

Dec. 2, 1958

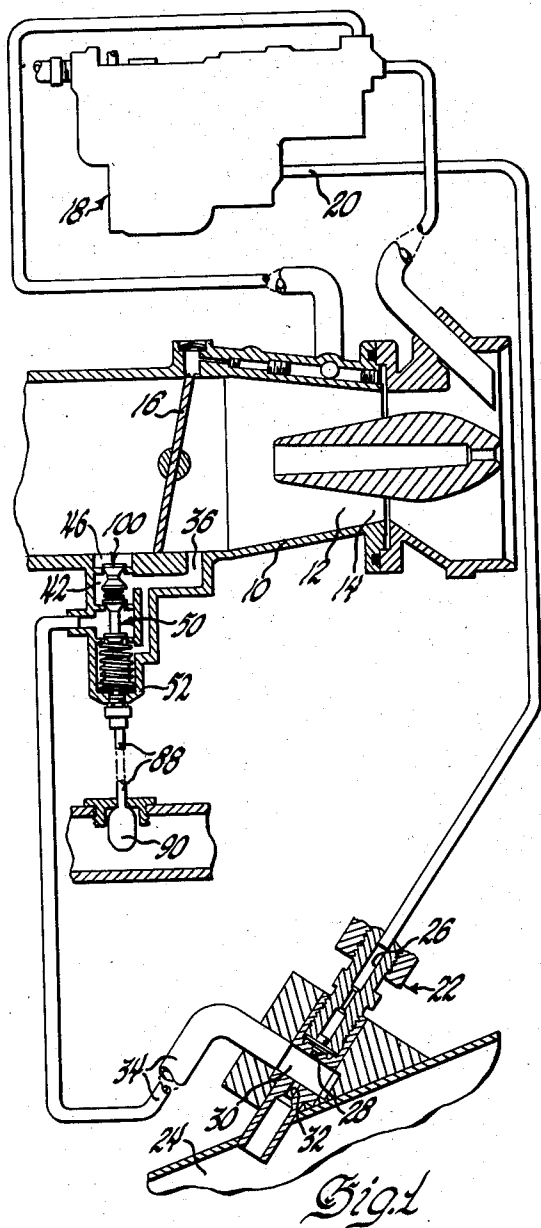
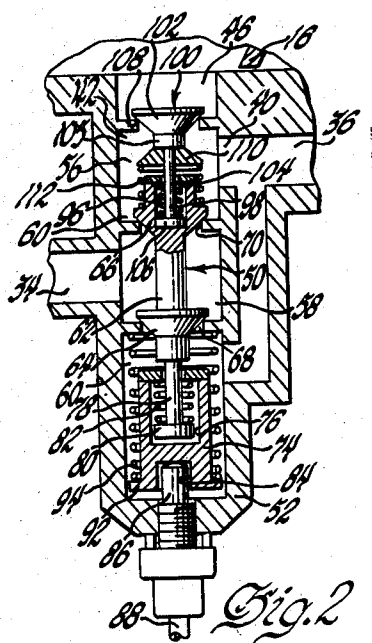
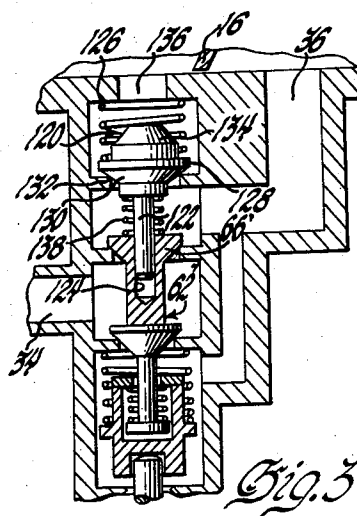
H. E. J. PRINGHAM

