liquid fuel as it enters the manifold chamber from supply conduit **12**. In consequence the fuel present in passage **89** flashes into vapor as it mixes with the preheated primary air.

This very rich mixture of fuel and air leaving passage **89** passes directly into the inlet end of slotted fuel dispensing tube **34** and issues in thin sheet-like jets through slots **35** of this tube into the surrounding stream of secondary air in passage **26**. The end of tube **34** remote from the preheating passage **89** has a close fit about the shaft M' of the main fuel metering valve M and projecting through a suitably sealed opening in the side wall of main housing **23**, in the manner illustrated in FIGURE 4. The lower end of tube **34** will be understood as provided with stepped hubs, the smallest diameter one of which has a close fit with the interior of a positioning bushing **95** mounted in housing **23**. The inner end of this bushing bears against the shoulder of tube **34** and is adjustable by reason of its threaded engagement with the housing to hold the inner face of main fuel valve M in close rotating engagement with the manifold wall and across the inlet to metering passage M''.

Fuel Leaning Mechanism

The mechanism for leaning the fuel mixture automatically is mounted on the small diameter end of tube **34** projecting outwardly beyond bushing **95**. This mechanism includes a hub **98** fixed to tube **34** by set screw **99** and having an arcuate shouldered flange **100** projecting axially from the rim of hub **98** and closely embracing a small diameter collar **101** fixed by set screw **102** to the outer end of valve shaft M''. Hub **98** and its operative relationship to collar **101** is illustrated on an enlarged scale in FIGURES 6 and 7 to which reference will now be had.

Projecting radially from flange **100** of hub **98** and from collar **101** are fixed pins **103**, **104** respectively, providing an anchorage for the opposite ends of a light-duty tension spring **105**. A stop pin **106** projecting radially from collar **101** is positioned between pins **103**, **104** and abutts the adjacent end of flange **100** thereby limiting the effectiveness of spring **105** in rotating shaft M'' of the main fuel valve M clockwise toward pin **103** which rotates with the slotted fuel dispensing tube **34** and with the air flow responsive vane **33** fixed to this tube. The means provided for biasing the above described part of the fuel leaning mechanism against a fixed reference stop includes pin **103** (FIGURES 2 and 6) provided with an opening seating the end of a light tension spring **107** having its opposite end encircling an anchor pin **103'** projecting laterally from the carburetor housing. Spring **107** is effective to urge air flow responsive to vane **33** to its normal closed position as shown in FIGURES 3 and 4, and against a stop provided by the tube enclosing shaft A' directly to the left of tube **34** as viewed in FIGURE 3. From the foregoing it will be recognized that spring **105** is effective to rotate collar **101** and shaft M' of main fuel valve M against the stop provided by flange **100**. (FIGURE 6). In this manner there is provided a definite reference point or stop for each of the separately and relatively movable components just described.

Normally the relative positions of main fuel valve M and of air flow responsive vane **33** remains fixed by reason of the described action of spring **105** and stop pin **106**. However under certain operating conditions and particularly during cruising operation of the engine, the fuel mixture flowing to the intake manifold may be leaned advantageously in the interest of better and more more economical operation. This is accomplished by reason of the above described mechanism operating in concert with a lost motion linkage now to be described and connected between collar **101** fixed to main fuel valve shaft M' and an operating component of pressure sensing device **38**.

This lost motion linkage is shown in FIGURES 1 and 2 and includes pivotally interconnected members comprising link **108**, lever arm **109** pivotally supported on anchor screw **110**, the three links **111**, and arm **112** welded or otherwise secured to the face of collar **101**. The opposite ends of lever **109** are provided with a series of openings, to the lower ones of which link **108** is selectively securable and to the upper ones of which the adjacent one of links **111** is selectively securable. When the engine is stopped, these parts occupy the relaxed positions shown as in FIGURE 2, the pressure sensing piston **40** then being held at the outer end of cylinder **39** by spring **43**. However under engine cruising operation, the intermediate low pressure conditions prevailing in the intake manifold will be effective on piston **40** to tension the described lost motion linkage thereby to rotate fuel valve M counterclockwise (FIGURE 10) to lean the fuel admitted to metering passage M''. Leaning of the fuel mixture will be understood as accomplished in part by pressure sensing device **38** and in part by the action of spring **106** acting in cooperation with air vane **33**. A fuller understanding of these details will be had in later portions of this disclosure.

While referring to FIGURES 2 and 4, it is desired to point out the operating relationships of the linkage interconnecting shaft I', A' for idling fuel valve I and accelerating fuel metering valve A with the other linkage members. From FIGURES 2 and 4, it will be noted that the idling valve shaft I' projects outwardly from the side wall of the carburetor and is helf firmly seated against the inlet end of metering port I'' by means of a collar **114** (FIGURE 4) fixed to shaft I' by a set screw. A similar collar locked to the outer end of shaft A' close against the side wall of the carburetor performs a similar function with respect to accelerating valve A. A second collar **116** locked to shaft I' by a set screw is provided with a pair of radial arms **78**, **117** spaced approximately ninety (90) degrees apart. The curved end of arm **78** overlies and normally bears against roller **77** carried by arm **75** fixed to shaft **49** of pressure sensing device **38**. The other arm **117** lies in the seven o'clock position, as viewed in FIGURE 2 and supports one end of a light tension spring **119** secured to a pin **120** projecting from the carburetor housing. It will be understood that spring **119** tends to rotate idling valve shaft I' counterclockwise thereby tending to maintain idling valve operating arm **78** against roller **77** of pressure sensing device **38**. It will be recalled that arm **78** is located in the path of both roller **77** and the shorter outer end of the L-shaped arm **62** which arm **62** forms part of the accelerator linkage **22**. Roller **77** is therefore seen to be responsive to movements of the pressure sensing device whereas arm **62** forms a part of the manually controlled accelerator linkage, and is operable independently of the pressure sensing device to open idle fuel valve I during engine starting. The accelerator pedal is retracted to its cutoff position (as it is in FIGURE 2), arm **62** occupies the four o'clock position and is spaced considerably

