May 20, 1947. E. O. WIRTH 2,420,925

CHARGE FORMING DEVICE

Filed Sept. 23, 1940 3 Sheets-Sheet 1

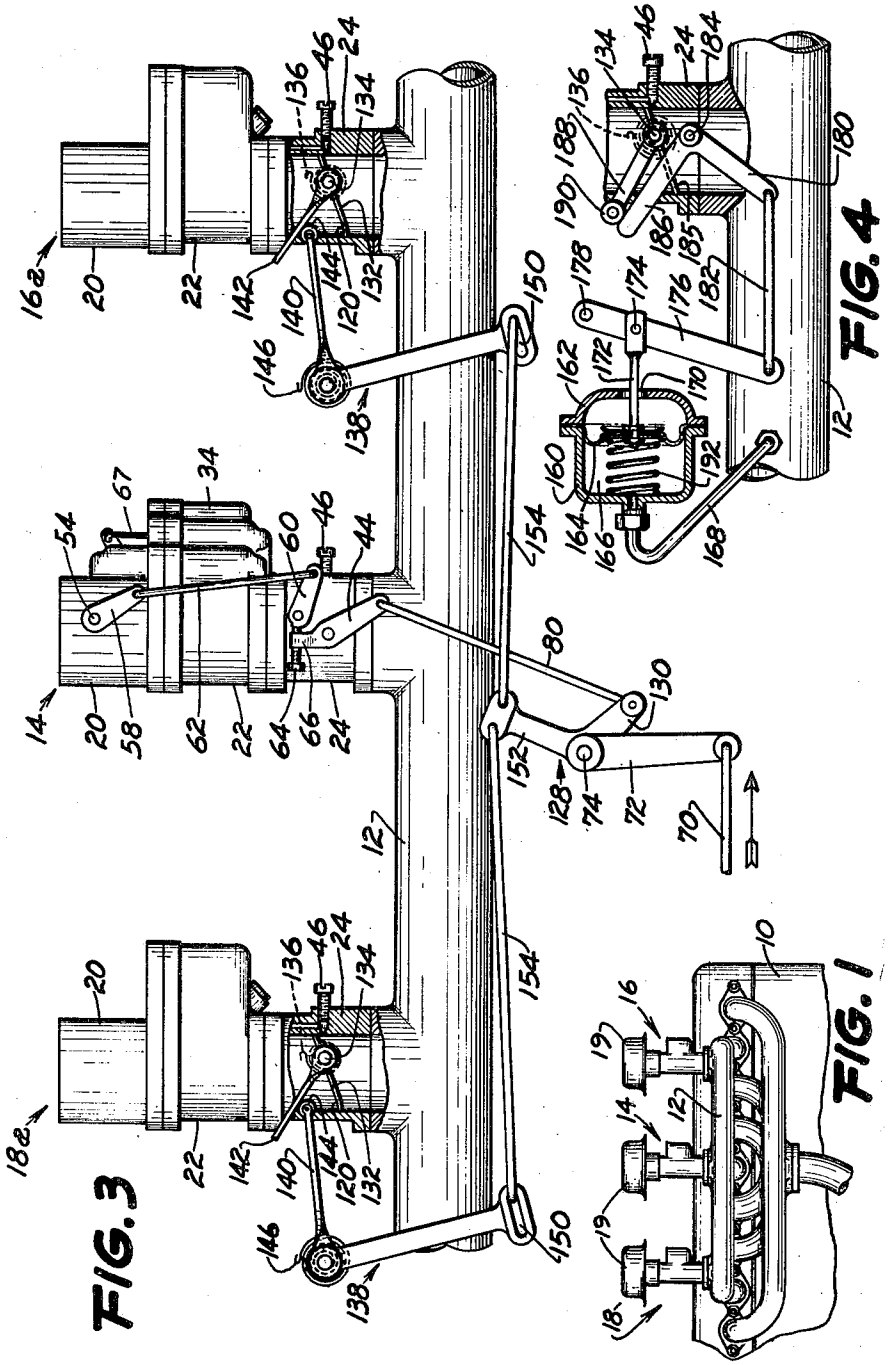


FIG. 3

FIG. 4

FIG. 1

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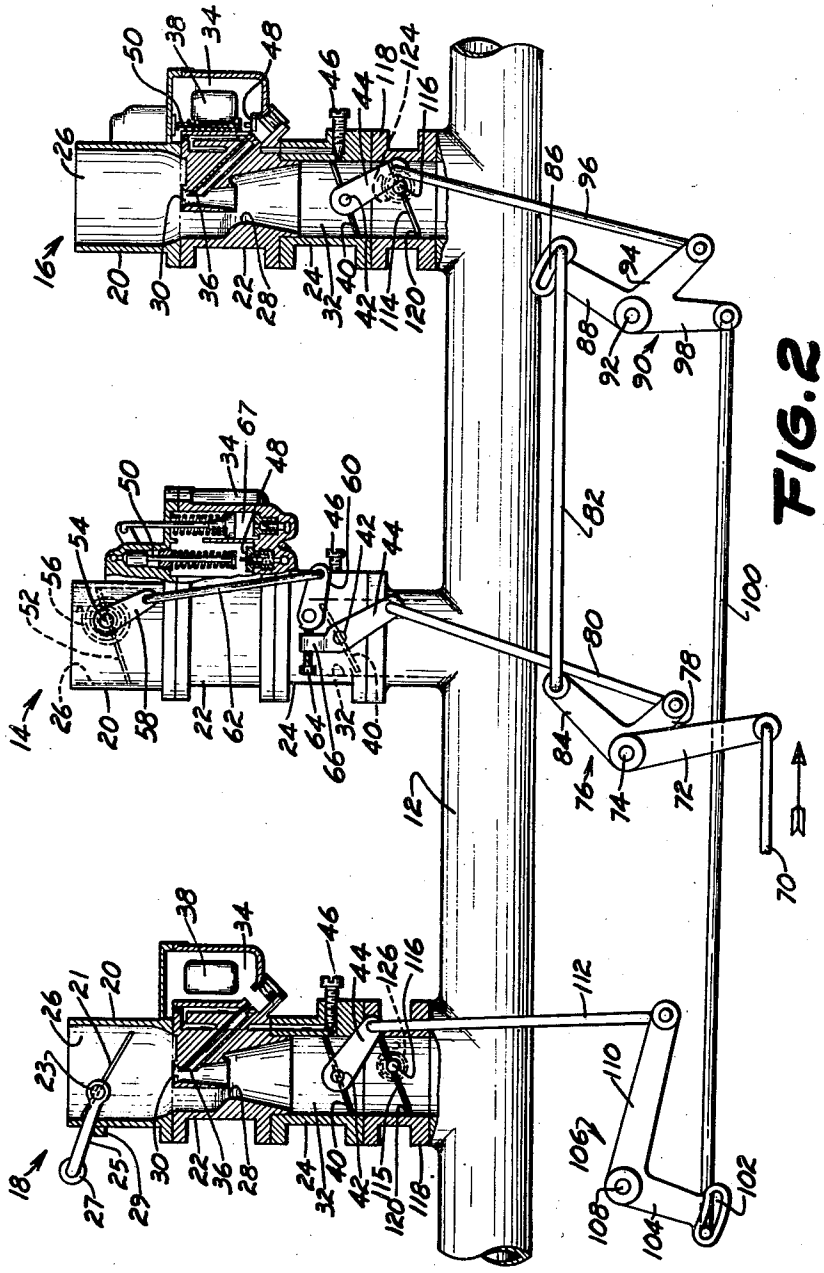