2,862,489

ENRICHMENT DEVICE FOR FUEL INJECTION SYSTEM

Filed Aug. 28, 1957

2 Sheets-Sheet 1



Dec. 2, 1958

H. E. J. PRINGHAM

2,862,489

ENRICHMENT DEVICE FOR FUEL INJECTION SYSTEM

Filed Aug. 28, 1957

2 Sheets-Sheet 2

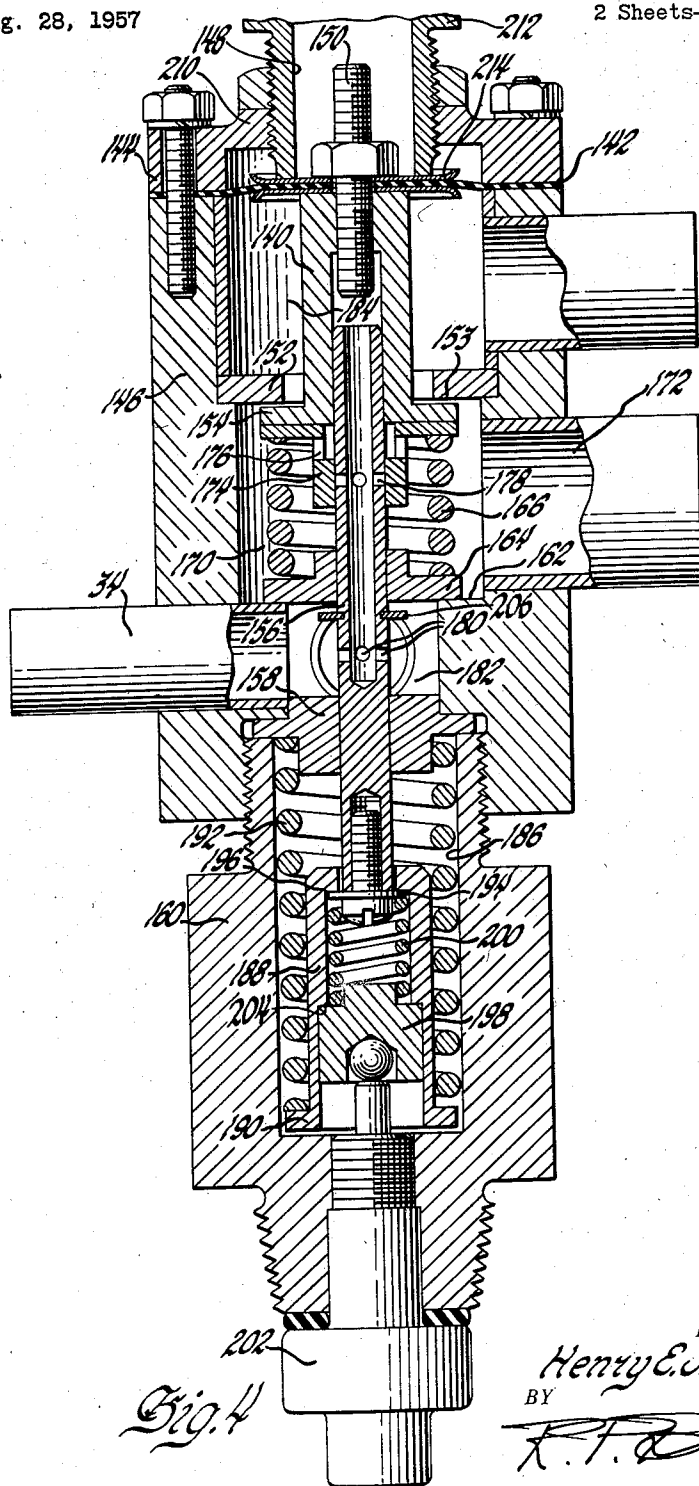


Fig. 4

INVENTOR.
Henry E. J. Pringham
BY
R. F. Barnard
ATTORNEY

1

2,862,489

ENRICHMENT DEVICE FOR FUEL INJECTION SYSTEM

Henry E. J. Pringham, Grosse Pointe, Mich., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application August 28, 1957, Serial No. 680,743

13 Claims. (Cl. 123—119)

The present device relates to a fuel enrichment mechanism for a fuel injection system. The present mechanism is particularly adapted for use with a fuel injection system of the type utilizing an atmospheric type nozzle such as shown in copending application Serial No. 608,893 Dolza, filed September 10, 1956 and more particularly is an improvement in the enrichment valve construction as shown in copending application Serial No. 667,153 filed June 21, 1957 by the present applicant.

In the fuel metering system of the previously noted copending Dolza application, fuel enrichment for starting and cold running operation is achieved by the use of a solenoid controlled mechanism which operates directly on the fuel metering valve to insure an increased fuel flow through the valve when fuel enrichment is necessary. While such a system works satisfactory, it represents a relatively expensive type control mechanism.

In the present device means is provided which is adapted to coact with the atmospheric nozzles to provide fuel enrichment during cold starting and running. It is the purpose of the present device to take advantage of the manifold vacuum which is available at the atmospheric nozzle to provide a force whereby fuel enrichment is achieved.

It is a further object of the present invention to utilize a control mechanism which is adapted to restrict the flow of atmospheric reference air to the atmospheric nozzle whereby manifold vacuum is adapted to increase the fuel flow through said nozzle and further which device is adapted to coact with the idle air system in such a way as to increase the manifold vacuum force available to achieve the fuel enrichment noted.

It is a primary object of the present invention to provide an improved temperature controlled enrichment valve and more particularly one so constructed that the air flow therearound will not bind or otherwise restrict the actuation of such valve.

The details of the present invention as well as other objects and advantages are set forth in the description which follows.