below arm 78 of the idling fuel valve. However, when the accelerator is depressed to rotate throttle valve 28 counterclockwise to its open position, link 65 rotates disc 60 and arm 62 counterclockwise to engage arm 78 and open the idle fuel valve I. In this operation it will be understood that the shorter leg of L-shaped arm 62 bypasses the periphery of roller 77.

The remaining undescribed part of the linkage comprises the operating connection between the accelerator linkage 22 and the exposed outer end of shaft A' of accelerating fuel valve A. This connection includes a link 122 having its upper end socketed in disc 31 fixed to the shaft of throttle valve 28 and its lower end pivotally connected to the outer end of an arm 123 fixed to shaft A' of accelerating valve A. Arm 123 is so located as to swing counterclockwise from the position shown in FIGURE 2 without interference with any of the other illustrated arms and links and will be understood as controlled entirely by the manually operated accelerator linkage 22.

Referring to FIGURES 5, 8, 9 and 10, it will be understood that FIGURE 5 shows the position of the three fuel valves I, A and M when the engine is stopped and all fuel is positively cut off. Each of these valves are of different configuration. For example, idling valve I has a cutout 125 of approximately 120 degrees along its periphery as well as a port 126 positioned to move into and out of registry with the entrance to the idling fuel metering passage I''. Likewise, accelerating metering valve A has a key-hole shaped port 127 cooperating with the inlet to the accelerating metering passage A''. Main fuel metering valve M is of more complex contour and is cut away along the precision and complexly curved line 128 and in the manner necessary to meter the main flow of fuel into metering passage M''.

Catalyzer for promoting combustion mixture

As has been disclosed in my copending application for Letters Patent Serial Number 837,993, filed September 3, 1959, for a Carbureting System, complete combustion of the combustible mixture is greatly enhanced by subjecting the mixture to contact with a catalytic agent as for example hot copper. This important step may be carried out in various ways, as for example, by continually passing hot exhaust gases through a copper tube in heat exchange with the fuel and air mixture enroute to the engine cylinders. A suitable heat exchanger may comprise a hollow copper ring 21 located in passage 26 downstream from vane 33 (FIGURES 3, 8). An inlet tube 21*a* conducts hot exhaust gases directly from the exhaust manifold (not shown), these very hot gases passing through heat exchanger 21 and then into conduit 20 leading into the interior of the carburetor as described above and with the remainder passing back into a downstream portion of the exhaust pipe by way of conduit 21*b*.

It will be understood that the very hot copper tube 21 is found to be a highly effective catalyzer for the fuel and air mixture for reasons not fully understood. It is pointed out that the area of hot copper in contact with the fuel mixture may be increased as desired and found to provide the most effective and efficient catalytic effective, the particular relative proportions shown in the drawings being generally illustrative of proportions and arrangements found to provide superior and beneficial results.

Operation

STARTING

While the engine is stopped the parts are in the position shown in FIGURES 1 to 5 and each of the fuel metering valves I, A and M is fully closed over its respective metering passages I'', A'' and M'', the flow responsive air vane 33 is positioned transversely of main air passage 26, and throttle valve 28 is likewise fully closed. Exhaust gas valve 52 is also fully closed across port 20*b* and the cold bimetal 56 is under slight stress with its free end pressed against the side of stop 54 on hub 53. It will be understood that bimetal 56 has insufficient strength to rotate hub 53 at any time.

To start the engine, the operator turns on the switch to the ignition system and depresses the accelerator (not shown) thereby shifting accelerator linkage 22 to the left as viewed in FIGURES 1 and 2 and opening throttle valve 28 substantially fully. At this time the various parts and valves will be positioned as represented schematically in FIGURE 8 it being noted that counterclockwise movement of hub 53 by the accelerator linkage permits bimetal 56 to flex against guard finger 55 with its end position to abut stop 54 as the operator releases the accelerator. Prior to rotation of the engine crank shaft by the starter motor, flow responsive vane 33 and main fuel valve M will both be held closed by springs 105 and 107 acting in concert with one another.

Counterclockwise rotation of the throttle valve by depression of the accelerator also acts through links 65 and 122 to open idling fuel valve I and accelerating valve A to provide an augmented flow of fuel for starting. For example, link 122 rotates arm 123 counterclockwise to rotate shaft A' of valve A to bring the larger end of port 127 (FIGURE 8) into registry with outlet passage A''. At the same time link 65 rotates arm 62 counterclockwise until its outer end contacts arm 78 to rotate the latter along with idling valve I clockwise from the dotted line to the full line shown in FIGURE 8 so that idling fuel is free to flow through passage I'' into primary air passage 89. The opening of the idling fuel valve by the accelerator linkage is also effective through disc 60 (FIGURE 2) and its attachment to hub 53 (FIGURE 4) to rotate hub 53 counterclockwise thereby permitting the cold bimetal 56 to flex upwardly against guard finger 55 (FIGURE 8) with its free end positioned to abut stop 54 as the operator removes his foot from the accelerator. The bimetal then locks throttle valve 28 slightly open in fast idling position until the engine warms. Rotation of the engine by the starter motor operates the fuel pump 18 (FIGURE 1) to supply fuel under predetermined pressure, as determined by the automatic relief valve R, to flow into the manifold passage containing the three metering valves. Since main fuel valve M remains closed at this time, fuel can flow into air passage 89 only by way of accelerating valve port 127 and idling valve port 126, it being borne in mind that the idling fuel flow is controlled by the adjustment of needle valve 85.