FIG. 2

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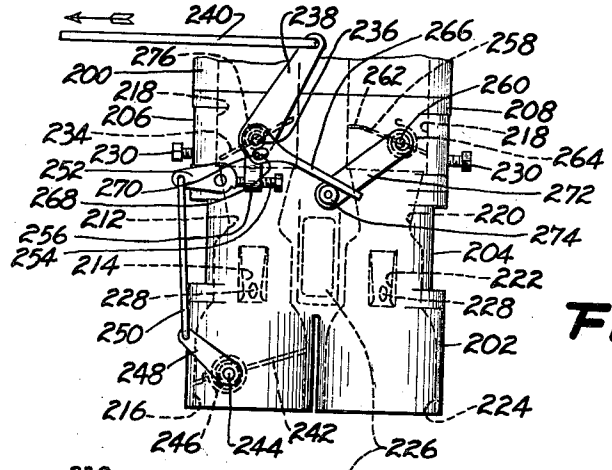


FIG. 6

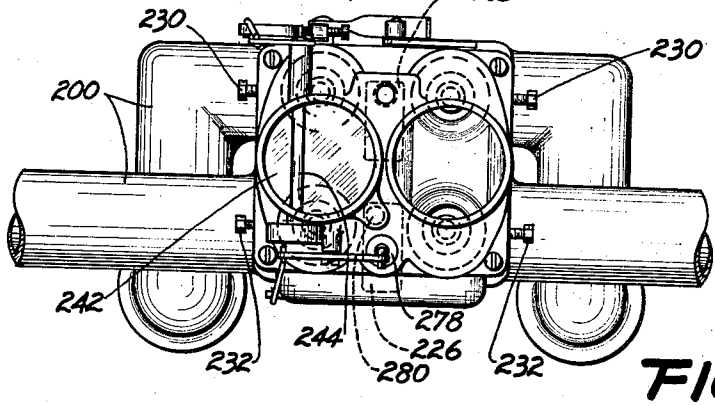


FIG. 5

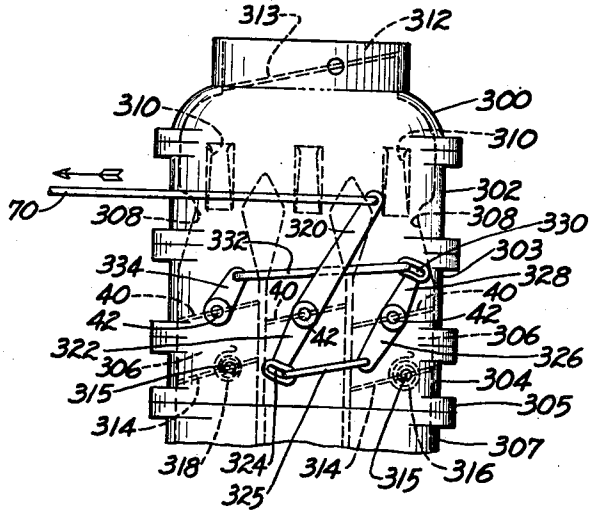


FIG. 7

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UNITED STATES PATENT OFFICE

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CHARGE FORMING DEVICE

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Application September 23, 1940, Serial No. 357,860

29 Claims. (Cl. 123—127)

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This invention relates generally to charge forming devices and more particularly to multiple stage carburetor systems for internal combustion engines.

In widely variable-speed internal combustion engines, such as are used in present day automotive vehicles, a carburetor having a single induction passage or having one induction passage for each conduit of a multiple conduit intake manifold is unable to satisfactorily meet all the requirements of such engines throughout their intended operating range.

A carburetor adapted to supply an economical fuel mixture at low engine speeds is generally incapable of supplying a sufficient volume of fuel mixture for maximum power output at high engine speeds so that with such a carburetor power is sacrificed for economy. On the other hand, a carburetor of sufficiently large capacity to supply the necessary volume of fuel mixture for maximum power output and high engine speed will not provide an economical mixture at the lower engine speeds. A further important operating fault of the latter carburetor occurs at the low end curve, that is, when the engine is running at low speed with a wide open throttle. Under such operating conditions the fuel mixture becomes very lean due to the low suction or draft in the large capacity induction passage, the air therein having insufficient velocity to pick up the necessary quantity of fuel for a mixture of the required richness. This results in the engine rapidly losing power when its speed decreases beyond a certain value, and with continued loss of speed a point is finally reached whereat the mixture is so lean that the engine ceases to fire. However, with the use of a smaller carburetor, the engine can be operated with a wide open throttle at a substantially lower speed than with a large one before a material loss of power occurs, due essentially to the higher air velocity or draft for a given engine speed in the smaller induction passage.

With the foregoing in view, the present invention provides improved means for supplying an internal combustion engine with its fuel mixture whereby improved fuel economy is effected over the entire throttle range and the efficiency and general overall performance of the engine is substantially increased.

Another object of the invention is to provide a device of this character having a plurality of carburetor induction passages each controlled by valve means operable in stages.

Another object of the invention is to provide

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a plurality of carburetors for an internal combustion engine so arranged and operated that a single source of mixture supply provides an economical fuel mixture up to a predetermined speed, that is over the normal lower speeds of the engine power range customarily used to the greatest extent where the engine is operating an automobile, for example. At speeds above said lower power range the fuel mixture is supplemented by a secondary source of mixture supply which is combined with the primary source to supply the greater volume of fuel mixture required for maximum engine power and speed; and at the low end curve when the engine is running at low speed wide open throttle a single source supplies the engine with fuel mixture thereby reducing to a minimum the speed at which the engine power output will seriously drop off under such conditions.

Still another object of the invention is to provide a device of this character wherein the sources of fuel mixture may be incorporated in an integral carburetor unit.

Another object of the invention is to provide means in a device of this character wherein there is effected a smooth flow of power throughout the range of engine operation and wherein unevenness of engine operation is eliminated at times when a secondary carburetor or induction passage starts to function.

A further object is to provide a device of this character wherein a secondary induction passage is provided with an offset choke valve counter-balanced to normally close the same and to thereby correct a lean condition of said secondary source of fuel mixture when it starts to feed from the main metering system.

A further object of the invention is to provide a device of this character wherein the closing of the counter-balanced choke valve is limited to prevent its fully closing, so that when the throttle valve of the secondary carburetor is closed leakage past same will not cause suction on the main fuel nozzle such as would draw fuel therefrom.

A still further object of the invention is to provide a device of this character wherein the induction passages are progressively opened and wherein the throttle valves of said passages reach the wide open position at substantially the same time.

Other objects of the invention are to provide increased acceleration, quicker and smoother power, increased flexibility, and increased top speed.