In the drawings:

Figure 1 is a partially sectioned elevational view of a fuel system embodying the subject invention;

Figure 2 is a fragmentary enlargement of Figure 1;

Figure 3 represents a modification of the idle air flow valve controlling portion of the enrichment valve; and

Figure 4 is another modification of the subject invention.

The fuel injection system functions in substantially the same manner as in the aforementioned copending applications except as will be specifically described herein. In general, the fuel injection system comprises an air intake casing 10 having air induction passage 12 formed therein. A venturi 14 is formed in said induction passage which also includes a throttle valve 16 disposed posteriorly of said venturi. A fuel metering mechanism is shown generally at 18 and is adapted to supply metered quantities of fuel to the individual cylinder fuel supply conduits 20.

2

The quantity of fuel supplied to the fuel conduits 20 is proportional to the mass of air flow through induction passage 12 as described in detail in the aforementioned copending Dolza application.

Each fuel conduit 20 terminates in a nozzle 22 supported upon and partially projecting within an individual cylinder intake passage 24. Each fuel nozzle 22 includes a fuel inlet passage 26 which terminates in a fuel metering orifice 28. The fuel from metering orifice 28 is projected in a stream across the enlarged chamber 30 where it is targeted through a larger orifice 32. The chamber 30 is adapted to communicate with a conduit 34 which communicates at its other end with the air intake casing 10 to provide reference air to the nozzle 22. The orifice 32 in the nozzle 22 has no metering effect on the fuel flow through the nozzle but does meter the quantity of air which is mixed with the fuel stream prior to its injection into the intake passage 24. As already noted, under normal operating conditions the reference air in chamber 30 neutralizes the manifold vacuum force acting on the end of the nozzle 22 and thereby stabilizes the metered fuel flow.

It is to be noted that air conduit 34 communicates through passage 36 with the air induction passage 12 intermediate the throttle valve 16 and the venturi 14. In this way all air flowing to the cylinders of the engine passes through the venturi 14 and insures a maximum metering signal for the fuel metering control device 18.

To provide idle air bypass flow around throttle 16 a branch passage 40 leads from anterior throttle passage 36 and communicates with chamber 42 and posterior throttle opening 46. In this way a flow network is provided which is adapted to bypass air around a closed throttle 16 for idling operation.

A plunger type control valve mechanism is indicated generally at 50 and is housed in a casing 52 extending laterally from the wall of the induction passage 12. Plunger valve 50 includes a bore formed through casing 52 and communicating at its inner end with induction passage opening 46 and which bore further includes counterbored sections 56, 58 and 60 within which a spindle valve member 62 is slidably disposed. Spindle valve 62 includes a pair of tapered lands 64 and 66 adapted to coact with bore seats 68 and 70. Passage 36 communicates with counterbored section 56 while the counterbored section 58 communicates with reference air passage 34. Branch passage 40 communicates with counterbored induction passage opening 46 as already noted. Thus with the tapered lands 64 and 66 respectively reposed on seats 68 and 70 the flow of atmospheric reference air from passage 36 will be blocked from reaching passage 34 permitting manifold vacuum to act on nozzle 22 to increase the quantity of fuel flow therethrough and thereby providing temporary fuel enrichment as described in the aforementioned Pringham application.

On the other hand, as the spindle valve 62 is moved upwardly the flow of atmospheric reference air will gradually be resumed to neutralize manifold vacuum at nozzle 22 and eliminating its effect on the flow of fuel through the nozzle. In view of the construction of the plunger valve in the earlier Pringham case, it was found that the atmospheric reference air flowing through passages 36 and 34 created a considerable side or binding pressure on the valve which impaired its movement. Accordingly, the present construction in which the atmospheric reference air controlling portion 62 of the valve mechanism 50 in providing the axially spaced lands 64 and 66 connected by a stem portion of greatly reduced diameter, in lieu of the earlier type valve construction, insures that the air pressures acting on the valve will be circumferentially balanced and therefore will not create a binding action to inhibit the valve actua-

tion. In addition, the tapered land construction results in less frictional resistance to movement to line contact with the valve seats. Further, the tapered lands provide improved metering of the air flow in that the flow increases as the second power of the longitudinal movement of valve 62 rather than as the first power when using cylindrical lands. This second power rate of air flow through valve 62 is desirable in that it responds more nearly to other air flow conditions in the injection system, e. g. the fuel metering vacuum signal controlling metering device 18 varies as the square of air flow through venturi 14.

A hollow piston member 74 is slidably disposed in counterbored section 56. Piston 74 includes a chamber or recess 76 within which a stem portion 78 of the slidable valve member 62 is received. Stem 78 includes an enlarged end portion 80 providing a seat for one end of a spring 82, the other end of which biases against the upper end of piston chamber 76 to normally maintain the stem and piston in the axially contracted position shown in Figure 2.