Rotation of the engine crankshaft lowers the pressure in the intake manifold and in the main air passage 26. This reduction in pressure causes the fuel and air mixture formed in primary air passage 89 to flow into the inlet end of slotted tube 34, through slots 35 therein, and into the main air passage 26, and thence into the intake manifold and to the engine cylinders.

As the engine starts, the operator partially removes his foot from the accelerator pedal, allowing the latter to partially close along with partial closure of the air throttling valve 28 and of port 127 of accelerating fuel valve A.

As this occurs, the released accelerator linkage also allows disc 60 and the attached hub 53 to rotate clockwise until stop 54 on hub 53 abuts the end of bimetal 56 thereby locking throttling valve 28 in fast idling speed position. In this manner the engine automatically operates at fast idle immediately on starting and as the operator takes his foot off the accelerator. As the engine warms, so does bimetal 56 causing it to flex downwardly off stop 54 to throttle valve 28 to close to normal slow idle speed.

Before the engine started, pressure sensing piston 40, 41 was located at the left hand end of cylinder 39, being held there by spring 43. However, as soon as rotation of the engine reduces the pressuer in the intake manifold (which occurs after patrial closure of throttle valve 28), this pressure reduction is communicated through passage 26 and pressure sensing passage 37 into the interior of

cylinder 39. Atmospheric pressure acting on the left hand or outer end of the piston by way of vent 46 is effective to shift this piston to the right. Simultaneously, with this action, the lower suction pressure and the consequent larger flow of air through carburetor passage 28 acts to pivot vane 33 clockwise in opposition to spring 107 (FIGURE 2), thereby metering and proportioning the flow of secondary air relative to the rich mixture of primary air and fuel mixture discharging through slots 35 of tube 34 supporting vane 33.

It should also be noted that when the engine is stopped and cold, valve 52 attached to hub 53 is closed across exhaust gas outlet port 20*b*. However, depression of the accelerator to start the engine moves valve 52 to a vertical position (FIGURE 8) entirely to one side of port 20*b*. After engine starting and removal of the foot from the accelerator, valve 52 moves to the right partially closing port 20*b*. After engine warm up and during slow idling, port 20*b* is substantially closed by valve 52.

IDLING OPERATION

The position of the various parts under idling conditions is best shown in FIGURE 9, it being understood that the foot is then removed from the accelerator with the result that throttle valve 28 is fully closed. Under these conditions substantially no air entering the top of main passage 26 can flow past the throttle valve. Accordingly, only filtered primary air enters and this air flows into the open end of air tube 88, past the regulatable end of the primary air regulating valve 90 into the preheating and mixing air passage 89. Also with throttle valve 28 closed, a rather low manifold pressure will prevail and this is effective on the pressure sensing piston 40 to move the latter to the left and rotating idling valve I counterclockwise to position valve port 126 over the inlet to idling fuel passage I''. Initially and during engine warm up, port 126 is open whereas during slow idling it is closed off somewhat.

At this time exhaust gases derived from the engine exhaust manifold pass along conduit 20 enroute to the preheating duct 20*a* and into cavity 50 containing regulating valve 52 for the exhaust gases. The presence of the hot exhaust gases in contact with the main body of the carburetor heats the mixing and preheating passage 89 thereby assuring rapid and substantially complete vaporization of the fuel admitted through the several metering passages. Since bimetal 56 is cold and curled upwardly initially, it abuts stop 54 of valve 52 and holds the latter sufficiently open to allow ample exhaust gas flow through conduit 20 and passages 20*a*, 20*c* to expedite preheating of the carburetor. As this occurs, the bimetal warms and flexes away from stop 54 allowing valve 52 to further throttle the flow of exhaust gases. However, under engine idling conditions the only fuel entering passage 89 is that admitted by idling valve I held in this position by pressure sensing piston 40. In this connection it is pointed out that the subatmospheric pressure within the intake manifold and characteristic of engine idling operation, holds piston 40 in the full line postion thereof illustrated in FIGURE 9. Under these conditions, piston 40 acting through shaft 49, arm 75 and roller 77, supports arm 78 fixed to idling valve shaft I to hold port 126 in registry with the inlet to passage I''. To be noted is the fact that spring 119 (FIGURE 2) acts through arm 117 of the idling valve and tends to rotate the latter to its fully closed position shown in FIGURE 5.