Still other objects and advantages of the in-

vention will become apparent from the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic elevational view of an internal combustion engine equipped with the present invention;

Figure 2 is a somewhat diagrammatic elevational view of a portion of the intake manifold equipped with the present invention, parts of the carburetors being in section;

Figure 3 is a somewhat diagrammatic elevational view of a modified embodiment of the invention with portions of the secondary carburetors broken away;

Figure 4 is a somewhat diagrammatic vertical section of a modified embodiment of the control means for the throttle valves of the secondary carburetors, said means being responsive to manifold vacuum;

Figure 5 is a front elevational view of an integral, horizontal delivery, four-barrel carburetor of a type adapted for use with an engine having a dual intake manifold, and embodying the present invention;

Figure 6 is a plan view of the same; and

Figure 7 is a diagrammatic front view, partly in section, of a downdraft three-barrel carburetor embodying the invention.

While the preferred embodiment of the invention, together with several alternative embodiments thereof, are shown in the accompanying drawings and herein described in detail, it is to be understood that this disclosure is given for the purpose of illustrating the invention and is not intended as a limitation thereof to the constructions disclosed, the appended claims being intended to cover all modifications and alternative constructions falling within the scope of the invention.

Throughout the drawings similar reference characters represent similar parts although where such parts are modified in structure and operation they are given a further differing reference character.

Referring now to Figures 1 and 2 which illustrate a preferred embodiment of the invention, reference numeral 10 indicates a six-cylinder internal combustion engine having an intake manifold 12 on which is mounted a primary carburetor 14 and secondary carburetors 16 and 18 respectively. The primary carburetor 14 is positioned adjacent the longitudinal center of the manifold 12 and carburetors 16 and 18 are located intermediately of said carburetor 14 and the front and rear ends respectively of said manifold. All of the carburetors are of the downdraft type although carburetors of any other suitable character may be used such as the updraft or the horizontal delivery types. The usual air filters 19 may also be provided on said carburetors.

Each of the carburetors includes an air horn section 20, a body section 22 and a throttle body section 24. The primary and secondary induction passages of the respective primary and secondary carburetors each comprise an air inlet 26, a large venturi 28, a small venturi 30 and a throttle barrel or mixture passage 32. Fuel from any suitable source (not shown) is supplied to the fuel chambers 34 which in turn deliver fuel to main fuel nozzles 36, of known construction and operation, the level of fuel in each chamber 34 being controlled in the well known manner by a float 38 and the usual float mechanism (not shown). The throttle barrel or mixture passage 32 is controlled by the usual throttle valve 40 mounted on a throttle shaft 42 on one end of which is secured a throttle lever 44. The carburetors also include simple idling systems 46 of known character, which function in the usual manner, the idling systems of the secondary carburetors particularly supplying fuel at the time said carburetors start to function, thereby tending to maintain the proper fuel to air ratio of the mixture supplied to the engine at said time. Carburetors 14 and 16 are provided with vacuum economizers of known construction and operation including valves 48 and valve actuating means 50 responsive to manifold vacuum although mechanically actuated economizers may be used. The primary carburetor 14 further includes an offset air flow choke valve 52 operable by manifold suction and controlling the air inlet 26 in the well known manner. Choke valve 52 is mounted on a shaft 54 to one end of which is connected automatic control means of known construction and operation, such for example as thermostatic element 56, although any other suitable automatic control means may be employed to control the valve 52 or it may be manually actuated. Well known fast idle mechanism for cold engine operation is also provided on the primary carburetor 14 and includes a lever 58 attached to shaft 54 and connected with a fast idle cam 60 by link 62, cam 60 being engageable in the usual manner with adjustment screw 64 in an extension 66 of throttle lever 44; however any other suitable fast idle mechanism may be employed. The primary carburetor 14 also includes an acceleration pump 67 of any well known type for supplying a supplemental fuel charge in the well known manner.

The throttle valves controlling the respective carburetors are correlated for operation in series by an accelerator pedal or the like (not shown) adapted to actuate rod 70 which is operably connected with the free end of lever 72, the other end of the latter being attached to rotatable shaft 74. A bell crank 76 is also attached to shaft 74 and has an arm 78 connected with lever 44 of the primary carburetor by a link 80. A rod 82 pivoted at one end to arm 84 of bell crank 76 has its other end operably connected with an arcuate slot 86 in an arm 88 of a three-armed lever 90 which is pivoted at 92, said slot 86 being adjacent the free end of arm 88. Arm 94 of lever 90 is connected with throttle lever 44 of the secondary carburetor 16 by a link 96 and arm 98 of lever 90 carries a link 100 which is operably connected with an arcuate slot 102 at the end of arm 104 of a bell crank 106. The bell crank 106 is pivoted at 108 and arm 110 thereof is connected with lever 44 of the secondary carburetor 18 by means of a rod 112. The carburetors are progressively brought into operation in three stages, movement of rod 70 in the direction indicated by the arrow in Figure 2 effecting opening movement of the throttle valve of the primary carburetor 14, while at the same time the end of rod 82 connected with slot 86 is moved from one end thereof toward the other thereby providing a limited amount of lost motion in the throttle actuating means between opening of the throttle valve of carburetor 14 and that of carburetor 16. Upon sufficient movement of rod 82 to exhaust said lost motion rotation of lever 90 is effected, which in turn effects opening movement of the throttle valve of the secondary carburetor 16. Simultaneously with the opening movement of lever 90

and the throttle valve of carburetor 16, the end of rod 100 which is connected with slot 102 moves from one end of said slot toward the other and upon reaching said other end of slot 102 and upon further opening movement of lever 90, bell crank 106 is rotated in a direction to effect opening of the throttle valve of secondary carburetor 18.

The primary source of fuel mixture is the primary carburetor 14 which is a normal one functioning in the usual manner. Its induction passage is of such size as to provide the greatest economy of engine operation and the actuating mechanism is so arranged that said primary carburetor alone supplies fuel mixture to the engine up to a predetermined speed covering the lower power range thereof which is customarily used to the greatest extent. Above said predetermined speed the secondary carburetor 16 supplies a supplemental mixture, both said primary and secondary carburetors thereafter functioning together to supply the engine with its fuel mixture. At a predetermined engine speed intermediate that at which carburetor 16 begins to supply fuel mixture to the engine and the intended top engine speed, the secondary carburetor 18 is brought into operation to supply an additional supplemental mixture for maximum power and speed of the engine, and thereafter the three carburetors function together delivering their fuel mixtures to the common manifold 12. It should be noted that the leverages of the various levers and arms of the actuating mechanism of the throttle valves are such that the throttle valve of carburetor 16 opens more rapidly than that of carburetor 14, and the opening of the throttle valve of carburetor 18 is effected more rapidly than that of carburetor 16 so that all the throttle valves will reach the wide open position at substantially the same time. In closing the throttle valves, the sequence above described is reversed. However, the throttle valves may be operated in other manners and by other means.