The inner end of piston 74 is recessed at 84 to receive an expandable member 86. Member 86 is in turn connected through a conduit 88 to a temperature responsive capsule 90 disposed in a portion of the engine, such as the cooling system, which is closely indicative of engine temperature. Piston 74 further includes a flange 92 formed at one end thereof and which provides a seat for one end of a spring 94 the other end of which biases against valve seat 68 resiliently maintaining the slidable piston in engagement with the expandable member 86.

The upper end of the slidable valve member 62 extends axially from tapered land 66 and includes a recess 96 adapted to slidably receive a stem portion 98 of an idle air bypass control valve 100. Valve 100 includes a tapered land 102 integral with or fixed to stem 98 and which land is disposed in counterbore 46. A spring element 104 disposed in recess 96 biases against an enlarged portion 106 of stem 98 and the upper wall of recess 96 to urge land 102 into engagement with a seat 108 to block the flow of idle air around throttle 16. An additional tapered land 110 is slidably mounted on stem 98 and is urged into engagement with a cylindrical portion 105 of land 102 by a spring 112 seated upon land 66 of valve 62. Lands 102 and 110 sequentially coact with opposite sides of a valve seat 108 to variably determine the quantity of air bypassed around the throttle 16 in accordance with the axial position of the valve member. It will be noted that the upper face of tapered land 102 is exposed to manifold vacuum in induction passage 12 anteriorly of throttle 16. Thus it is possible for manifold vacuum to raise the bypass valve member 100 against the force of spring 104 to cause air from above the throttle 16 to flow through passage 40 between tapered lands 102 and 110 into the induction passage to provide air for idling purposes.

The operation of the device as thus far described is as follows: with the engine cold and inoperative the parts will be in the position shown in Figures 1 and 2 in which all avenues for bypassing air around throttle 16 are blocked. Engine cranking preliminary to starting will thus create a vacuum in intake passage 24 which will act on the fuel nozzle 22 to increase the flow of fuel therethrough since the flow of atmospheric reference air to the nozzle is blocked. As the engine fires and becomes operative, but still remains cold, springs 82 and 94 will retain the slidable valve member 62 in the position seating the tapered lands 64 and 66 blocking air flow to passage 34. However, at this point the manifold vacuum posteriorly of the throttle 16 becomes sufficiently high to cause the bypass valve element 100 to move upwardly permitting air to bypass the throttle and maintaining the engine in an idling condition. It is to be understood that the maximum quantity of idle air flow through

valve 100 occurs when the reduced portion 105 is approximately adjacent the valve seat 108. Bypass valve element 100 is capable of a limited amount of movement away from the slidable valve element 62 until such time as the spring 104 is compressed after which manifold vacuum will tend to lift the slidable valve element partially uncovering seats 68 and 70 permitting a limited quantity of atmospheric reference air to flow to the nozzles 22. This movement of the slidable spindle valve 62 is possible through the resilient lost motion connection between the stem 78 and the piston 74.

As engine temperature increases member 86 will be expanded moving piston 74 upwardly against the force of spring 94 and in so doing will permit the bottom of the chamber 76 to engage the enlarged portion 80 of the stem 78 to move the spindle valve 62 upwardly until the tapered lands 64 and 66 completely unseat permitting the full flow of atmospheric reference air to the nozzles 22.

After land 110 has seated against seat 108 the upward movement of the slidable valve member 62 under the influence of the expandable member 86 will not be impeded since stem 98 will move relative to land 110 under which circumstance spring 112 will be compressed between lands 66 and 110.

The modification of Figure 3 relates to a different form of bypass valve 120 with the remainder of the plunger valve mechanism being the same as in Figures 1 and 2. In this instance, the bypass valve 120 includes a stem portion 122 slidably disposed in recessed portion 124 of the slidable valve member 62'. A spring 126 is adapted to engage land 128 of valve 120 to urge the tapered end 130 of the land into engagement with seat 132 blocking the flow of bypass air around throttle 16. Again in this case, manifold vacuum is adapted to act on valve 120 to unseat land 128 to increase bypass air flow. However, here again as manifold vacuum and engine temperature increases, member 120 will be moved upwardly causing tapered end 134 of land 128 to coact with induction passage opening 136 to restrict the flow of bypass air.

A spring member 138 is mounted between land 66' of the slidable member 62' and the bypass valve member 120 tending to urge the members apart. Again, after the valve member 120 has seated within opening 136 the slidable valve member 62' may continue to move upwardly due to the relative sliding between stem 122 and recess 124.

It is to be understood that a conventional warm idle air adjustment means, not shown, will be provided to insure normal idling operation after valves 100 and 120 have, in the respective modifications of Figures 1 and 3, closed idle air ports 46 and 136 to prevent further air flow therethrough.