In completing the description of engine idling, it should be pointed out that initially, the bimetal 56 is cold. Under these conditions its upwardly curled end is positioned to contact stop 54 on hub 53 and prevent the exhaust gas valve 52 rigid therewith from fully closing across the exhaust gas escape port 20*b* opening into passage 20*c*. This permits a greater flow of hot exhaust gases initially than after the engine and bimetal has warmed. However, soon after starting the hot gases present in cavity 50 heat bimetal 56 causing it to flex downwardly off stop 54, thereby permitting valve 52 to substantially close off flow through passage 20*c*. This avoids overheating the carburetor casing while only idling fuel is being evaporized. Under other than idling conditions, a greater quantity of heat is required to vaporize the greater quantity of fuel and to preheat the air. Likewise, at such times, a greater quantity of exhaust gases is required for admixture with the combustible mixture to slow down burning in the engine cylinders. Accordingly, with the foregoing in mind, it will be recognized that under other than engine idling conditions, the characteristic higher pressure in the intake manifold allows piston 40 to occupy a position closer to the left hand end of cylinder 39. Under these conditions exhaust valve 52 is held fully open or substantially so by the accelerator linkage. Although not shown, it will be understood that, if desired, a manually adjustable needle valve may be located in the exhaust gas supply conduit 20 and adjusted as necessary to provide the best operating results with a given engine and using the particular fuels available for it.

ACCELERATION AND CRUISING OPERATION

The operation of the described fuel supply system under acceleration and cruising conditions will be described next, reference being had primarily to FIGURE 10. To accelerate the engine quickly from idling, the operator simply depresses the accelerator pedal thereby fully opening throttle valve 28. The rise in the manifold pressure to nearly atmospheric conditions allows pressure sensing piston 40 to return to the left hand end of cylinder 39 under the action of spring 43. At the same time the accelerator linkage rotates disc 60 (FIGURE 2) counterclockwise, L-shaped arm 62 rigid therewith is rotated upwardly past roller 77 and into contact with idling valve clockwise and opening idling valve I to the position shown in FIGURE 10. Simultaneously, with the foregoing, the accelerator linkage acts through link 122 to rotate arm 123 of the accelerator valve. A counterclockwise until the large diameter portion of port 127 is in full registry with outlet passage A''.

The extra quantity of fuel thus supplied almost instantaneously into the primary air passage 89 is converted to vapor very quickly by the hot condition of this passage and of the primary air flowing therealong. The increase flow of air permitted by open throttle valve 28 also acts on flow responsive vane 33 to open the latter thereby fully opening main fuel valve M to the full line position showing in FIGURE 10. Accordingly, a maximum quantity of fuel is now supplied to the engine along with hot primary air, this rich mixture being jetted into the secondary air stream by way of slots 35 in the walls of tube 34 to which vane 33 is secured. Also added to this accurately proportioned stream of air and vaporized fuel is a predetermined quantity of semicooled exhaust gases flowing via passages 20*a*, 20*c* past the now fully open exhaust gas valve 52.

As the engine speed begins to level off after rising unusually abruptly to high speed, the pressure within the intake manifold drops toward a normal cruising pressure of 12 to 15 inches of mercury. This pressure reduction is communicated through passage 37 to the interior of pressure sensing device 38 causing piston 40 to move to the dotted line position shown in FIGURE 10. As this occurs, attached shaft 49 is rotated clockwise carrying with it arm 75. At the same time the operator normally retracts his foot partially from the accelerator pedal allowing the accelerator linkage 22 to move toward the right and rotating disc 31 and the attached throttle valve 28 clockwise to a partially closed position. This retraction of the accelerator linkage rotates arm 62 downwardly away from arm 78 of idle valve I, thereby permitting spring 119 attached to this valve to rotate the latter counterclockwise to close the inlet to passage I'' and discontinue further idling fuel to the engine. Partial release

of the accelerator pedal also acts through link **122** and arm **123** to rotate accelerator valve A clockwise to cut off or substantially cut off the supply of fuel into passage A".

Also flow responsive vane **33** in air passage **26** responds to the decreased flow of air permitted by the partially closed throttle valve and rotates slightly counterclockwise correspondingly to the lower rate of secondary air flowing in passage **26**. This movement is transmitted directly through shaft M" to main fuel valve M adjusting the latter counterclockwise with edge **128** cooperating with the fuel outlet port to proportion the fuel flow to the actual air flow. The positive and accurate proportioning of air to fuel in the manner just described is a most important feature of the invention and is determined in major part by the contour of edge **128** of valve M relative to the fuel outlet port into passage M".

Let it be assumed now that the vehicle driven by the engine is cruising at an intermediate speed without need for power other than to maintain speed. Under these conditions relatively low subatmospheric pressure conditions exist in the engine intake manifold, and piston **40** will be positioned relatively close to the right hand end of cylinder **39**. In consequence shaft **49** attached thereto will be rotated slightly further clockwise than otherwise along with attached arm **76**. Under these same conditions, air flow responsive vane **33** is pivoted clockwise to an intermediate position. With the foregoing in mind and by viewing FIGURE 2, it will be apparent that the described divergent positions of shafts **49** and vane **33** cooperate to strengthen and tension the normally relaxed fuel "leaning" linkage. In other words the three links **111** will be placed under tension and effective to rotate arm **112** slightly counterclockwise, arm **112** benig fixed to collar **101** anchored to shaft M' of main fuel valve M. Hence, valve M is rotated slightly counterclockwise in opposition to the light duty leaning spring **105** (FIGURES 2, 6 and 7). Only a slight relative rotary movement takes place between hubs **99** and **101** supporting the opposite ends of leaning spring **105**, but this is sufficient to lean the fuel mixture for more efficient operation under cruising conditions.