When the engine is running at wide open throttle and slows down to a relatively low speed, due to any load increase, it begins to lose power below a certain speed. With a carburetor having a large air passage to provide a sufficient volume of fuel mixture for maximum power, the speed at which the engine commences to lose power is substantially higher than the speed at which power loss begins to occur when a small carburetor is used. This is due to the fact that the draft in the induction passage of a large carburetor is much weaker for a given engine speed particularly at low speed wide open throttle than in a carburetor having a small induction passage, the weak air draft in the large induction passage naturally picking up less fuel from the main fuel nozzle than the stronger draft in the smaller induction passage. Where a plurality of smaller carburetors are used to supply fuel mixture to a common intake manifold, such as in the present invention, and arranged so that one carburetor functions throughout the driving range of an automobile and a secondary carburetor or carburetors supply a supplemental mixture at the higher speeds of the vehicle to increase its power and speed, the situation at low speed wide open throttle is comparable to that where the engine is supplied with fuel mixture by a large carburetor. Leaning of the fuel mixture with consequent loss of engine power occurs at higher speeds than where a single small capacity carburetor is used. In order to maintain maximum

engine power with a wide open throttle to as low a vehicle speed as possible, the present invention provides automatic means for cutting out the secondary carburetors in a plurality of stages as the vehicle slows down to a speed at which the engine power would otherwise begin to seriously drop off. This automatic means comprises air flow auxiliary valves 114 and 115, which are operated by the differential of pressures on the respective sides thereof and opened by manifold vacuum. The valves 115 and 114 are of similar construction, being offset on respective shafts 116 to which they are secured, said shafts 116 and valves 114 and 115 being mounted in respective risers 118 interposed between the secondary carburetors and the intake manifold. As it is desirable to have the valves 114 and 115 opened quickly and widely by the air stream when the respective throttle valves are opened, except under conditions hereinafter described, each valve is provided with a bent lip 120 at its greatest proportion which offers resistance to the air stream even when the valve is substantially fully open. In this respect, the valves 114 and 115 are similar to the auxiliary valve disclosed in the Barfod Patent No. 2,156,104 although said valves may be flat disks or formed in any other suitable manner. Springs 124 and 126 are provided for the valves 114 and 115, respectively, and are adapted to apply closing pressure to said valves. The characteristics of spring 124 are such that manifold suction above a predetermined value will effect opening of valve 114, but manifold suction below said predetermined value is insufficient to overcome the force of the spring which therefore closes the valve. The operation of the auxiliary valve 115 is similar to that of the valve 114 except that the spring 126 is of such character that it closes valve 115 when the manifold vacuum drops to a predetermined value below that at which spring 124 is calibrated to close its valve. As the manifold vacuum drops with the loss of engine speed when the latter is running at wide open throttle, the auxiliary valves 114 and 115 progressively close (although they may be arranged to close simultaneously), so that when the speed of the engine operating at wide open throttle drops to that at which its power would otherwise begin to seriously fall off when the three carburetors supply it with fuel mixture, one of the secondary carburetors is cut out thereby increasing the velocity of the air passing through the induction passages of the other carburetors, and upon a further drop of manifold vacuum the other secondary carburetor is cut out so that the air velocity in the primary induction passage is again stepped up. The engine is then supplied with fuel mixture only by the primary carburetor 14, the throttle valve of which is maintained in wide open position, and the draft in the induction passage of said carburetor is therefore strong enough to supply a suitably rich mixture to the engine so that its power is maintained down to a very low vehicle speed before said power begins to seriously drop off.

When the engine is cold the choke valve 52 of the primary carburetor 14 is in the closed position and said primary carburetor supplies an enriched fuel mixture to the engine in accordance with well known present day engine starting practice, the throttle valves 40 of secondary carburetors 16 and 18 being closed at this time so that said carburetors are not functioning during the starting period. As soon as the cold engine is running under its own power, the fast idle mecha-

nism provides the usual fast idle mixture until the engine has become sufficiently warmed up to operate satisfactorily without said fast idle mixture and it is thereafter supplied with idling mixture only from the simple idle system 46.

The invention is not limited to any particular range of activity over which the primary carburetor is adapted to function, or in which the secondary carburetors are adapted to function, such ranges of operation depending on the characteristics of the engine, such as its size, top speed, maximum power, et cetera. As an example of the ranges of the respective carburetors, the primary carburetor may be utilized to normally supply the engine with its requirements of fuel mixture for speeds up to approximately fifty miles per hour of vehicle travel, the secondary carburetor 16 then being utilized to provide a supplemental mixture for vehicle speeds in excess of fifty miles per hour and the secondary carburetor 18 being utilized to supply a second supplementary mixture for vehicle speeds in excess of approximately seventy miles per hour. It is to be understood that when the requirements of the engine exceed normal conditions of straight running, as when quick acceleration is needed, the secondary carburetors will supply a supplemental mixture in conjunction with the primary carburetor if the throttle actuating mechanism has been actuated sufficiently in the throttle opening direction.

The springs 124 and 126 of the auxiliary valves may be so calibrated that when the manifold vacuum drops to one inch of mercury, valve 114 will be closed by spring 124, and when the manifold vacuum drops to one-half inch of mercury, valve 115 will be closed by spring 126. However, the springs 124 and 126 may be otherwise calibrated for closing the respective auxiliary valves at other manifold pressures or to close said valves simultaneously. The primary carburetor should be adjusted to secure good average performance and maximum mileage while the secondary supplies should be adjusted to obtain maximum results from the engine in speed, torque and horsepower.

In the preferred arrangement of the carburetors, the secondary carburetor 16 begins to function before the economizer of the primary carburetor 14 begins to deliver its supplemental fuel mixture. Consequently, it has been found desirable to provide said secondary carburetor 16 with an economizer. The actuating means for both economizers are responsive to manifold vacuum, and they are so adjusted that they both start to function simultaneously when the manifold vacuum reaches a predetermined value, although they may be set to function otherwise if so desired. The secondary carburetor 18 begins to supply its fuel mixture after the economizers of the carburetors 14 and 16 begin to function, and it has been found desirable to dispense with the economizer in carburetor 18 but to set same for a power mixture.

However, to correct a very lean condition that may occur when carburetor 18 starts to feed from the main metering system, a choke valve 21 is provided in air inlet passage 26 of carburetor 18, said choke valve being offset on shaft 23 and operable by suction in the induction passage of carburetor 18. On one end of shaft 23 is an arm 25 carrying a counter-weight 27 adjacent its free end which is adapted to normally close the valve in the absence of manifold vacuum as when throttle valve 40 of carburetor 18 is in the closed position. However, other suitable means for yieldingly closing the valve 21 may be used. The arm 25 engages a stop member 29 which limits valve closing movement thereby normally retaining the valve in a slightly open position, so that when the throttle valve 40 is closed air leakage past said throttle valve will not cause suction on the main fuel nozzle such as would draw fuel therefrom. The valve 21 prevents an excess of air, substantially unmixed with fuel, from rushing into the manifold as carburetor 18 starts to function and thereby eliminates uneven running of the engine at such time. While the offset, counter-weighted choke valve has been disclosed as being used in only one of the secondary carburetors, it may also be used in the other and may be incorporated in any modification of a multiple stage charge forming system.