A further modification of the present pneumatic starting device is shown in Figure 4. In this instance a cold idle air control valve 140 is centrally connected to a diaphragm 142 peripherally clamped between casing members 144 and 146. Sleeve 212 has an opening 148 formed therein which permits an adjusting screw 150 to project therethrough. A centrally perforated wall 152 is disposed in casing member 146 and provides a seat 153 for the enlarged end 154 of valve 140. Enlarged valve end 154 is disposed below perforate wall 152 such that the valve may be moved downwardly to uncover seat 153.

A hollow stem member 156 is slidably mounted in a supporting sleeve 158 which is peripherally clamped between casing members 146 and 160. The upper end of stem 156 projects axially within the casing 146 to provide a guide for the valve member 140 in its axial movement relative to seat 153. An additional seat 162 is provided in casing 146 with which a valve member 164 is adapted to coact to control the flow of reference

5

air to the nozzles 22. Valve member 164 is slidably supported upon the hollow stem 156. A spring member 166 is disposed between the idle air valve 140 and the reference air valve 164 and biases said valves in opposite axial directions and into seating relation with their respective seats 153 and 162.

The chamber 170 disposed between the valve seats 153 and 162 is adapted to communicate with the induction passage 12 anteriorly of the throttle 16 through an air supply passage 172.

A sleeve member 174 is fixed to the idle air valve 140 for movement therewith and relative axial movement with respect to stem 156. Sleeve 174 includes a plurality of radial ports 176 which, under conditions to be described, are adapted to convey air from chamber 170 through corresponding radial ports 178 formed in hollow stem 156 to an additional set of radial ports 180 in the stem to the chamber 182 disposed between reference air valve 164 and the sleeve supporting member 158. Chamber 180 is communicated with nozzles 22 through passage 34.

With the engine cold and being cranked radial ports 176 in sleeve 174 will be out of registry with the radial ports 178 in the hollow stem 156, as shown in Figure 4, and therefore no reference air will flow to the nozzles 22. When the engine begins to fire manifold vacuum will be conveyed to chamber 184, disposed between diaphragm 142 and wall 152, where the vacuum force will act on the diaphragm to move the idle air valve head 154 away from seat 153 permitting idle air to be supplied from passage 172 to the induction passage posteriorly of the throttle 16 and thereby providing a relatively large quantity of idle air while the engine is cold. At the same time, the opening movement of the valve 140 causes the sleeve 174 to move downwardly and to bring the radial ports 176 into registry with the radial ports 178 in hollow stem 156 permitting a limited amount of air to flow to the nozzles 22 thereby slightly reducing the fuel-air enrichment from that value required for starting.

The bore 186 of casing 160 includes a sleeve or piston member 188 slidably mounted therein and which member includes a flange 190 at its lower end. A spring element 192 seats against member 158 and through flange 190 biases the sleeve in a downwardly direction.

The lower end of hollow stem 156 extends within sleeve 188 and is retained therewithin through a washer 194 adapted to abut sleeve shoulder 196 so as to permit relative axial movement between stem 156 and sleeve 188. A plug 198 is in turn slidably disposed within sleeve 188 and is urged in a downwardly direction relative thereto by a spring element 200. The other end of plug 198 is in engagement with a heat sensitive capsule or unit 202.

Thus, as engine temperature warms the heat sensitive unit 202 will expand causing the plug 198 to engage sleeve shoulder 204 and to thereby move the slidable sleeve 188 upwardly to compress the springs 200 and 192. Compression of spring 200, which seats against washer 194, urges stem 156 upwardly until a washer or snap ring 206 fixed thereto engages the reference air controlling valve 164 to lift the same off seat 162 to gradually permit an increased quantity of reference air from passage 172 to flow to the nozzles 22.

As the engine temperature increases and with it the upward movement of valve member 164, the spring 166 will be compressed and cause the cold idle air controlled valve 140 to gradually be moved upwardly reducing the quantity of idle air flow past seat 153 consistent with the idling needs of a warm engine. Thus, as control valve 164 opens permitting reference air to flow to the nozzles 22, the vacuum acting on the nozzles 22 is gradually eliminated and in turn eliminates the enrichment caused by the action of such vacuum on the nozzle.

6

After the cold idle air control valve 140 has become seated against seat 153, blocking the flow of idle air therethrough, the heat sensitive unit 202 may continue to expand and open valve 164 by further compressing spring 166.

By adjusting screw 150 the maximum opening between valve 153 and seat 152 may be varied and with it the maximum fast idle speed of the cold engine before the hollow stem 156 begins to move upward under the force of heat sensitive unit 202.