DECELERATION OPERATION

Deceleration operation is also of special significance since, during deceleration and coasting, the described carbureting system operates automatically to cut off all fuel flow very abruptly and positively until the vehicle and engine slows or approaches idling speed. Irrespective of whether a positive action clutch or a fluid drive connection is employed between the engine and the rear wheels, the crankshaft of the engine typically continues to rotate as the vehicle slows down. Hence the engine remains in readiness to draw fuel and air into the cylinders instantly that the supply of fuel is resumed with the result that operation of the engine resumes smoothly and without action on the part of the operator and, in fact, without his realization that the engine has not been operating with fuel during coasting and deceleration.

The manner in which all fuel flow is automatically discontinued during coasting and deceleration will now be described. The removal of the operator's foot from the accelerator pedal to initiate deceleration permits throttle valve **28** to close tightly. At the same time flow responsive vane **33** closes under the action of spring **107** (FIGURE 2) and comes to rest against the stop provided by the housing surrounding shaft A' of the accelerator valve (FIGURE 3) thereby closing main fuel valve M.

At the same time the accelerator pedal was released, link **122** of the accelerator linkage rotated arm **123** secured to accelerator valve shaft A' to rotate valve A clockwise positively closing the fuel outlet port into passage A".

Additionally, the very low intake manifold pressure characteristic of deceleration conditions is effective on piston **40** to rotate shaft **49** and arm **75** turning roller **77** clockwise until circular port **126** of idling valve I is out of registry with the idling fuel passage I". Hence, all fuel flow to the engine is cut off during deceleration as well as during vehicle coasting. As the motor continues to slow down, and as it approaches idling speed, the pressure within the intake manifold gradually rises allowing piston **40** to move to the left, thereby rotating arm **75** and idling valve I counterclockwise until port **126** is in registry with passage I" and the engine thereupon runs at idling speed until the accelerator is depressed to resume power operation.

While the particular fuel supply system, carburetor and method herein shown and disclosed in detail is fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that it is merely illustrative of the presently preferred embodiments of the invention and that no limitations are intended to the details of construction or design herein shown other than as defined in the appended claims.

I claim:

1. That improved method of forming and controlling a combustible mixture enroute to the cylinders of an internal combustion engine through an intake manifold passage in communication with the atmosphere, said method comprising providing a source of fuel under predetermined super-atmospheric pressure, admitting a metered quantity ot pressurized fuel from said source into primary air under conditions effective to vaporize liquid constituents of the fuel and to mix the same with the primary air, jetting said mixture of fuel and primary air into a stream of secondary air while the latter is enroute through said manifold passage, utilizing manifold pressure conidtions to cut-off all flow of fuel under certain engine operating conditions, and manually initiating and regulating the metering of pressurized fuel under engine idling and power demand operating conditions.

2. That improved method of forming and controlling a combustible mixture enroute to the combustion chamber of an engine which method comprises, providing a source of liquid fuel under predetermined superatmospheric pressure, metering pressurized fuel from said source into a stream of primary combustion air and vaporizing major portions of the fuel into said primary air stream, jetting said fuel and primary air mixture into a stream of secondary air to atomize remaining constituents of liquid fuel while admixing all of said fuel with sufficient air to provide a proper combustible mixture and sensing the rate of flow of secondary air and utilizing the results to vary the amount of pressurized fuel admitted to said combustible mixture.

3. That method defined in claim **2** characterized in the step of jetting said mixture of fuel and primary air in a plurality of thin wide streams into a flowing stream of said secondary air.

4. That method defined in claim **2** characterized in that said stream of primary air is adequate to supply engine idling requirements, and said method including the steps of discontinuing the flow of secondary air and of all fuel whenever there is no need for power output from said engine.

5. That method defined in claim **2** characterized in that said supply of pressurized fuel includes means for the controlled metering of the same into said stream of primary air in three separate streams a first one of which is controllable to satisfy engine idling requirements, a second one of which is controllable during acceleration conditions to provide a temporarily augmented supply of fuel, and the third one of which is controllable to regulate varying engine power output requirements.

6. That method defined in claim **2** characterized in the step of jetting said mixture of fuel and primary air into said stream of secondary air from an area surrounded by a flowing stream of said secondary air.

7. That improved method of forming and controlling

the burning rate of a combustible fuel mixture for use in operating an internal combustion engine which method comprises providing a supply of pressurized liquid fuel, metering said pressurized fuel directly into a stream of combustion air en route to the engine, regulating the relative volumes of air and pressurized liquid fuel flow in proportion to one another over a wide range of engine speed operating requirements, withdrawing a portion of the hot products of combustion from the exhaust gases of the engine, and mixing a predetermined portion of said products of combustion with the fuel and air mixture entering the engine to slow down the rate of burning of the mixture and prevent shock and hammering of engine components.

8. That improved method defined in claim 7 characterized in passing said hot products of combustion in heat exchange with said liquid fuel and with said combustion air to preheat and vaporize said fuel before the combustible mixture is supplied into the engine combustion chamber.

9. That improved method defined in claim 8 characterized in the steps of supplying combustion air to said engine in a stream formed from separate streams of primary air and secondary air, said primary air stream being relatively small in comparison with said secondary air stream, and initially mixing said fuel with preheated primary air to promote substantial vaporization of the fuel prior to passing the warm and rich mixture of fuel and primary air into said stream of secondary air.

10. That improved method defined in claim 9 characterized in that said portion of products combustion is passed in heat exchange relation to but out of contact with said fuel and primary air mixture and is thereafter passed into and mixed with the stream of secondary air.

11. That improved method defined in claim 9 characterized in the step of increasing the proportion of hot exhaust gases admitted to the combustible mixture during starting of the engine and decreasing the proportion of admitted exhaust gases as the engine warms during idling conditions, and increasing the volume of admitted exhaust gases into the combustible mixture during power operating conditions.