An alternative adaptation of the foregoing arrangement is illustrated in Figure 3 wherein three carburetors are also used to supply fuel mixture to a common manifold. In the embodiment of Figure 3 the primary carburetor 14 is the same in construction and operation as that shown in Figures 1 and 2 and hereinbefore described. Rod 70 is actuated by an accelerator pedal or the like (not shown) and is operably connected with lever 72 secured to shaft 74. Bell crank 128 is secured to shaft 74 and arm 130 of said bell crank is connected with throttle lever 44 of carburetor 14 by link 80. The secondary carburetors 16*a* and 18*a* are both without economizers or auxiliary valves but have simple idling systems 46. The throttle valves 132 of carburetors 16*a* and 18*a* are of the air flow type and are similar in construction to the auxiliary valves 114 and 115. However, the throttle valve actuating mechanism in this embodiment of the invention differs from that shown in Figures 1 and 2, being arranged so that the throttle valves of carburetors 16*a* and 18*a* open simultaneously when the throttle valve of the primary carburetor has been opened a predetermined amount.

The throttle valves 132 are offset on their respective shafts 134 and are operable by the differential of pressures on their opposite sides. Each of said valves is provided with a spring 136 adapted to exert closing pressure thereon through shafts 134, said springs being adapted to independently close the valves against a manifold vacuum below a predetermined value whereas manifold vacuum above said predetermined value is sufficient to open the valves against the force of said springs.

Control means for each of the throttle valves 132 includes a one-way connection limiting opening of said valves and comprises a bell crank 138 having an arm 140 engageable with a throttle lever 142, said arm 140 carrying a roller 144 adjacent the free end thereof adapted to engage one side of lever 142. The bell cranks 138 are provided with springs 146 of sufficient strength to yieldably close the throttle valves 132 against any manifold vacuum pressure to which said valves may be subjected. Arms 148 of the bell cranks 138 are provided with respective slots 150 adjacent their free ends which are operably connected with arm 152 of bell crank 128 by links 154.

Upon opening movement of rod 70 as indicated by the adjacent arrow in Figure 3, the throttle valve of the primary carburetor is opened and at the same time the connections of the rods 154 with slots 150 move from one end of said slots toward the other. When the last mentioned

slot ends are reached, and upon further opening movement of rod 70, the arms 140 are moved in a direction which permits opening movement of throttle levers 142 which follow arms 140 when the throttle valves 132 are subjected to manifold vacuum above the value for which springs 136 are calibrated. Therefore in this embodiment of the invention, the primary carburetor 14 alone supplies fuel mixture to the engine up to a predetermined speed, such for example as would drive an automobile at a speed of approximately seventy-five miles per hour, although the device may be arranged so that the primary carburetor functions alone over any other suitable speed range. Above this automobile speed, all the carburetors will supply the engine with fuel mixture except when the engine is running at low speed wide open throttle. Under the latter conditions, the springs 136 are adapted to close the valves 132 independently of the hereinbefore described control means when the manifold vacuum drops below the value for which the springs are calibrated, as for example manifold vacuum of one-half inch of mercury or any other desired manifold vacuum pressure. The throttle valves 132 are preferably closed simultaneously, although they may be arranged to close progressively as do the auxiliary valves 114 of Figure 2. The throttle valve actuating mechanism of the embodiment of Figure 3 is such that the throttle valves of the secondary carburetors open faster than the throttle valve of the primary carburetor and all of said valves reach wide open position at substantially the same time, although they may be otherwise actuated.

With the arrangement of carburetors disclosed in Figure 3, the secondary carburetors do not begin to function until after the economizer of the primary carburetor 14 begins to function, and it has been found that neither of the secondary carburetors need be provided with economizers, said secondary carburetors being preferably set at a power mixture. It should be noted that each of the secondary carburetors 16*a* and 18*a* may be provided with a counter-weighted choke valve such as illustrated in Figure 2 and hereinbefore described to aid the simple idle systems 46 thereof in eliminating uneven running of the engine at the time said secondary carburetors start to feed from their main metering systems.

Another embodiment for controlling the throttle valves of the secondary carburetors is shown in Figure 4. In this embodiment of the throttle valve control means a vacuum motor is employed and comprises a pair of casing members 160 and 162 secured together in any suitable manner and peripherally clamping therebetween a flexible diaphragm 164. Chamber 166 on one side of the diaphragm is adapted to be subjected to manifold vacuum transmitted thereto by conduit 168, and the other side of the diaphragm is open to atmosphere by reason of opening 170 in casing 162 in which a rod 172 is freely movable, said rod being connected at one end to the diaphragm 164. The other end of rod 172 is pivotally connected at 174 with a lever 176 intermediate the ends thereof, and one end of said lever is swingable on a fixed pivot 178. The free swinging end of lever 176 is operably connected by a link 182 with an arm 180 of a bell crank included in a one-way connection limiting opening of the throttle valve, said bell crank being pivoted at 184 and provided with an arm 186 engageable with a throttle lever 188 through a roller 190 carried on the end of lever 188. A compression spring 192 is provided in chamber 166 and reacts between one wall of said chamber and the diaphragm, said spring being adapted to yieldably urge the diaphragm in a direction which will effect outward movement of rod 172, which in turn effects movement of the bell crank in a counter-clockwise direction as seen in Figure 4. Upon such movement of the bell crank, throttle valve 185, which is a flat disk offset on shaft 134, will be opened by manifold vacuum above a suitable predetermined value in accordance with the calibration of spring 136, lever 188 under these conditions following arm 186 of the bell crank. Upon a drop in the manifold vacuum below that for which spring 136 is calibrated, as for example, one-half inch of mercury or any other suitable predetermined manifold pressure, spring 136 will closes the throttle valve 132, lever 188 being so associated with arm 186 of the bell crank that closing movement of the throttle valve can be independently effected by spring 136 from an open position of the throttle valve control mechanism. Spring 192 is of such character that vacuum in chamber 166 above a predetermined value, as approximately twelve inches of mercury or any other suitable manifold vacuum, will overcome the expansive force of said spring and retain the throttle valve 132 in closed position. A drop in vacuum in chamber 166 below approximately twelve inches of mercury or such other pressure as spring 192 may be calibrated for will permit a corresponding expansion of spring 192, which permits opening of the throttle valve a corresponding amount. In a multiple carburetor system wherein the mechanism illustrated in Figure 4 is employed to actuate the throttle valves of the secondary carburetors, the primary carburetor supplies fuel mixture to the engine throughout its range of operation. When the manifold vacuum drops to a certain value, the spring 192 overcomes the vacuum in chamber 166 and effects counterclockwise movement of arm 186 as shown in Figure 4 so that the throttle valve of the secondary carburetor begins to open. A further drop in manifold vacuum will permit further opening of the throttle valve until the vacuum drops below the value for which spring 136 is calibrated, said spring then closing the throttle valve. By this arrangement the secondary carburetors are controlled by and in accordance with the conditions of pressure in the intake manifold so as to automatically respond at predetermined pressure differences in any desired manner. For example, the secondary carburetors may be operated in series as are those of the embodiment illustrated in Figures 1 and 2, or the control mechanism of the secondary carburetors may be so arranged that they will start to function simultaneously after the primary carburetor has begun to function as in the embodiment disclosed in Figure 3 or in any other suitable manner. Where the manifold pressure control is used, it will be noted that the secondary carburetors will be automatically responsive to load demands, as for example, when the motor vehicle encounters a change in gradient or road load variations with fixed setting of the throttle of the primary carburetor.

While Figure 1 illustrates a six-cylinder in-line engine the present invention may be used with other types of engines having other types of intake manifolds, as well as those having a different number of cylinders, and it may also be used on motors employed in other types of ve-

hicles than passenger automobiles, such as for example, trucks, busses, et cetera.

