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DUAL BALANCED AIR METER FOR SPLIT ENGINE

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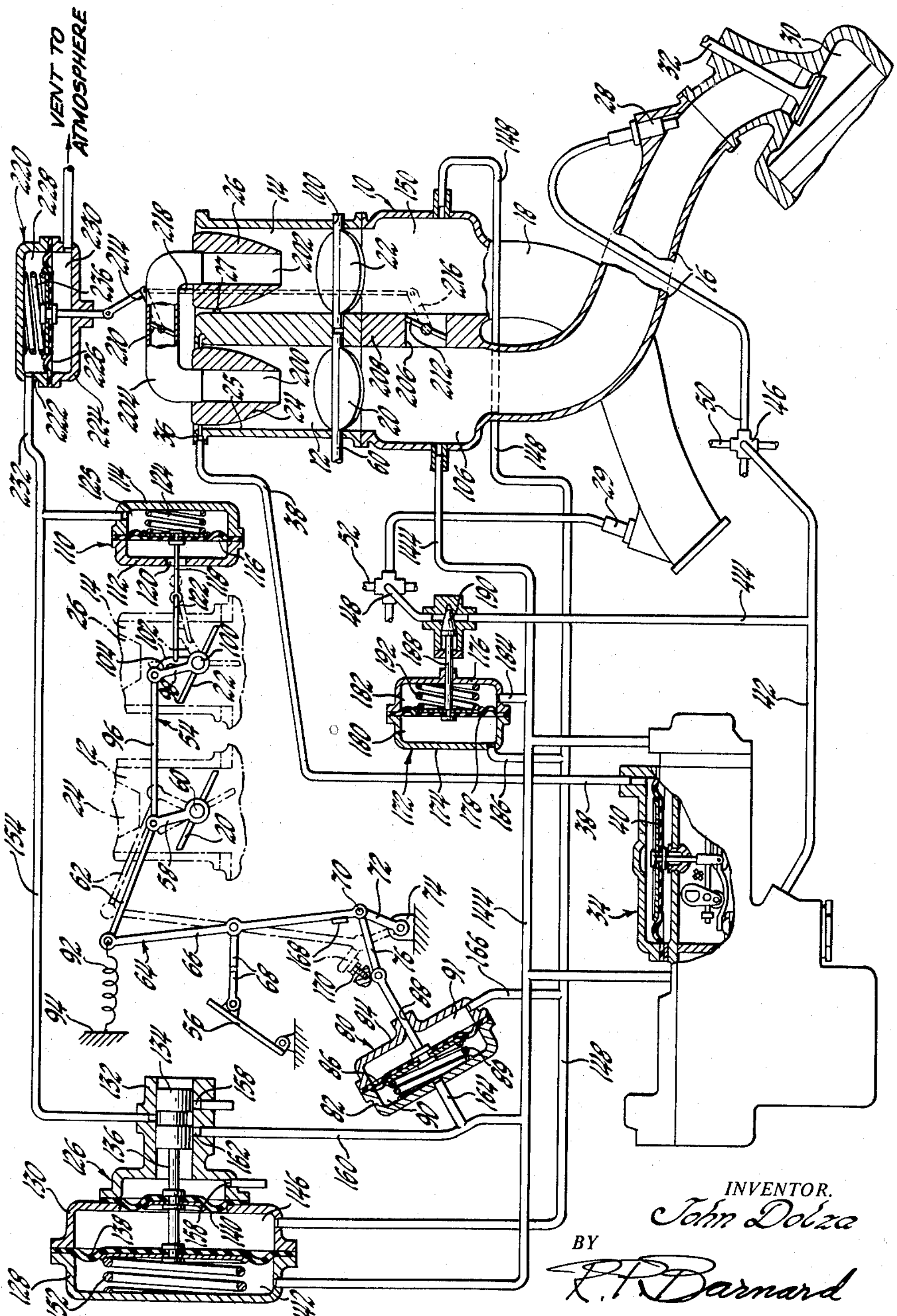

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DUAL BALANCED AIR METER FOR SPLIT ENGINE

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The present invention relates to an engine control system in which it is possible to operate the engine on less than all of the cylinders under normal or light load conditions but in which full engine operation is possible when the engine load exceeds a given value. The present invention is an improvement over copending application Serial No. 608,828, Dolza, filed September 10, 1956, now Patent No. 2,875,742, granted March 3, 1959.