An internally threaded boss 210 is formed on casing 144 and is adapted to receive a threaded sleeve 212. Sleeve 212 is adapted to abuttingly engage the reinforcing washer 214 of diaphragm 142 to limit the closed position of valve 154 for warm engine operation. Thus sleeve 212 may be adjusted and locked by nut 218 to provide the proper idle air flow for the engine when warm.

I claim:

1. A charge forming device for an internal combustion engine comprising an air intake casing, an air induction passage formed in said casing, a venturi formed in said induction passage, a throttle valve rotatably mounted in said induction passage posteriorly of said venturi, a source of fuel under pressure, and conduit means for communicating said fuel source with the individual cylinders of the engine, means for metering the quantity of fuel flow through said conduit means in accordance with the mass of air flow through said venturi, each of said fuel conduit means terminating in a nozzle for supplying fuel to each cylinder of the engine, first passage means communicating said nozzle with said induction passage anteriorly of said throttle for supplying air to said fuel stream prior to its injection into said cylinder, second passage means formed in said casing for bypassing air around said throttle, a common bore intersecting said first and second passage means and communicating at one end with the induction passage posteriorly of the throttle valve, a first valve element slidably disposed in said bore and comprising a stem, a pair of axially spaced lands formed on said stem and respectively coacting with said first passage means to control the air flow therethrough, a piston slidably disposed in said bore, a portion of said stem being slidably retained in said piston, first spring means biasing said first valve element towards said piston, an engine temperature responsive means disposed adjacent one end of said slidable piston, second spring means biasing said piston into engagement with said temperature responsive means, a second valve element slidably disposed in said bore and adapted to coact with said second passage means to control the flow of air therethrough, means for connecting said second valve element to said first valve element for relative axial movement with respect thereto, spring means for biasing said second valve element toward said first valve element, said second valve element being disposed in said bore proximate said induction passage so as to be axially movable in accordance with the manifold depression posteriorly of said throttle, said first and second valve elements being adapted to be moved axially by said temperature responsive means as engine temperature increases to at least initially increase the flow of air through said first and second passage means.

2. A charge forming device for an internal combustion engine comprising an air intake casing, an air induction passage formed in said casing, a venturi formed in said induction passage, a throttle valve rotatably mounted in said induction passage posteriorly of said venturi, a source of fuel under pressure, and conduit means for communicating said fuel source with the individual cylinders of the engine, means for metering the quantity of fuel flow through said conduit means in accordance with the mass of air flow through said venturi, each of said fuel conduit means terminating in a nozzle for supplying fuel to each cylinder of the engine, first passage means communicating said nozzle with said induction passage an-

teriorly of said throttle for supplying air to said fuel stream prior to its injection into said cylinder, second passage means formed in said casing for bypassing air around said throttle, a common bore intersecting said first and second passage means and communicating at one end with the induction passage posteriorly of the throttle valve, a first valve element slidably disposed in said bore and adapted to coact with said first passage means to control the flow of air therethrough, means movable with changes in engine temperature and operatively connected to said first valve element, a second valve element slidably disposed in said bore and adapted to coact with said second passage means to control the flow of air therethrough, means for connecting said second valve element to said first valve element for relative axial movement with respect thereto, spring means for biasing said second valve element toward said first valve element, said second valve element being disposed in said bore proximate said induction passage so as to be axially movable in accordance with the manifold depression posteriorly of said throttle, said first and second valve elements being adapted to be moved axially by said temperature movable means to at least initially increase the flow of air through said first and second passage means as engine temperature increases.

3. A charge forming device for an internal combustion engine comprising an air intake casing, an air induction passage formed in said casing, a venturi formed in said induction passage, a throttle valve rotatably mounted in said induction passage posteriorly of said venturi, a source of fuel under pressure, and conduit means for communicating said fuel source with the individual cylinders of the engine, means for metering the quantity of fuel flow through said conduit means in accordance with the mass of air flow through said venturi, each of said fuel conduit means terminating in a nozzle for supplying fuel to each cylinder of the engine, first passage means communicating said nozzle with said induction passage anteriorly of said throttle for supplying air to said fuel stream prior to its injection into said cylinder, second passage means formed in said casing for bypassing air around said throttle, a common bore intersecting said first and second passage means and communicating at one end with the induction passage posteriorly of the throttle valve, a first valve element slidably disposed in said bore and adapted to coact with said first passage means to control the flow of air therethrough, means movable with changes in engine temperature and operatively connected to said first valve element, a second valve element slidably disposed in said bore and adapted to coact with said second passage means to control the flow of air therethrough, said second valve element being disposed in said bore proximate said induction passage so as to be axially movable in accordance with the manifold depression posteriorly of said throttle, and a resilient lost motion connection between said first and second valve elements permitting an initial opening movement of said second valve element to provide idle air flow in advance of any opening of said first valve element, said first and second valve elements being adapted to be moved axially by said temperature movable means to at least initially increase the flow of air through said first and second passage means as engine temperature increases.

4. A charge forming device for an internal combustion engine comprising an air intake casing, an air induction passage formed in said casing, a venturi formed in said induction passage, a throttle valve rotatably mounted in said induction passage posteriorly of said venturi, a source of fuel under pressure, and conduit means for communicating said fuel source with the individual cylinders of the engine, means for metering the quantity of fuel flow through said conduit means in accordance with the mass of air flow through said venturi, each of said fuel conduit means terminating in a nozzle for supplying fuel to each cylinder of the engine, first

passage means communicating said nozzle with said induction passage anteriorly of said throttle for supplying air to said fuel stream prior to its injection into said cylinder, second passage means formed in said casing for bypassing air around said throttle, a common bore intersecting said first and second passage means and communicating at one end with the induction passage posteriorly of the throttle valve, a first valve element slidably disposed in said bore and comprising a stem, a pair of axially spaced lands formed on said stem and respectively coacting with said first passage means to control the air flow therethrough, a piston slidably disposed in said bore, a portion of said stem being slidably retained in said piston, first spring means biasing said first valve element towards said piston, an engine temperature responsive means disposed adjacent one end of said slidable piston, second spring means biasing said piston into engagement with said temperature responsive means, a second valve element slidably disposed in said bore and adapted to coact with said second passage means to control the flow of air therethrough, said second valve element being disposed in said bore proximate said induction passage so as to be axially movable in accordance with the manifold depression posteriorly of said throttle, and a resilient lost motion connection between said first and second valve elements permitting an initial opening movement of said second valve element to provide idle air flow in advance of any opening of said first valve element, said first and second valve elements being adapted to be moved axially by said temperature responsive means to at least initially increase the flow of air through said first and second passage means as engine temperature increases.

5. A charge forming device for an internal combustion engine comprising an air intake casing, an air induction passage formed in said casing, a venturi formed in said induction passage, a throttle valve rotatably mounted in said induction passage posteriorly of said venturi, a source of fuel under pressure, and conduit means for communicating said fuel source with the individual cylinders of the engine, means for metering the quantity of fuel flow through said conduit means in accordance with the mass of air flow through said venturi, each of said fuel conduit means terminating in a nozzle for supplying fuel to each cylinder of the engine, first passage means communicating said nozzle with said induction passage anteriorly of said throttle for supplying air to said fuel stream prior to its injection into said cylinder, second passage means formed in said casing for bypassing air around said throttle, a common bore intersecting said first and second passage means and communicating at one end with the induction passage posteriorly of the throttle valve, a first valve element slidably disposed in said bore and adapted to coact with said first passage means to control the flow of air therethrough, means movable with changes in engine temperature operatively connected to said first valve element, a second valve element slidably disposed in said bore and adapted to coact with said second passage means to control the flow of air therethrough, means for connecting said second valve element to said first valve element for relative axial movement with respect thereto, spring means for biasing said second valve element toward said first valve element, said second valve element being disposed in said bore proximate said induction passage so as to be axially movable in accordance with the manifold depression posteriorly of said throttle, said first and second valve elements being adapted to be moved axially by said temperature responsive means to at least initially increase the flow of air through said first and second passage means.

6. A charge forming device as set forth in claim 3 in which said second valve element comprises a stem, a first land fixed to said stem and adapted to block flow through said second passage when said element moves in one

direction, a second land axially spaced from the first land and adapted to block flow through said second passage when said second valve element moves in the other direction.

7. A charge forming device as set forth in claim 5 in which the second land of said second valve element is slidably mounted upon the associated stem and a spring element biasing said second land in the direction of the first land of said second valve.

8. A charge forming device as set forth in claim 3 in which said second valve element includes a member having oppositely tapered end portions adapted respectively to block idle air flow when said member moves toward or away from said first valve element.

9. A charge forming device for an internal combustion engine comprising an air intake casing, an air induction passage formed in said casing, a venturi formed in said induction passage, a throttle valve rotatably mounted in said induction passage posteriorly of said venturi, a source of fuel under pressure, and conduit means for communicating said fuel source with the individual cylinders of the engine, means for metering the quantity of fuel flow through said conduit means in accordance with the mass of air flow through said venturi, each of said fuel conduit means terminating in a nozzle for supplying fuel to each cylinder of the engine, first passage means communicating said nozzle with said induction passage anteriorly of said throttle for supplying air to said fuel stream prior to its injection into said cylinder, second passage means formed in said casing for bypassing air around said throttle, a common bore intersecting said first and second passage means and communicating at one end with the induction passage posteriorly of the throttle valve, a first valve element slidably disposed in said bore and adapted to coact with said first passage means to control the flow of air therethrough, means movable with changes in engine temperature and operatively connected to said first valve element, a second valve element slidably disposed in said bore and adapted to coact with said second passage means to control the flow of air therethrough, said second valve element being disposed in said bore proximate said induction passage so as to be axially movable in accordance with the manifold depression posteriorly of said throttle, a stem slidably supported in said bore, said first and second valve elements slidably mounted in spaced relation on said stem, a spring member disposed intermediate and biasing said valve elements in a closed direction, a diaphragm connected to said second valve element and exposed to manifold depression so that said second valve element may open to provide idle air flow in advance of the opening of said first valve element, said first and second valve elements being adapted to be moved axially by said temperature movable means to vary the rate of air flow through said first and second passage means as engine temperature increases.