Figures 5 and 6 illustrate a two stage embodiment of the invention for use on an engine, such as one having eight, in-line cylinders and using a dual intake manifold 200, one conduit of the dual intake system adapted to deliver fuel mixture to half of the cylinders and the other conduit supplying the other half. The device shown in Figures 5 and 6 is an integral four-barrel horizontal delivery type and includes an air horn section 202, a body section 204 and a throttle body section 206 having a flange 208 for attachment to the intake manifold 200. There are two pairs of induction passages, which for convenience are termed primary and secondary respectively. The primary passages include throttle barrels 210, large venturis 212, small venturis 214 and a common air inlet 216 and the secondary passages include throttle barrels 218, large venturis 220, small venturis 222 and a common air inlet 224. The induction passages are arranged in the form of a square with the primary passages arranged one above the other and with the secondary passages forwardly of the respective primary passages with respect to the front end of the engine. Thus one primary and one secondary passage communicates with the central horizontal portion of each of the conduits of the intake manifold although any other suitable arrangement may be used. Two floats 226 control the fuel level in respective float chambers (not shown) in the well known manner. The float chambers with the respective floats are positioned one above the other, and fuel is supplied from the upper chamber to main fuel nozzles 228 of the upper tier of induction passages, one of which is a primary passage and the other a secondary passage and fuel from the lower chamber is supplied to the nozzles 228 of the lower induction passages one of which is also a primary and one a secondary passage. Fuel from the fuel chambers is also supplied to the simple idling jets 230 and 232 of the upper and lower induction passages respectively. Throttle valves 234 for controlling the respective primary throttle barrels or mixture passages 210 are secured to a common shaft 236. One end of shaft 236 is provided with a throttle lever 238 to the free end of which is connected a rod 240 of the accelerator mechanism (not shown). The air inlet 216 is controlled in the usual manner by an offset choke valve 242 on a shaft 244 controlled by any automatic means and including a thermostatic element 246. However, the choke valve may be otherwise automatically controlled or may be actuated by any well known manual means. Fast idle mechanism is provided for cold engine operation and includes a lever 248 secured to one end of shaft 244 connected by rod 250 with a fast idle cam 252, said cam being engageable in the usual manner with adjustment screw 254 in an extension 256 of throttle lever 238. Throttle valves 258 controlling the secondary induction passages are offset on a common shaft 260 and open simultaneously and each valve 258 has a bent lip 262 at its greatest proportion for the purpose hereinbefore described in connection with valves 114 and 115 in Figure 2. A spring 264 is connected with shaft 260 and is calibrated to close the valves 258 when the suction in the intake manifold drops below a predetermined value as will be hereinafter more fully described.

Control means for the valves 258 include a one-way connection limiting opening of said valves and comprises a lever 266 which floats on shaft 252 and is provided with a slot 268 in which is received a pin 270 fixed in lever 238. A throttle lever 272 on shaft 260 engages lever 266 through a roller 274 in such a manner as to permit closing of valves 258 by spring 264 when lever 266 is moved counterclockwise (as shown in Figure 6) in the valve opening direction. A spring 276 yieldingly urges the lever in the valve closing direction with sufficient force to close valves 258 against any manifold vacuum pressure that they may be subjected to.

In operation fuel mixture is supplied to the engine through the respective intake conduits from the primary induction passages over the lower throttle range and thereafter the valves of the secondary passages are opened and said passages also deliver fuel mixture to the engine. The secondary throttle valves 258 do not begin to open until pin 270 has moved from one end of slot 268 to the other, engaged said end and moved lever 266 in the valve opening direction.

The embodiment of the invention disclosed in Figures 5 and 6 includes an acceleration pump 278 which delivers its fuel into both primary induction passages and a vacuum economizer 280 is also provided for the primary induction passages. The secondary passages deliver a power mixture and valves 258 do not open until after the economizer begins to function.

The vehicle speed at which the secondary valves 258 begin to open may be approximately seventy miles per hour although the device may be arranged for any other desired speed ranges for the respective primary and secondary mixtures. Springs 264 may be calibrated to close valves 258 at the low end curve of operation when the manifold vacuum drops to one-half inch of mercury although it may be calibrated to close said valves at any other desired manifold vacuum pressure. It should also be understood that this embodiment of the invention may be independent carburetors as well as in an integral unit and there may be conventional throttle valves in all the throttle barrels with an auxiliary valve in the secondary passages as shown in Figures 2 and 7, the latter being a three-barrel adaptation of the invention in a downdraft integral carburetor including an air horn section 300, a body section 302 and a throttle body section 303 and a riser section 304 having a flange 305 for attachment to a single conduit intake manifold 307. The induction passages include throttle barrels or mixture passages 306, large venturis 308, small venturis 310 and a common air inlet 312, the latter being controlled by an offset choke valve 313 and controlled in the well known manner by any suitable automatic or manual means (not shown). The auxiliary valves 314 on shafts 315 in the riser section 304 are controlled by respective springs 316 and 318 similarly to the auxiliary valves shown in said Figure 2. The means for actuating the throttle valves includes a lever 320 secured to the shaft 42 of the valve 40 in the primary induction passage which is the center one. Lever 320 is connected with the acceleration pedal (not shown) by rod 70 and has an extension 322 with a slot 324 therein. A link 325 is connected with the slot and a lever 326 secured to shaft 42 of the throttle valve in one of the secondary induction passages, said lever having an extension 328 with a slot 330 therein. A link 332 is connected with slot 330 and a throttle lever 334 of the other secondary induction passage. Thus the

throttle valves are opened in series as in the embodiment shown in Figure 2.

It is to be understood that in the embodiments shown in Figures 1, 2 and 3 the invention may include separate units as shown therein or it may be included in one unit as disclosed in Figure 7. The embodiment of the invention shown in Figure 4 may be incorporated in a plurality of separate units such as shown in Figures 1, 2 and 3 or in a single unit such as shown in Figures 5, 6 and 7, and the embodiments of the invention illustrated in Figures 5, 6 and 7 may have a plurality of single units or units having fewer induction passages than shown in said figures. In addition to the adaptations of the invention above referred to, certain parts shown in certain figures, and operations thereof, may be incorporated or substituted in other embodiments of the invention where suitable and desirable.

It will be obvious that the relative positions of the primary and secondary carburetors or the primary and secondary induction passages may be changed or that but two carburetors or induction passages may be used. However, the arrangements shown in the drawings and described herein are preferred in the interest of good performance and improved economy of operation.

From the foregoing it is thought that the invention and many of its attendant advantages will be understood from the foregoing description, and it will be apparent that various changes may be made in the form, construction and arrangement of the parts without departing from the spirit and scope of the invention or sacrificing all of its material advantages, the forms hereinbefore described including merely a preferred and several modified embodiments thereof.