As explained in the aforenoted copending application, it has been found that considerable economies can be realized when it is possible to resort to split engine operation, for example, being able to operate an eight cylinder engine on four cylinders under moderate load conditions. The economy is effected by the fact that individual cylinder efficiency is increased when the individual cylinder load is increased during split engine operation in contrast to reduced cylinder loads as occurs with full engine operation during light or moderate load conditions.

It is an inherent characteristic of an internal combustion engine to be most efficient under high load conditions. This is attributable to the quantity of air fed to the cylinders. Maximum air is supplied to the cylinders when the throttle is open, indicative of high load, therefore, more air may be compressed in turn increasing the compression pressure. Since engine efficiency increases with compression pressure and compression pressure increases with cylinder load, the desirability of split or part cylinder engine operation as a means for maintaining high cylinder loads becomes apparent.

Split engine operation has long been recognized as a theoretically desirable goal. However, the general complication of mechanisms which have been developed to achieve this type of operation have thus far precluded its commercial feasibility. The present invention relates to a greatly simplified split engine control system which has been operated over a considerable period of time and has proved to be most satisfactory in operation.

The invention is illustrated with an eight cylinder although it is apparent that it may be applied to engines having any number of cylinders in excess of one. Separate air intake passages, throttles and manifolds are provided for the active and inactive cylinders.

It is apparent that alternate firing cylinders should be selected for active or inactive cylinders. In other words, a normal firing order for an eight cylinder engine might be 1–8–4–3–6–5–7–2. The active cylinder group might then be cylinders 1–4–6–7.

In general, the operation of the split engine control system is such that when the manifold vacuum is above a given value, e.g., 4 inches of mercury or greater, in the manifold serving the four active cylinders, the engine is operated on these four cylinders only and controlled by an "active" throttle device which regulates flow through one of the two air intake passages. When part or four cylinder operation is effected, an "inactive" throttle in the other air induction passage is moved to a full open position to prevent pumping losses in the inactive cylinders. At the same time fuel flow to the "inactive" nozzles is also cut off.

Contemporaneously with the opening of the "inactive" throttle and the cutting off of fuel flow to the "inactive" nozzles, means is provided for shifting an accelerator pedal controlled throttle linkage to a position increasing the opening of the "active" throttle beyond the amount which would otherwise exist during eight cylinder engine operation. This latter adjustment of the "active" throttle during four cylinder operation as well as its corollary in which the "active" throttle is moved towards a more closed position when eight cylinder operation is in effect necessary in order to provide a smooth transition between four and eight cylinder engine operation. The latter is necessary in order to make the transition at substantially consant engine torque.

The present split engine system is basically the same as that shown in copending application Serial No. 736,915, Mick, field May 21, 1958. This present invention is an improvement in the Mick system in providing means for equalizing air flow to all engine cylinders during full engine operation. In any mechanical system for controlling the flow of air through more than one passage simultaneously an exact balance of flow cannot be obtained because of tolerances in the manufacture of parts. The subject dual balanced air meter insures equal air flow by providing two balance passages between the "active" and "inactive" air induction system. One of the balance passages is between intake headers posteriorly of the throttle valves. The other balance passage is between the air meter cavities anteriorly of the throttle valves.

Valves are provided in the balance passages and are adapted to be opened during full engine operation to balance air flow and to be closed during split engine operation.

Other objects and advantages will be apparent from a perusal of the detailed description which follows.

The drawing is a diagrammatic representation of a fuel system embodying the subject invention.

Referring to the drawing, a manifold is indicated generally at **10** and is of the divided header type in which individual air induction passages **12** and **14** are adapted respectively to supply air to four of the engine cylinders through individual cylinder intake passages **16** and **18**. Throttle valves **20** and **22** are disposed in each of the induction passages as are contoured diffusers **24** and **26**. The diffusers and induction passages respectively coact to define venturis **25** and **27**. Fuel nozzles **28** and **29** are disposed in the individual cylinder intake passages and are adapted to supply fuel to cylinders **30** when the cylinder intake valves **32** are open.