10. A charge forming device for an internal combustion engine comprising an air intake casing, an air induction passage formed in said casing, a venturi formed in said induction passage, a throttle valve rotatably mounted in said induction passage posteriorly of said venturi, a source of fuel under pressure, and conduit means for communicating said fuel source with the individual cylinders of the engine, means for metering the quantity of fuel flow through said conduit means in accordance with the mass of air flow through said venturi, each of said fuel conduit means terminating in a nozzle for supplying fuel to each cylinder of the engine, first passage means communicating said nozzle with said induction passage anteriorly of said throttle for supplying air to said fuel stream prior to its injection into said cylinder, second passage means formed in said casing for bypassing air around said throttle, a common bore intersecting said first and second passage means and communicating at one end with the induction passage posteriorly of the

throttle valve, a first valve element slidably disposed in said bore and adapted to coact with said first passage means to control the flow of air therethrough, a second valve element slidably disposed in said bore and adapted to coact with said second passage means to control the flow of air therethrough, said second valve element being disposed in said bore proximate said induction passage so as to be axially movable in accordance with the manifold depression posteriorly of said throttle, a stem slidably supported in said bore, said first and second valve elements slidably mounted in spaced relation on said stem, a spring member disposed intermediate and biasing said valve elements in a closed direction, a diaphragm connected to said second valve element and exposed to manifold depression so that said second valve element may open to provide idle air flow in advance of the opening of said first valve element, means movable with changes in engine temperature, said stem being operatively connected to said temperature movable means, a stop member fixed to said stem and adapted to engage one of said valve elements to vary the rate of air flow therpast as the temperature movable means varies the axial position of said stem.

11. A charge forming device as set forth in claim 10 in which said stop member is adapted to engage said first valve element to increase air flow through said first passage means, said spring member being adapted to bias said second valve element to reduce air flow therethrough as said first valve element opens.

12. A charge forming device for an internal combustion engine comprising an air intake casing, an air induction passage formed in said casing, a venturi formed in said induction passage, a throttle valve rotatably mounted in said induction passage posteriorly of said venturi, a source of fuel under pressure, and conduit means for communicating said fuel source with the individual cylinders of the engine, means for metering the quantity of fuel flow through said conduit means in accordance with the mass of air flow through said venturi, each of said fuel conduit means terminating in a nozzle for supplying fuel to each cylinder of the engine, first passage means communicating said nozzle with said induction passage anteriorly of said throttle for supplying air to said fuel stream prior to its injection into said cylinder, second passage means formed in said casing for bypassing air around said throttle, a common bore intersecting said first and second passage means and communicating at one end with the induction passage posteriorly of the throttle valve, a first valve element slidably disposed in said bore and adapted to coact with said first passage means to control the flow of air therethrough, means movable with changes in engine temperature and operatively connected to said first valve element, a second valve element slidably disposed in said bore and adapted to coact with said second passage means to control the flow of air therethrough, said second valve element being disposed in said bore proximate said induction passage so as to be axially movable in accordance with the manifold depression posteriorly of said throttle, a stem slidably supported in said bore, said first and second valve elements slidably mounted in spaced relation on said stem, a spring member disposed intermediate and biasing said valve elements in a closed direction, a diaphragm connected to said second valve element and exposed to manifold depression so that said second valve element may open to provide idle air flow in advance of the opening of said first valve element, said first and second valve elements being adapted to be moved axially by said temperature movable means to vary the rate of air flow through said first and second passage means as engine temperature increases, and means operable by said second valve for bypassing air around said first valve element into said first passage means during the initial opening movement of said second valve element.

11

13. A charge forming device as set forth in claim 12 in which said air bypass means comprises a longitudinal passage in said stem, first radial passage means communicating said longitudinal passage with said first passage posteriorly of said first valve element, second radial pas- 5 sage means communicating said longitudinal passage

12

with said first passage means anteriorly of said first valve element, and means fixed to said second valve element to control the flow of air through said second radial passage means.

No references cited.