I claim:

1. In a charge forming device for an internal combustion engine having an intake manifold: a primary carburetor adapted to deliver its fuel mixture to the intake manifold substantially midway of the ends thereof, said carburetor including a throttle valve, a choke valve, automatic means controlling the choke valve, a vacuum economizer, acceleration pump. an idle system and fast idle mechanism; a second carburetor adapted to deliver its fuel mixture intermediately of the position of the primary carburetor mixture delivery and one end of the manifold and including a throttle valve, an idle system, and a vacuum economizer; and a third carburetor adapted to deliver its mixture intermediate of the position of the primary carburetor mixture delivery and the other end of the manifold and including a throttle valve and an idle system; an offset auxiliary valve in the second and the third carburetors posterior to the throttle valves thereof and independently operable by the differential pressure thereacross; a spring for each auxiliary valve adapted to close said valves when said differential pressure is under a predetermined value; manual means for progressively opening the throttle valves of the carburetors in the order mentioned; the throttle valve of the second carburetor being opened before the economizers begin to function, the throttle valve of the third carburetor thereafter, the third carburetor being set for a power mixture, an air flow responsive choke valve in the third carburetor, and yielding means closing said choke valve.

2. In a charge forming device for internal combustion engines having an intake manifold, a primary carburetor adapted to function throughout the range of engine operation, a plurality of

secondary carburetors, throttle valves for the carburetors, means controlling the throttle valves whereby the throttle valve of the primary carburetor is opened prior to the opening of the throttle valves of the secondary carburetors, an offset air flow auxiliary valve for each secondary carburetor and operable by the differential pressure there across, yielding means adapted to close the auxiliary valves, the yielding means of one auxiliary valve being adapted to close said valve when manifold vacuum is below approximately one inch of mercury and the yielding means of the other auxiliary valve being adapted to close same when the manifold vacuum drops below approximately one-half inch of mercury.

3. In a multi-stage charge forming device for an internal combustion engine having an intake manifold, three down-draft carburetors adapted to supply fuel mixture to the manifold, one of said carburetors being positioned midway of the ends of said manifold and the other carburetors being spaced therefrom toward the respective ends of the manifold, throttle valves for said carburetors, means for manually operating said valves so that the one carburetor opens first, and means for cutting out two of the carburetors when the throttle valves are substantially wide open and the manifold vacuum drops below a predetermined value.

4. In a charge forming and distributing system for an internal combustion engine: an intake manifold; a primary induction passage, a choke valve, automatic choke valve control, economizer, acceleration pump, an idle system, and fast idle mechanism for said primary passage; a second induction passage; an idle system therefor; throttle valves for said passages; and means for manually controlling said throttle valves whereby said valves are opened progressively.

5. In a charge forming device for an internal combustion engine having an intake manifold, an offset throttle valve openable by manifold vacuum, a one-way connection limiting the opening of the valve, a flexible diaphragm connected with said connection and responsive to manifold vacuum, a spring associated with the diaphragm and having characteristics such that manifold vacuum above a predetermined value will close the valve against the force of said spring and manifold vacuum below said value will allow the spring to move the connection to permit opening of said valve, and valve closing means adapted to close the valve when manifold vacuum is below a predetermined value substantially less than the first-mentioned predetermined value.

6. In a charge forming device for an internal combustion engine, an induction passage, an offset throttle valve responsive to manifold suction, valve control means including a connection adapted to positively close said valve when actuated in one direction and when actuated in another direction to permit opening of the valve, yielding means adapted to move the connection in the opening direction, manifold vacuum responsive means adapted to control said yielding means, said yielding means being so calibrated that it will effect opening movement of the valve control means when the manifold vacuum is below a predetermined value, manifold vacuum above said value being adapted to overcome the force of the yielding means and effect positive closing of the valve, and yielding means adapted to close the offset valve against manifold vacuum thereon below a predetermined value less than the first mentioned value.

7. In an integral horizontal delivery charge forming device for a multi-cylinder internal combustion engine having a dual intake manifold wherein the respective conduits thereof receive fuel mixture horizontally and deliver said mixture to different sets of cylinders, four induction passages arranged in the form of a square, said passages being in pairs, a primary pair supplying a primary fuel mixture to the respective intake manifold conduits and a secondary pair supplying a secondary mixture thereto, a throttle shaft for each pair of passages, throttle valves for each passage and secured to the respective shafts, the throttle valves in the secondary passages being offset, manual means for actuating the throttle shaft of the primary passages, a one-way connection between said shaft and the shaft for the offset valves, said connection limiting opening of the offset valves, and means connected with the shaft for the offset valves adapted to close said valves when the manifold vacuum is low.

8. In a charge forming device for an internal combustion engine, a plurality of primary induction passages, a plurality of secondary induction passages, throttle valves in said passages, the valves in the secondary passages being offset, means for simultaneously controlling the primary throttle valves, means for simultaneously controlling the opening of the offset valves, and means for simultaneously closing the offset valves when the primary valves are substantially wide open and engine suction is low.

9. In a fuel mixture supply system for internal combustion engines, an induction passage, an air flow throttle valve in the passage openable by engine suction, means for adjustably limiting opening of the valve, and yielding means for closing the valve against engine suction below a predetermined value.

10. In a unitary horizontal charge forming device having a plurality of induction passages, certain passages being disposed above the other passages, a fuel chamber for each tier of passages, and floats for the fuel chambers, said floats being disposed between the induction passages of the respective tiers.

11. In a charge forming and distributing system for an internal combustion engine, a multiple conduit intake manifold, a primary induction passage for each conduit, a secondary induction passage for each conduit, a throttle valve in each of said passages, the throttle valves of the secondary passages being offset, means for simultaneously controlling the primary throttle valves, means for simultaneously controlling the opening of the offset valves, and means for simultaneously closing the offset valves when the primary valves are substantially wide open and engine suction is low.

12. In a charge forming and distributing system for an internal combustion engine, a pair of induction passages, a throttle valve in each passage, one of said valves being offset and openable by engine suction, and means for controlling said throttle valves including a one-way connection limiting opening of the offset valve.

13. The invention defined in claim 12 including a spring adapted to close the offset valve when the engine suction is below a predetermined value.

14. In a charge forming device for an internal combustion engine having an intake manifold, a primary induction passage, a pair of secondary induction passages, throttle valves for said passages, means for actuating said throttle valves, two of said pasasges having auxiliary throttle valves operable by manifold vacuum, and yielding means for each auxiliary valve adapted to close same when the throttle valves are open and manifold vacuum is low, the yielding means of one of the auxiliary valves being adapted to close said valve at a predetermined manifold vacuum below that at which the yielding means of the other valve closes same.

15. In a charge forming device for an internal combustion engine having an intake manifold, a primary carburetor, a secondary carburetor, a main fuel system for each of said carburetors, throttle valve means for said carburetors, means to progressively open said throttle valve means, and a choke valve for the secondary carburetor counter-weighted to substantially close said choke valve whenever the main fuel system of said secondary carburetor is not in operation, said choke valve being operable by air flow therepast.

16. In a multiple stage charge forming device for internal combustion engines, a plurality of induction passages, throttle valves for said passages, means for progressively opening the throttle valves, a choke valve for a later opening passage, said choke valve being operable by engine suction, the closing movement of said choke valve being limited to prevent complete closing thereof, and yielding means urging said choke valve toward its closed position.

17. In a charge forming device for an internal combustion engine, a primary induction passage and a secondary induction passage, throttle valves for said passages, means for manually controlling said throttle valves whereby the secondary throttle valve is opened after the primary valve has been but partially opened, said manual means being adapted to positively close said valves, and means for rendering the secondary passage substantially inoperative at engine suctions below a predetermined value.