12. That improved method defined in claim 9 characterized in the step of varying the volume of hot exhaust gases admitted into said combustible mixture during normal engine operating conditions in accordance with variation of the volume of pressurized fuel admitted to said stream of primary air.

13. That method defined in claim 9 characterized in utilizing said hot exhaust gases to preheat said stream of primary air before the metered flow of pressurized fuel is admitted to said primary air thereby to facilitate vaporization of said fuel and to supply heat of vaporization for the purpose of preventing a temperature decrease in the rich mixture of fuel and primary air en route to admixture with said stream of secondary air.

14. That method of controlling the formation and supply of a combustible fuel mixture to an internal combustion engine of the type used to propel a vehicle, said method comprising providing a combustion air passage having its inlet in communication with the atmosphere and discharging into the engine intake manifold, manually controlling the flow of air through said passage inwardly of its inlet end, utilizing the flow of air along said passage downstream from said manual flow control point to meter pressurized fuel into air flowing to said inlet manifold, terminating all fuel flow to the engine in response to the substantial cutoff of air flow past said manual flow control point, and resuming the supply of pressurized fuel to said inlet manifold sufficient to meet engine idling requirements as the engine slows and approaches idling speed.

15. That method defined in claim 14 characterized in the steps of withdrawing hot products of combustion from the combustion products discharging from the engine and routing a variable portion of said hot products into said combustible mixture of fuel and air flowing into the engine intake manifold, and utilizing said hot products initially to preheat and vaporize metered fuel present in air stream and thereafter to slow the rate of combustion of the mixture while said mixture is present in the engine combustion chamber.

16. That method defined in claim 14 characterized in the step of utilizing an increase in suction pressure in said intake manifold to effect leaning of the mixture of fuel and air flowing into the engine while the engine is operating as a selected cruising speed.

17. That method defined in claim 14 characterized in the step of utilizing a variation in the suction pressure in the engine manifold to vary the richness of the fuel mixture, said variation suction pressure operating in response to an increase in manifold pressure during cruising to lean the combustible mixture and operating in response to a decrease in manifold pressure during cruising operation to restore the combustible mixture to the richness thereof before being leaned.

18. In combustion with the intake manifold of an internal combustion engine, a fuel and air carbureting device having a main air passage for secondary air and a smaller passage for a relatively small stream of primary air, a manually adjustable throttle valve in said main air passage for regulating air flow therepast between flow cutoff and full open position, a plurality of adjustable fuel metering means opening into said primary air passage and including a first metering means adjustable between fuel cutoff and maximum fuel flow, means for supplying fuel under pressure through said metering means and into said primary air whenever said metering means is open, air flow responsive means located in said main air passage and responsive to changes in air flow past said throttle valve, said flow responsive means having operating connections with said first adjustable fuel metering means and being operable to cutoff all fuel flow through said first metering means when said throttle valve is closed.

19. The combination defined in claim 18 characterized in that said fuel metering means includes regulatable idling fuel metering means movable between fuel cutoff and maximum idling fuel flow conditions, and means responsive to engine operating conditions indicative of deceleration and engine coasting conditions to close said idling fuel metering means to cutoff fuel flow therethrough until engine speed approaches engine idling speed whereupon said means is effective to restore fuel flow through said idling fuel metering means to supply engine idling fuel requirements.

20. The combination defined in claim 18 characterized in the provision of means operable in response to an abrupt rise in the intake manifold pressure indicative of engine acceleration to increase the supply of pressurized fuel to provide rich fuel mixture to facilitate rapid acceleration of the engine speed.

21. The combination defined in claim 18 characterized in that said air flow responsive means is effective to sense variations in air flow passing to the engine manifold and to adjust said first fuel metering means in accordance therewith thereby to proportion the pressurized fuel admitted into said primary air stream and provide a predetermined balanced air and fuel mixture as necessary to satisfy wide-range engine operating requirements.

22. The combination defined in claim 18 characterized in that said fuel metering means includes means connected with said air throttle valve and operable during wide opening of said throttle valve to meter additional fuel into the fuel and air mitxure flowing to the engine intake manifold.

23. The combination defined in claim 18 characterized in the provision of means for passing hot exhaust gases discharging from the engine cylinders in heat exchange with said primary air and fuel mixture while said mixture is enroute to admixture with said secondary air.

24. The combination defined in claim 23 characterized

in the provision of valve-controlled means for admitting a regulated portion of said exhaust gases into the combustible mixture of fuel and air passing into the engine intake manifold.

25. The combination defined in claim 23 characterized in the provision of operating connection means between said exhaust gas control means and said throttle valve for adjusting the quantity of exhaust gas supplied to the combustible mixture in a predetermined relationship with respect to the volume of combustion air flowing into the engine intake manifold.

26. A fuel carbureting assembly for attachment to the intake manifold of an internal combustion engine, said assembly having a main body formed with a main air passage leading into said intake manifold and its other end being in communication with the atmosphere, a main air flow throttle valve movable between a normal fully closed position and different open positions for regulating the valume of secondary air flow therepast, means for supplying a relatively small stream of primary air to said main air passage in a path by-passing said throttle valve, valve controlled means for supplying controlled amounts of pressurized fuel into said primary air stream, and operating linkage means between said throttle valve and said valve controlled means for the pressurized fuel and effective to close said valve controlled means as said throttle valve closes.

27. A fuel carbureting assembly as defined in claim 26 characterized in the provision of a conduit mounted crosswise of said main air passage downstream from said throttle valve having elongated slots through the walls thereof, and said primary air supply means being arranged to discharge a rich mixture of fuel and primary air into said tube for distribution through said slots into said stream of secondary air flowing past the exterior of said conduit.

28. A fuel carbureting assembly as defined in claim 27 characterized in the provision of journal means rotatably supporting said slotted conduit, said conduit having vane means attached thereto and located in the path of flow along said main air passage and responsive to changes in air flow therepast to rotate said vane means, and resilient means attached to said slotted conduit resisting the rotation thereof by said air flow and normally urging said vane means to occupy a flow restricting position transversely of said main air passage.

29. A fuel carbureting assembly as defined in claim 28 characterized in that said slotted conduit is mounted to one side of the axis of said main air passage and in that said vane means has a large area thereof positioned laterally of said slotted conduit and on the side thereof closest to said air passage axis.

30. A fuel carbureting assembly as defined in claim 28 characterized in that said vane means has provision for bypassing engine idling air requirements when closed in a position lying substantially normal to the axis of said main air passage.

31. A carburetor assembly for attachment to the fuel mixture inlet of the intake manifold of an internal combustion engine, said assembly having a main housing formed with a main air passage adapted to discharge a combustible mixture of fuel and air into said intake manifold, a main manually operable throttle valve mounted across said main air passage in the upstream end thereof and movable between a position substantially blocking air flow therepast to different open engine-operating positions, flow responsive valve means in said main air passage downstream from said throttle valve and normally spring biased to a generally closed position, a primary air passage in said housing discharging into said main air passage downstream from said throttle valve, first fuel flow control means connected to and responsive to the position of said throttle valve for supplying fuel under pressure into said primary air passage whenever said throttle valve is open, and second fuel flow control means having communication with said main air passage downstream from said throttle valve for supplying fuel to said primary air passage to satisfy engine idling fuel requirements in response to pressure conditions in said intake manifold indicative of engine idling operation and effective to maintain the idling fuel supply closed at engine speeds above normal idling speed.

32. A carburetor assembly as defined in claim 31 characterized in the provision of third fuel supply control means connected to said throttle valve and operable upon generally wide opening of said throttle valve to accelerate the engine rapidly by supplying additional fuel under super atmospheric pressure into said primary air passage temporarily while the engine is speeding up, and pressure responsive means connected to the intake manifold and operable in response to pressure conditions therein indicative of cruising operating conditions to change the position of said third fuel supply control means.

33. A carburetor assembly as defined in claim 31 characterized in the provision of means for passing hot products of combustion from the engine in heat exchange relation with liquid fuel and primary air to vaporize and preheat the fuel, and means for bleeding variable portions of said products of combustion after being cooled by said heat exchange into the mixture of fuel and air flowing into said intake manifold, and operating connection means between said pressure responsive means and said bleeding means for varying the volume of the products of combustion added to said fuel and air mixture.

34. A carburetor assembly as defined in claim 31 characterized in the provision of pressure responsive means arranged to provide an activating force in response to changing pressure conditions in the intake manifold, and means connecting said pressure responsive means to said first fuel flow control means and effective to lean or enrich the main fuel and air mixture automatically and in accordance with pressure conditions within the intake manifold.

35. In a fuel supply system for an internal combustion engine, a carburetor having non-restricted venturi-free a main air supply passage opening into the engine intake manifold therein, a manually operated throttle valve in the upstream end of said air passage, a liquid fuel supply conduit connected to said air passage and including an adjustable fuel metering means for regulating the quantity of fuel flowing therepast and into said main air passage, and air flow responsive means connected to said fuel metering means operable in response to variations in the rate of air flow in said air passage when said throttle valve is open to adjust said fuel metering means to maintain a desirable ratio of fuel and air flowing to the engine over a wide range of engine speeds.

36. A fuel system as defined in claim 35 characterized in that said air flow responsive means is located downstream from said throttle valve and becomes effective to open said fuel metering means only in response to air flow in said air passage occurring after said throttle valve has been opened, said air flow responsive means and said fuel metering means including means effective to hold said fuel metering means closed when said throttle valve is closed.

37. A fuel system as defined in claim 35 characterized in that said carburetor includes means for supplying a combustible mixture of fuel and air adequate for engine idling operation to said air passage at a point downstream from said throttle valve so long as the engine is operating at idling speed, and means responsive to pressure conditions in the engine intake manifold and indicative of engine speeds above idling speed operable to shut off the flow of idling fuel until the engine speed slows substantially to idling speed and to then restore the flow of idling fuel to the intake manifold.

38. That improved method of forming and controlling a combustible mixture enroute to the clyinder of an internal combustion engine through the intake manifold of the engine, said method comprising maintaining a source of liquid fuel in a chamber sealed from the atmosphere, withdrawing liquid fuel from said chamber and supplying a metered flow thereof under predetermined pressure into air under subatmospheric pressure to provide a combustible mixture of air and fuel vapor flowing into said intake manifold, and venting the upper portion of said sealed chamber and the crankcase of the engine into the subatmospheric pressure, air enroute to said intake manifold thereby to consume combustible fuel vapors there present to provide useful power while preventing the escape of such combustible vapors to the atmosphere.

39. In combination with an internal combustion engine of the type having an intake manifold, a carburetor for supplying a variable combustible mixture thereto including atmospheric air and liquid fuel from a supply tank thereof and supplied to said carburetor under predetermined pressure by a liquid fuel pump, that improvement which comprises operator-regulated metering means in said carburetor for admitting pressurized liquid fuel into subatmospheric air in varying quantities in accordance with changing engine power and speed requirements, venting the top portion of the fuel tank and the engine crankcase into the subatmospheric pressure air used to form said combustible mixture, and means responsive to engine operating conditions characteristic of coasting and deceleration to cut off all flow of liquid fuel to the engine until the engine slows substantially to the vicinity of engine idling speed and for then restoring sufficient fuel to meet engine idling requirements.

40. In combination with an internal combustion engine of the type having an intake manifold, a carburetor for supplying a variable combustible mixture thereto including atmospheric air and liquid fuel from a supply tank thereof and supplied to said carburetor under predetermined pressure by a liquid fuel pump, that improvement which comprises operator-regulated metering means in said carburetor for admitting pressurized liquid fuel into sub-atmospheric air in varying quantities in accordance with idling fuel valve means for supplying pressurized idling fuel to said carburetor during starting of the engine, thermostatic means for locking said idling fuel valve means in a high idling speed position as an incident to the starting of the engine and operable as said thermostatic means warms from the heat of engine operation to throttle the flow of idling fuel to slow the idling speed of the engine automatically as the engine warms and without need for adjustment on the part of the operator.

41. The combination defined in claim 40 characterized in that said carburetor includes means for supplying a regulated flow of hot products of combustion from said engine to said carburetor and there using the same to heat the carburetor and for admixture of portions thereof with the combustible mixture of fuel and air to slow the combustion rate thereof, and said thermostatic means including means for regulating said flow of hot products of combustion.

42. In a fuel and air carbureting device for an internal combustion engine of the type having an operator-controlled accelerator for adjusting the rate of fuel and air flow to the engine intake manifold as necessary to meet changing speed and power requirements, normally closed means for supplying liquid fuel at superatmospheric pressure to said carbureting device for engine starting purposes upon operation of said accelerator to open said normally closed fuel supply means, thermostatic means for locking said fuel supply means open sufficiently to operate the engine at fast idling speed as the accelerator is released immediately following engine start, and said thermostatic means being effective to release said fuel supply means to its slow idling speed position automatically and in response to engine warm up following a short period of operation at fast idling speed, and said thermostatic means thereafter remaining ineffective to lock the fuel supply means in fast idle position so long as said thermostatic means remains warm from the engine heat.

43. Carbureting apparatus operable to provide a readily regulated combustible mixture for a combustion chamber and operable equally effectively for indefinite periods in upright, inverted and in various intermediate positions, said apparatus having a main body provided with a tublular passage therethrough one end of which is adapted to communicate with the atmosphere and the other end of which is adapted to be connected with the inlet of a combustion chamber, means forming a fuel chamber adapted to be maintained continuously charged with fuel under predetermined conditions so long as there is need for a combustible mixture, fuel outlet passage means of regulated cross-sectional size extending between said chamber and said tubular air passage and operable to supply fuel at widely varying flow rates to said air passage, means responsive to chnges in the flow of air in said air passage to regulate the cross-sectional size of said fuel outlet passage means thereby to proportion the fuel flow to the flow of air in said passage substantially independently of pressure conditions in said air passage, and means for preheating said combustible mixture prior to the introduction thereof into a combustion chamber which means includes copper, means for heating said copper, and means for introducing gas passing in contact with said hot copper into air flowing in said tubular passage.

44. Carbureting apparatus as defined in claim 43 characterized in that the same is free of calibrated fuel orifices of predetermined cross-sectional size and flow characteristics.

45. Carbureting apparatus as defined in claim 43 characterized in the provision of adjustable throttle valve means in said tubular passage upstream from said airflow responsive means, and means for adjusting the position of said adjustable throttle valve means to vary air flow past said airflow responsive means.

46. A fuel carbureting assembly for attachment to the intake manifold of an internal combustion engine, said assembly having a main body formed with a main air passage leading into said intake manifold and its other end in communication with the atmosphere, a main airflow throttle valve movable between a normal fully closed position and different open positions for regulating the volume of secondary air flow therepast, means for supplying a relatively small stream of primary air to said main air passage in a path bypassing said throttle valve, valve-controlled means for supplying varying amounts of fuel into said primary air, and airflow responsive means in said main air passage operable to adjust said valve-controlled means to vary the flow of fuel admitted to said main air passage in response to variations in the flow of air past said airflow responsive means.

47. In a fuel supply system for an internal combustion engine, a carburetor having a tubular main air supply passage free of venturi throat means between its ends with its inlet end open to the atmosphere and its outlet end adapted to be connected to an engine intake manifold, means forming a primary air supply passage having its outlet end opening into the midportion of said main air passage, adjustable throttle valve means in said main air passage upstream from the outlet of said primary air passage, airflow responsive means in said main air passage downstream from said primary air outlet, and adjustable valve means for controlling the flow of fuel into said primary air passage including operating connection means therefor with said airflow responsive means.

48. That improved method of forming and regulating the volume of a combustible mixture enroute to the combustion chamber of an engine independently of changing positions and orientations of the engine with respect to the horizon, said method comprising maintaining a fuel

chamber lacking an atmospheric vent charged with liquid fuel, withdrawing liquid fuel from said chamber through an orifice of variable size into an air stream enroute to a combustion chamber, varying the size of said fuel orifice in response to changes in the flow of air in a downstream portion of said air stream, and adjusting the quantity of air admitted to said air stream.

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