In the present control system, as in the aforenoted copending application, a group of cylinders and associated air intakes are always "active" whereas the remaining cylinders are normally "inactive" with the latter being activated only after the engine load exceeds a given value. In the present illustration, intake **12**, throttle **20** and the four associated cylinder intake pasages **16** are the "active" part of the system whereas intake **14**, throttle **22** and intake passages **18** constitute the normally inactive part of the system.

Fuel is adapted to be supplied to the nozzles **28–29** through a fuel injection metering device indicated generally at **34** which is shown and described in detail in copending application Serial No. 608,853, Dolza, filed September 10, 1956, now Patent No. 2,843,098 granted July 15, 1958. The fuel metering system functions in the same manner as described in the aforenoted copending applicaion and does not, per se, constitute a part of the present invention.

Air is drawn in through both induction passages as already noted. However, only the active induction passage 12 includes a piezometer ring 36 which transmits a vacuum signal proportional to mass air flow through conduit 38 to a metering control diaphragm 40 of the fuel control mechanism 34. Inasmuch as two intake induction passages are utilized in the subject split engine, it is possible for venturi 25 to be reduced sufficiently in size such that one-half engine operation will produce the same metering signal in piezometer ring 36 as total engine air flow would produce on the single venturi used in the aforenoted Dolza application Serial No. 608,853. Further, since venturi depression in piezometer ring 36 is proportional to the nozzle pressure drop across all of the nozzles 28 and with equal air flow restriction in each induction passage, due to coordinated (equal opening) positioning of the throttles, the venturi signal may be taken off from the active induction passage during all operating conditions.

Fuel control mechanism 34 is adapted to supply fuel pressure to conduit 42 in proportion to mass air flow. A branch conduit 44 is supplied from conduit 42. Conduits 42 and 44 respectively lead to distributors 46 and 48 which in turn supply the active and inactive nozzles through individual conduits 50 and 52.

Throttles 20 and 22 are interconnected through a linkage mechanism indicated generally at 54 for synchronized operation by the operator through the actuation of an accelerator pedal 56. Accelerator controlled linkage operation is, however, modified by other mechanisms to be subsequently described.

The accelerator pedal controlled linkage 54 includes an arm 58 fixed to the active throttle shaft 60. Arm 58 is articulated through a link 62 to a double articulated lever 64. The upper portion 66 of lever 64 is articulated intermediate its ends to a link 68 connected at its other end to accelerator pedal 56. The lower end of lever portion 66 is articulated at 70 to member 72 of the lever 64. The lower end of member 72 is pivotally mounted on a fixed support 74.

The pivotal connection 70 between lever portions 66 and 70 has a link 76 articulated thereto and the other end of which link is connected to a rod 78 of a servo device indicated generally at 80. Servo device 80 includes a pair of casing members 82 and 84 which peripherally clamp a flexible diaphragm 86 therebetween. Rod 78 is centrally fixed to the diaphragm and extends through an opening 88 in casing 84. A spring 89 is disposed in servo chamber 90 and tends to bias diaphragm 86 to the right. It is possible, however, to eliminate spring 89 if desired.

The upper end of lever 64 has a spring 92 connected thereto, the other end of which is grounded at 94. Assuming for the moment that all other control forces remain unchanged, it is apparent that as the accelerator pedal 56 is depressed the throttle linkage system is such that the active throttle 20 will be opened. It should be noted at this point that the pivoted connection 70 between members 66 and 72 of double articulated lever 64 may be pivoted between two positions by servo mechanism 80 in conjunction with spring 89. When, as is the case during eight cylinder operation, the vacuum forces on either side of diaphragm 86 are substantially balanced, spring 89, through rod 78 and link 76, will shift pivoted connection point 70 in a rightward direction as shown in the drawing. This action causes a counterclockwise rotation of member 66 moving throttle 20 in a closing direction. As will be subsequently considered in greater detail when the vacuum in chamber 90 overcomes spring 89 the parts will be shifted to the dotted line positions to open throttle 20. As will subsequently be more apparent, this differential movement of the active throttle 20 is for the purpose of readjusting the throttle position to facilitate a smooth transition between four and eight cylinder operation.

During this eight or full cylinder operation, actuation of accelerator pedal 56 will cause the double articulated lever 64 to pivot about support 74. As will subsequently be considered in greater detail, however, during four or part cylinder operation, lever portion 66 will pivot about point 70 thus providing differential control of throttle actuation.

Active throttle lever 58 is articulated through a link 96 to an arm 98 loosely mounted on the inactive throttle valve shaft 100 so that the actuation of the active throttle may or may not affect a similar movement of the inactive throttle 22 depending on the actuation of other devices which will be subsequently considered. A lever 102 is fixed to the inactive throttle shaft 100 and includes a tab portion 104 adapted to engage with the loosely mounted lever 98. Assuming the system control forces are such that the inactive throttle 22 is in a closed position, as shown, then the levers 98 and 102 are in operative engagement and opening movement of the active throttle 20 will likewise open the inactive throttle.

The various devices utilized to vary the subject fuel system between split and full operation will now be considered. In general, it has been found that as long as the manifold vacuum in the active portion 106 of manifold 10 is above a predetermined value, e.g., four inches of mercury, most economical engine operation will be achieved by split or four cylinder operation of the engine with the remaining cyilnders being inactivated.

As already noted, in order to prevent pumping losses in the inactive engine cylinder it is desired to fully open inactive throttle 22 during split engine operation. This full opening movement of throttle 22 is achieved by a servo mechanism 110 which includes a pair of casing members 112 and 114 peripherally clamping a diaphragm 116 therebetween. A control rod 118 is centrally fixed to diaphragm 116 and projects through an opening 120 in the casing 112 and is connected to link 122 articulated to lever 102. A spring 124 disposed in chamber 125 between diaphragm 116 and casing 114 normally urges the lever 102 and throttle 22 in a counterclockwise or closing direction and under which condition, as noted, tab 104 of lever 102 is in engagement with active throttle controlled lever 98.

The actuation of servo 110 is under the control of a shift valve device indicated generally at 126. Device 126 includes a plurality of casing members 128, 130 and 132. Casing 132 includes a ported cylindrical opening within which a spool type valve member 134 is slidably disposed. Valve member 134 includes a stem 136 extending toward casings 128 and 130 and upon which a pair of flexible diaphragms 138 and 140 are centrally mounted. The first diaphragm 138 is peripherally clamped between casings 128 and 130 while the second and smaller diaphragm 140 is peripherally clamped by the casings 130 and 132. Chamber 142 defined by casing 128 and diaphragm 138 is connected through a passage 144 with the active manifold 106 whereby active manifold vacuum is at all times transmitted to the chamber.

Chamber 146 defined by diaphragms 138 and 140 and casing 130 is communicated through a conduit 148 with the inactive manifold 150 and likewise is at all times subject to the vacuum force extant therein. A spring 152 is also disposed in vacuum chamber 142 and biases spindle valve 134 in a rightward direction which, other control forces permitting, causes conduit 154 communicating with chamber 125 of servo 110 to be exhausted to the atmosphere through an exhaust port 158 in casing 132. In such case spring 124 would move inactive throttle 22 in a throttle closing direction.

So long as the vacuum in manifold 106 exceeds that in manifold 150 by a differential of four inches of mercury, the vacuum force in chamber 142 will be sufficiently strong to overcome spring 152 as well as the vacuum force in chamber 146 to shift value 134 to the left. Under this circumstance active manifold vacuum from conduit 160 will be admitted from valve casing port 162 between the lands of valve 134 where it will act through conduit 154 on inactive throttle diaphragm 116 to shift the diaphragm to the right against the force of spring 124 to fully open the inactive throttle.

At the same time, the vacuum forces from manifolds 106 and 150 are respectively transmitted through conduits 164 and 166 to chambers 90 and 91 of accelerator control linkage servo 80. The same vacuum differential will cause diaphragm 86 of servo 80 to be shifted to the left moving the pivotal connection 70 to its leftmost position in which a stop 168 on member 72 of lever 64 abuts a fixed stop 170. The leftward movement of pivotal connection 70 causes member 66 of lever 64 to be rotated in a clockwise direction increasing the opening of the active throttle in order to maintain a constant engine torque for smooth transition to four cylinder operation, supra. As noted, supra, lever 66 now pivots about point 70 providing differential control whereby the active throttle 20 will open to a greater extent than during corresponding eight cylinder operation.

Contemporaneously with the shifting of the throttle linkage and the opening of the inactive throttle, a servo valve device 172 is adapted to cut off the flow of fuel to the inactive nozzle distributor 48. Servo valve device 172 includes a pair of casing members 174 and 176 peripherally clamping a diaphragm 178 therebetween and thereby forming a pair of vacum chambers 180 and 182. Vacuum chambers 180 and 182 in turn communicate through conduits 184 and 186 with active and inactive manifold vacuum conduits 144 and 148. A control rod 188 is centrally fixed to diaphragm 178 and terminates in a valve portion 190 which, when the predetermined vacuum differential exists between manifolds 106 and 150, is shifted to the right against the force of spring 192 to cut off the flow of fuel from conduit 44 to nozzles 29.

The transition from split or four cylinder operation to eight or full engine operation is, as noted, effected when the vacuum in the manifold 106 drops below a predetermined value, e.g., four inches of mercury. When this happens the force of spring 152 acting on the shift valve device diaphragm 138 will cause valve 134 to be moved to the right atmospherically venting inactive throttle servo chamber 125 and causing the spring 124 to move the inactive throttle towards a closed position and operatively engaging inactive throttle levers 102 and 98 whereby synchronized operation of the throttles will thereafter take place.

Closing the inactive throttle substantially equalizes the vacuum in manifolds 106 and 150 under which conditions the vacum forces on either side of linkage controlling servo diaphragm 86 will be substantially equal and spring 89 will shift the active throttle 20 to a more closed position, supra. Again, the equal vacuum in manifolds 106 and 150 will be transmitted to fuel cut-off valve servo chambers 180 and 182 permitting spring 192 to open valve 190 and thereby initiating fuel flow to inactive nozzles 29.

During eight or full cylinder operation the active and inactive manifold vacuums are equal resulting in no vacuum force differential acting on shift valve diaphragm 138. However, when the vacuum in chamber 146 of the shift valve device 126 exceeds a given value, e.g., 15 inches of mercury, it will act on the small diaphragm 140 with sufficient force to overcome spring 152 and shift the valve 134 to the left. This again fully opens the inactive throttle which once again causes the servos 80 and 172 to again adjust the throttle valves and fuel flow to four cylinder operation.

Up to this point it has been assumed that air flows through active and inactive induction passages 12 and 14 were equal during full or eight cylinder operation. As already noted, this assumption is not necessarily correct and that due to slight differences in manufacture, the air flow may vary from one passage to the other.

To insure balanced air flow between induction passages 12 and 14 it has been found necessary to provide means for interconnecting these passages during full engine operation. More specifically it has been found to be desirable to connect the air induction systems both anteriorly and posteriorly of throttle valves 20 and 22. Accordingly, longitudinal passages 200 and 202 are formed through tapered diffusers 24 and 26. Passages 200 and 202 are interconnected by a conduit 204. Thus induction passages 12 and 14 are adapted to be communicated anteriorly of throttles 20 and 22. This connection will compensate for any flow inbalance due mainly to size variations between the active and inactive venturis.

Another balance passage 206 is formed in the header wall 208 between passages 12 and 14. Passage 206 is adapted to compensate for any flow inbalance created posteriorly of throttles 20 and 22.

Balance passages 204 and 206 respectively include valves 210 and 212 which are interconnected through levers 214 and 216 and a common actuating rod 218. A servo device 220 is adapted to control the actuation of rod 218 and hence valves 210 and 212. Servo device 220 includes casings 222 and 224 peripherally clamping a flexible diaphragm 226 therebetween. Rod 218 extends through an opening in casing 224 and is centrally fixed to diaphragm 226. Servo chambers 228 and 230 are respectively connected to active manifold vacuum conduit 144 and atmosphere through conduits 232 and 234.

Since air flow through induction passages 12 and 14 is naturally and desirably unequal during split engine operation, the higher vacuum in conduit 144 will be transmitted through shift valve device 126 and conduit 154 to servo chamber 228 where it will overcome a spring 236 to raise rod 218 and close valves 210 and 212. During full engine operation the active manifold vacuum in conduits 144, 154 and 232 is not of a sufficiently high value to overcome the force of spring 236 whereby the latter will move diaphragm 226 and rod 218 downwardly to open valves 210 and 212. In this way air flow through induction passages 12 and 14 and to the cylinders supplied thereby will be equalized during full or eight cylinder operation.

It is apparent that the subject invention has been diagrammatically represented in order to simplify the understanding of its operation. It is also apparent that the substance of the subject invention may be embodied in various structural arrangements within the intended scope of the hereinafter appended claims.

I claim:

1. A charge forming device for an internal combustion engine comprising a first air induction system for supplying air to certain cylinders of the engine, a second air induction system for supplying air to the remaining engine cylinders, first and second throttle valves for respectively controlling the flow of air through said first and second systems, means for supplying fuel to each of said air induction systems in accordance with engine demand, means for synchronizing the actuation of said throttles, means responsive to the engine vacuum differential in said air induction systems posteriorly of said throttles for fully opening one of said throttles when said differential exceeds a predetermined value, additional means responsive to said predetermined vacuum differential for moving the other throttle to a more open position when said one throttle is fully opened, means operable in response to said predetermined vacuum differential to cut off the flow of fuel to the air induction system associated with the fully opened throttle, and means for equalizing air flow through said induction systems when all engine cylinders are operative to supply power.

2. A charge forming device for an internal combustion engine comprising a first air induction system for supplying air to certain cylinders of the engine, a second air induction system for supplying air to the remaining engine cylinders, first and second throttle valves for re-

spectively controlling the flow of air through said first and second systems, means for supplying fuel to each of said air induction systems in accordance with engine demand, means for synchronizing the actuation of said throttles, means responsive to the engine vacuum differential in said air induction systems posteriorly of said throttles for fully opening one of said throttles when said differential exceeds a predetermined value, additional means responsive to said predetermined vacuum differential for moving the other throttle to a more open position when said one throttle is fully opened, means operable in response to said predetermined vacuum differential to cut off the flow of fuel to the air induction system associated with the fully opened throttle, and valve means for interconnecting said induction systems to equalize air flow therethrough when all engine cylinders are operative to supply power.

3. A charge forming device for an internal combustion engine comprising a first air induction system for supplying air to certain cylinders of the engine, a second air induction system for supplying air to the remaining engine cylinders, first and second throttle valves for respectively controlling the flow of air through said first and second systems, means for supplying fuel to each of said air induction systems in accordance with engine demand, means for synchronizing the actuation of said throttles, means responsive to the engine vacuum differential in said air induction systems posteriorly of said throttles for fully opening one of said throttles when said differential exceeds a predetermined value, additional means responsive to said predetermined vacuum differential for moving the other throttle to a more open position when said one throttle is fully opened, means operable in response to said predetermined vacuum differential to cut off the flow of fuel to the air induction system associated with the fully opened throttle, and first and second valves for respectively interconnecting said induction systems anteriorly and posteriorly of said throttle valves to equalize air flow through said systems when all engine cylinders are operative to supply power.

4. A charge forming device as set forth in claim 2 in which said valve means comprises a first passage interconnecting said induction systems anteriorly of the throttle valves, a second passage interconnecting said systems posteriorly of said throttle valves, valves respectively disposed in said passages, and a common actuating device for said latter valves, said device being adapted to close said valves when fuel flow is cut off to one of the air induction systems and to open said valves when all engine cylinders are operative to supply power.

5. A charge forming device as set forth in claim 4 in which said common actuating device includes a servo mechanism comprising a pair of casing members, a flexible diaphragm peripherally clamped between said casing members, a rod member centrally fixed to said diaphragm and operatively connected to the first and second passage valves, said casing members respectively coacting with said diaphragm to define a pair of chambers, a spring member biasing said diaphragm in a direction tending to open said valves, and conduit means respectively connecting said chambers with the first and second air induction systems posteriorly of the throttle valves, and a spring member adapted to bias said diaphragm in a direction to open said first and second passage valves when the vacuum forces in said chambers are substantially equal, said diaphragm being adapted to close the latter valves when the vacuum in one of said induction systems exceeds that of the other system.

No references cited.