18. In a charge forming device for an internal combustion engine having an intake manifold, an induction passage, an offset throttle valve therein openable by manifold vacuum, a movable wall responsive to manifold vacuum, a one-way connection controlled by the movable wall and limiting opening of said valve, an increase of manifold vacuum permitting increased opening of the valve, and means for closing the valve without regard to the position of the one-way connection when the manifold vacuum is below a predetermined value.

19. In a charge forming device for an internal combustion engine, an induction passage, an unbalanced throttle valve therein responsive to engine suction, means responsive to engine suction limiting opening of the valve but permitting closing thereof independently of said means, and means adapted to close said valve when the engine suction is low and the first mentioned means is in a position permitting opening thereof.

20. In a fuel mixture supply system for an internal combustion engine, an induction passage, an air flow throttle valve in the passage operable by engine suction, manual control means adapted to limit opening of the valve, and yielding means for closing the valve when the engine suction is low.

21. In an internal combustion engine having an intake manifold, a fuel mixture supply system including first and second carburetors each having a fuel mixture outlet communicating with said intake manifold, a throttle valve in said

first carburetor, control apparatus for positively opening and closing the same at the will of an operator, an off-center throttle valve freely rotatably mounted in said second carburetor adapted to open in response to the total pressure differential on respectively opposite sides thereof, and control apparatus for said last mentioned throttle valve operable by said control apparatus of said first mentioned throttle valve throughout a portion of its operating range, said second mentioned control apparatus including a variable abutment for positively closing said second mentioned throttle valve simultaneously with closing movements of said first mentioned throttle valve and so constructed and arranged as to variably accommodate opening of said second mentioned throttle valve by said pressure differential in accordance with the extent of opening of said first mentioned throttle valve beyond a predetermined initially open position.

22. In an internal combustion engine having an intake manifold, a fuel mixture supply system including first and second carburetors each having a fuel mixture outlet communicating with said intake manifold, a throttle valve in said first carburetor, control apparatus for positively opening and closing the same at the will of an operator, an off-center throttle valve freely rotatably mounted in said second carburetor adapted to open in response to the total pressure differential on respectively opposite sides thereof; and control apparatus for said last mentioned throttle valve including an element engageable with and operable by said first mentioned control apparatus during all but its initial stage of throttle valve opening movement, said second mentioned control apparatus including a variable abutment for positively closing said second mentioned throttle valve simultaneously with closing movements of said first mentioned throttle valve and so constructed and arranged as to variably accommodate opening of said second mentioned throttle valve by said pressure differential in accordance with the extent of opening of said first mentioned throttle valve beyond a predetermined initially open position.

23. In an internal combustion engine having an intake manifold, a fuel mixture supply system including a primary carburetor and a secondary carburetor having main and idling fuel jets and each having a fuel mixture outlet communicating with said manifold, manually operable means for positively controlling the flow of fuel mixture from said primary carburetor at the will of an operator including a throttle valve in the outlet of said primary carburetor, means for controlling the flow of fuel mixture from said secondary carburetor and the flow of liquid fuel from the idling jet thereof including a throttle valve in said outlet of said secondary carburetor normally urged toward open position by the total pressure differential in said outlet on respectively opposite sides of said throttle valve during operation of said engine, means for opposing opening of said second mentioned throttle valve until said pressure differential reaches a predetermined value, and means responsive to movement of said manually operable means for variably limiting opening of said second mentioned throttle valve in accordance with opening movement of said first mentioned throttle.

24. In an internal combustion engine having an intake manifold, a feul mixture supply system including a primary carburetor and a secondary carburetor having main and idling fuel jets and each having a fuel mixture outlet communicating with said manifold, manually operable means for positively controlling the flow of fuel mixture from said primary carburetor at the will of an operator including a throttle valve in the outlet of said primary carburetor, means for controlling the flow of fuel mixture from said secondary carburetor and the flow of liquid fuel from the idling jet thereof including a throttle valve in said outlet of said secondary carburetor normally urged toward open position by the total pressure differential in said outlet on respectively opposite sides of said throttle valve during operation of said engine, means for opposing opening of said second mentioned throttle valve until said pressure differential reaches a predetermined value, and mechanism for releasably holding said second mentioned throttle valve closed, said mechanism being engageable by said manually operable means during opening of said first mentioned throttle valve thereby beyond a predetermined open position for releasing said second mentioned throttle valve and thereafter variably limiting opening thereof in accordance with opening movement of said first mentioned throttle.

25. In an internal combustion engine having an intake manifold, a fuel mixture supply system including a carburetor having main and idling fuel jets and having a fuel mixture outlet communicating with said manifold, means for controlling the flow of fuel mixture from said outlet and the flow of liquid fuel from said idling jet including a throttle valve in said outlet normally urged toward open position by the total pressure differential in said outlet on its respectively opposite sides, manually operable means for positively urging said throttle valve toward its closed position and adapted to variably limit opening movement of said throttle, and means yieldably opposing opening of said throttle valve in response to said pressure differential.

26. In an internal combustion engine having a plurality of cylinders, an intake manifold having a plurality of outlet ports for supplying fuel to certain of said cylinders, a pair of carburetors communicating with said manifold, a manually operated throttle for one of said carburetors, a second throttle for the other carburetor, means responsive to suction as determined by the attainment of a predetermined engine speed for operating said second throttle to open position, a common manually operable control member for said throttle valves, and means mechanically interconnecting said throttle valves with each other and with said control member including an element for positively opening and closing said first throttle valve and an element for only positively closing said second throttle valve.

27. In an internal combustion engine having an intake manifold, a fuel mixture supply system including a primary carburetor and a secondary carburetor having main and idling fuel jets and each having a fuel mixture outlet communicating with said manifold, manually operable means for positively controlling the flow of fuel mixture from said primary carburetor at the will of an operator, means for controlling the flow of fuel mixture from said secondary carburetor and the flow of liquid fuel from the idling jet thereof including a throttle valve in said outlet of said secondary carburetor normally urged toward open position by the total pressure differential in said outlet on respectively opposite sides of said throttle valve during operation of said engine, means for opposing opening of said throttle

valve until said pressure differential reaches a predetermined value.

28. In an internal combustion engine having an intake manifold, a fuel mixture supply system including a carburetor having main and idling fuel jets and having a fuel mixture outlet communicating with said manifold, means for controlling the flow of fuel mixture from said outlet and the flow of liquid fuel from said idling jet including a throttle valve in said outlet normally urged toward open position by the total pressure differential in said outlet on its respectively opposite sides, and means for retarding opening of said throttle valve from its idle position in order that said main jet may be in normal operation as feeding of fuel from said idle jet is discontinued.

29. In an internal combustion engine having an intake passage, means forming a plurality of mixing conduits for supplying fuel to said passage, said conduits being longitudinally spaced with respect to said passage, a manually operated throttle valve for one of said conduits, a throttle valve responsive during opening movement to automatic control subsequent to the opening movement of the manually operated throttle valve for the other of said conduits, a common manually operable control member for said throttle valves, and means mechanically interconnecting said throttle valves with each other and with said control member.

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