Dec. 22, 1959 S. H. MICK 2,918,047

SPLIT ENGINE

Filed Aug. 28, 1958 2 Sheets-Sheet 1

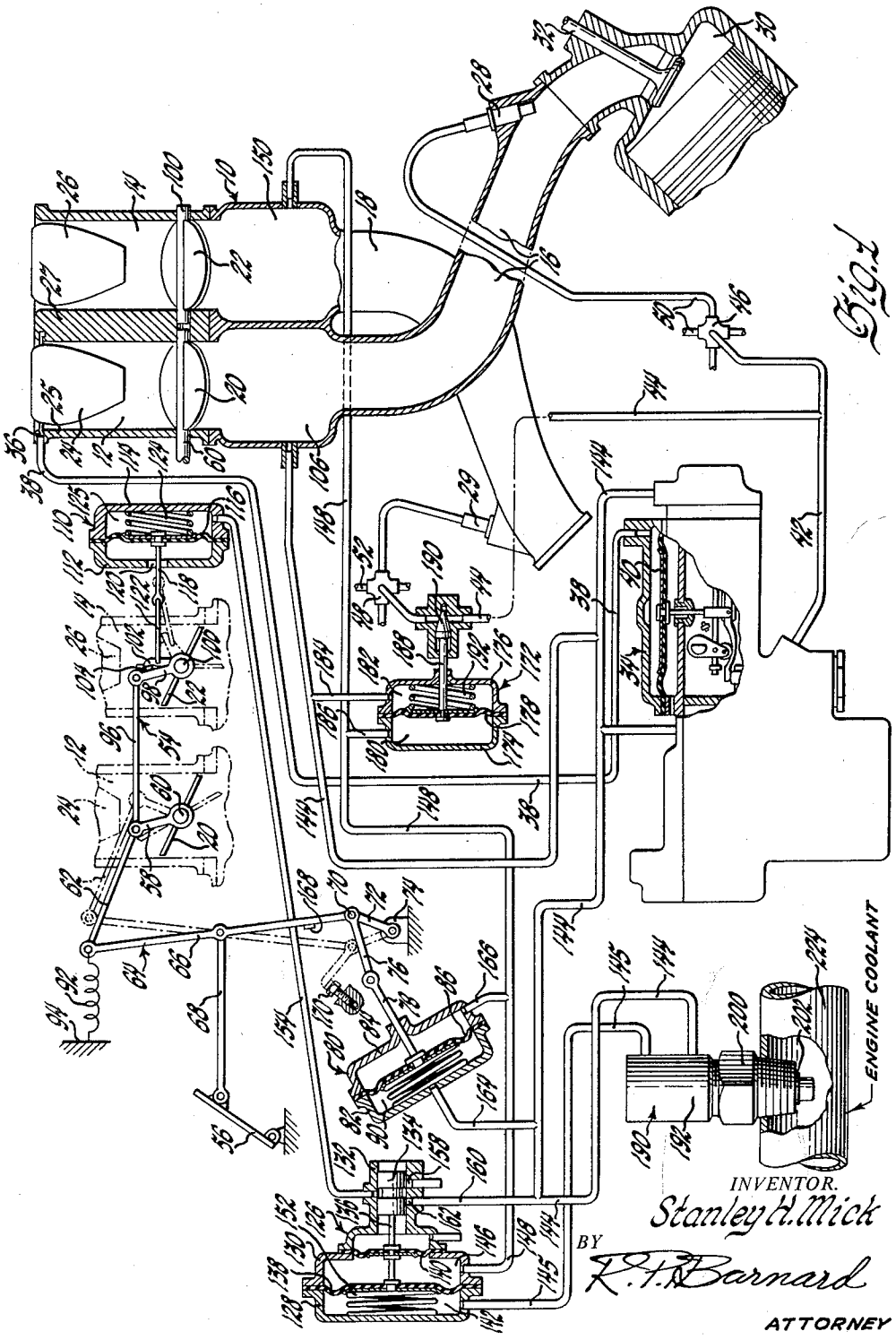


Fig. 1

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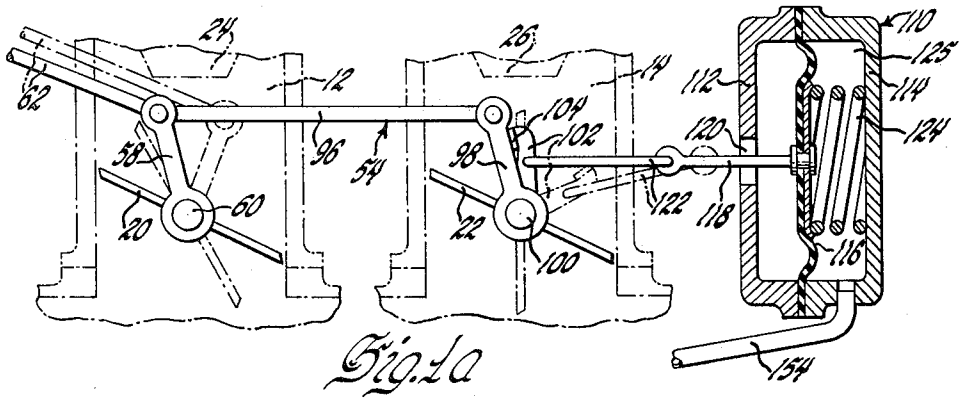


Fig. 2a

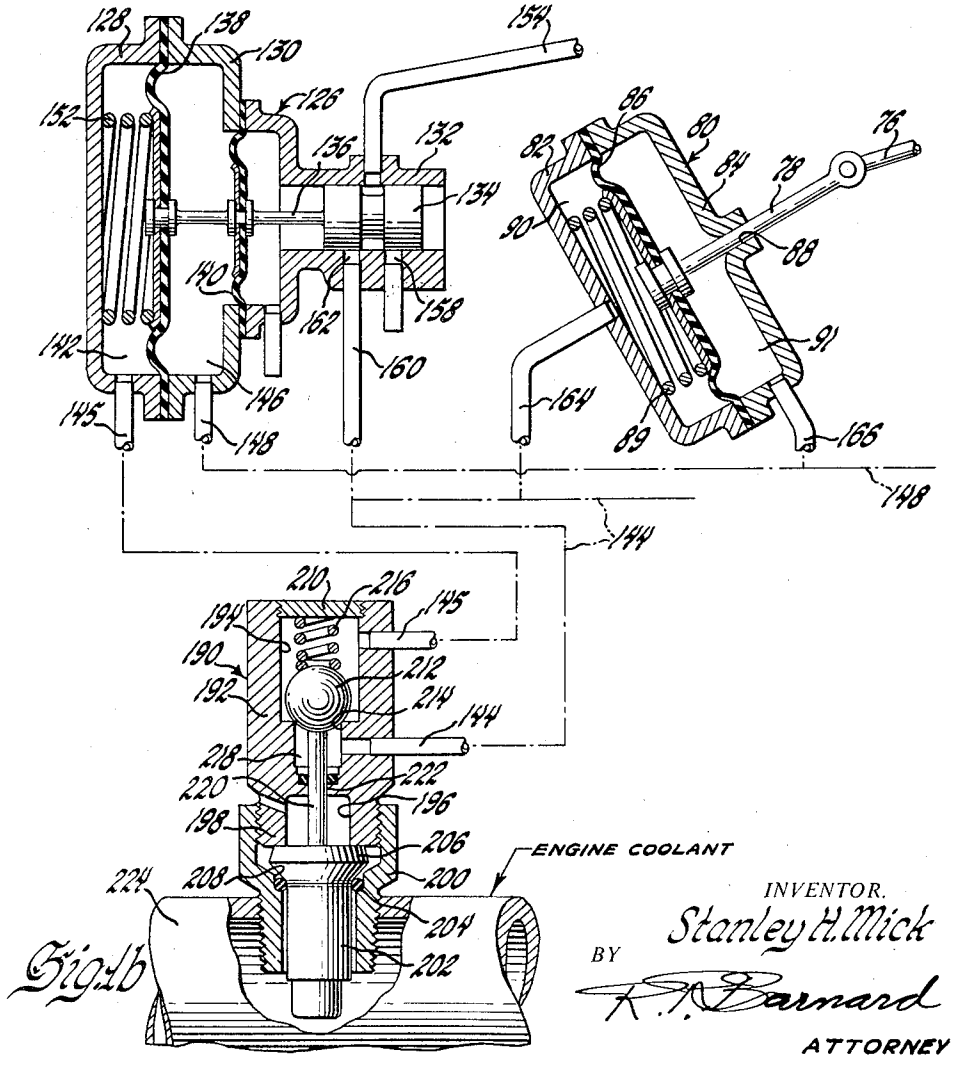


Fig. 2b

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SPLIT ENGINE

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Application August 28, 1958, Serial No. 757,839

8 Claims. (Cl. 123—119)

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 applications Serial No. 608,828, Dolza, filed September 10, 1956 and now Patent No. 2,875,742, granted Mar. 3, 1959 and Serial No. 736,915, Mick, filed May 21, 1958.

As explained in the aforenoted copending applications, 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 by 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 affected, 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 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 constant engine torque.

The present invention is an improvement over Serial No. 736,915, Mick in providing means whereby split engine operation is prevented until the engine has reached a predetermined operating temperature.

During the engine warm-up period immediately following a cold start, the amount of enrichment required by a particular cylinder depends not only on the overall engine temperature but also to a great extent on the temperature of individual parts of the particular cylinder. A cylinder which has been firing will have higher intake port, intake and exhaust valve, and combustion chamber, cylinder, and piston surface temperatures. These higher temperatures of a firing cylinder will allow the cylinder to run on considerably leaner mixtures than a non-firing cylinder.

In the proposed split engine system, a common fuel metering unit is used for both the active and the inactive cylinders. If the fuel metering is altered to meet the requirements of the active cylinders during warm-up, the mixtures will be too lean for the inactive cylinders when they are given fuel after a period of not firing. To avoid the complexity of altering the fuel metering according to each group of cylinders during warm-up, it is proposed that all cylinders be kept firing during initial warm-up.

Accordingly, the subject invention provides an engine temperature responsive valve device which prevents manifold vacuum from effectuating split engine operation until engine temperature reaches a predetermined value.

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

In the drawings:

Figure 1 is a diagrammatic representation of a fuel system embodying the subject invention; and

Figures 1*a* and 1*b* are enlargements of a portion of Figure 1.

Referring to the drawings, 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 passages 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. The fuel metering system functions in the same manner as described in the aforenoted copending application 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 the square of 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 the square of 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 72 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, until foot 168 on member 72 engages member 66 after which members 66 and 72 rotate as a unit about point 74. 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 cylinders being inactivated.

As already noted, in order to prevent pumping losses in the inactive engine cylinders 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 passages 144 and 145 with the active manifold 106 whereby active manifold vacuum is adapted 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 whereby the inactive manifold vacuum is at all times transmitted to the chamber. 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.

In order to prevent split engine operation until such time as the engine reaches a predetermined temperature for the reasons set forth above, a valve device 190 is provided intermediate passages 144 and 145. Valve device 190 includes an open ended casing 192 having counterbored chamber portions 194 and 196. Casing 192 has a reduced threaded end 198 upon which an internally threaded casing 200 is adapted to be mounted to clampingly retain a temperature responsive capsule 202. An O-ring seal 204 is disposed between a capsule flange 206 and a counterbored portion 208 of casing 200.

End portion 194 of casing 192 is enclosed by a cap 210. A ball valve member 212 is normally biased against valve seat 214 by a spring 216 the other end of which seats against cap 210.

A reduced counterbore chamber 218 is formed in casing 192 and is adapted to communicate with counterbore chamber 194 through valve 212. Chamber 218 is constantly communicated with active manifold vacuum through conduit 144. Chamber 194 communicates with chamber 142 of shaft valve servo 126.

Capsule 202 includes a rod 220 adapted to extend through an axial opening 222 in casing 192 to engage with ball valve 212. Capsule 202 may be of any well known type such that the capsule or a part thereof will expand with increases in temperature. In the present instance valve device may be mounted on the engine cooling system so that capsule 202 is directly exposed to the engine coolant in conduit 224.

When the engine temperature is below a predetermined value, spring 216 will maintain ball valve 212 seated preventing active manifold vacuum from reaching servo 126 and thereby maintaining full engine operation. After the engine has warmed sufficiently, expansion of capsule 202 will cause rod 220 to unseat valve 212 to communicate passages 144 and 145. Other conditions being appropriate, the system is now conditioned for split engine operation.

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 valve 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 vacuum 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, affected 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 vacuum 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.

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, first 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, second means responsive to said predetermined vacuum differential for moving the other throttle to a more open position when said one throttle is fully opened, third 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 an engine temperature responsive device for rendering said first, second and third means non-responsive to said engine vacuum differential until said temperature reaches a predetermined value.

2. A charge forming device as set forth in claim 1 in which the means for fully opening said one throttle comprises a first servo device connected to said one throttle, said servo including spring means normally biasing said one throttle in a closing direction, and a second servo device, said second servo device including a valve responsive to the predetermined vacuum differential between said induction systems, spring means normally biasing said valve to a position venting said first servo whereby the first servo spring means moves said one throttle in a closing direction, said second servo being adapted to shift said valve to a position admitting manifold vacuum to said first servo to fully open said one throttle when the manifold vacuum differential exceeds said predetermined value.

3. A charge forming device as set forth in claim 1 in which the means for fully opening said one throttle comprises a first servo device connected to said one throttle, said servo including spring means normally biasing said one throttle in a closing direction, and a second servo device, said second servo device including a valve responsive to the predetermined vacuum differential between said induction systems, spring means normally biasing said valve to a position venting said first servo whereby the first servo spring means moves said one throttle in a closing direction, said second servo being adapted to shift said valve to a position admitting manifold vacuum to said first servo to fully open said one throttle when the manifold vacuum differential exceeds said predetermined value and further in which the engine temperature responsive devices includes a valve in series with the second servo to prevent manifold from acting on the servo until the engine warms sufficiently.

4. A charge forming device as set forth in claim 1 in which said throttle synchronizing means comprises a pair of levers respectively operatively connected to said first and second throttle valves, a rod interconnecting said levers, a double articulated lever means operatively connected to said pair of levers, one end of said double articulated lever mounted upon a fixed pivot, and an accelerator pedal pivotally connected to the double articulated lever for actuating said throttles.

5. A charge forming device as set forth in claim 4 in which the double articulated lever means comprises first and second lever members, a pivotal connection between said members, said accelerator pedal being pivotally connected to one of said lever members remote from said pivotal connection.

6. A charge forming device as set forth in claim 5 in which the second means responsive to said predetermined vacuum differential for moving the other throttle to a more open position is connected to said double articulated lever means for rotating the pivotal connection of the lever members about said fixed pivot.

7. 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 cylinders of the engine, first and second throttle valve means for respectively controlling the flow of air through said first and second systems, first and second levers respectively fixed for rotating with said first and second throttle valve means, a third lever mounted on said second throttle means for rotation relative thereto, a link interconnecting said first and third levers, an accelerator pedal, accelerator pedal control means for actuating said link, spring means biasing said second and third levers into operative engagement whereby movement of the accelerator pedal will cause synchronized operation of said throttle valve means, engine load responsive means for fully opening the second throttle valve means irrespective of the position of the first throttle valve means, and an engine temperature responsive device for rendering the engine load responsive means inoperative until said temperature reaches a predetermined value.

8. A charge forming device for an internal combustion engine comprising a first air intake passage, a first manifold communicating with said intake passage and a first group of individual cylinder mixture passages leading from said manifold to certain of the cylinders of the engine, a second air induction passage, a second manifold communicating with said second induction passage, a second group of individual cylinder mixture passages communicating with said second manifold and leading to the remainder of the engine cylinders, venturi means in each of said air intake passages, throttle valves for respectively controlling the flow of air through said intake passages, a fuel nozzle disposed in each of said individual cylinder mixture passages, fuel metering means for supplying fuel to said nozzles in accordance with the mass of air flow through the venturi means of said first intake passages, linkage means interconnecting said throttle valves and adapted to synchronize operation of said valves, accelerator pedal control means adapted to actuate said linkage means, a lost motion connection between said linkage means and the throttle controlling the second air intake passage, means responsive to the vacuum differential between said manifolds and adapted when said differential exceeds a predetermined value for fully opening said second air intake passage throttle, a servo mechanism responsive to said predetermined vacuum differential to move the first air intake passage throttle valve toward a more open position, another servo operable in response to said vacuum differential to cut off the flow of fuel to those nozzles associated with the second group of individual cylinder mixture passages, and an engine temperature responsive device for rendering said servos inoperative until said temperature reaches a predetermined value.

No references cited.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,918,047 December 22, 1959

Stanley H. Mick

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 63, for "by" read -- be --; column 2, line 5, for "of flow" read -- of fuel flow --.

Signed and sealed this 13th day of September 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents