

Sept. 15, 1953

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2,652,038

MULTIPLE CYLINDER INTERNAL-COMBUSTION ENGINE

Filed May 29, 1947

6 Sheets-Sheet 1

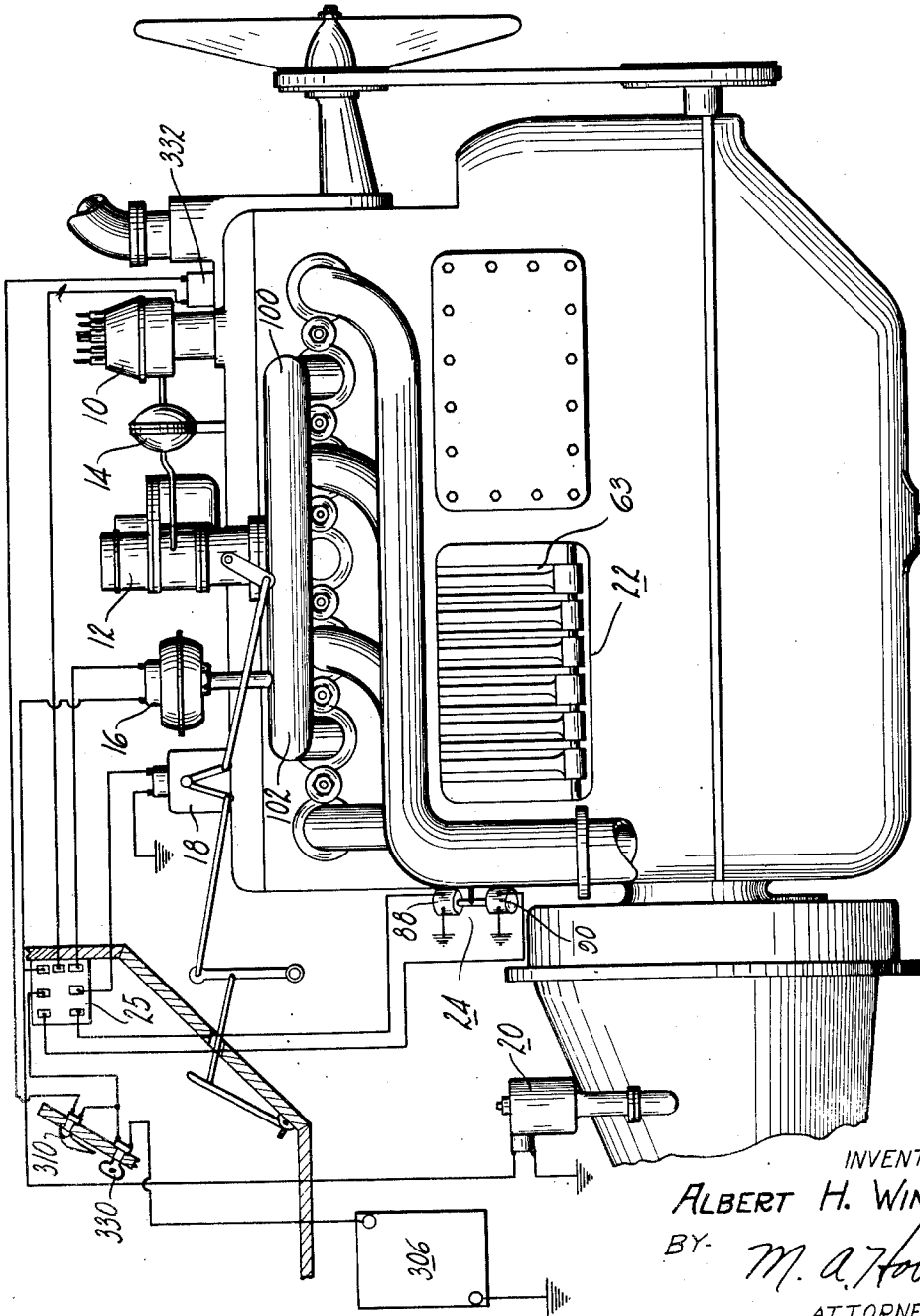


Fig. 1

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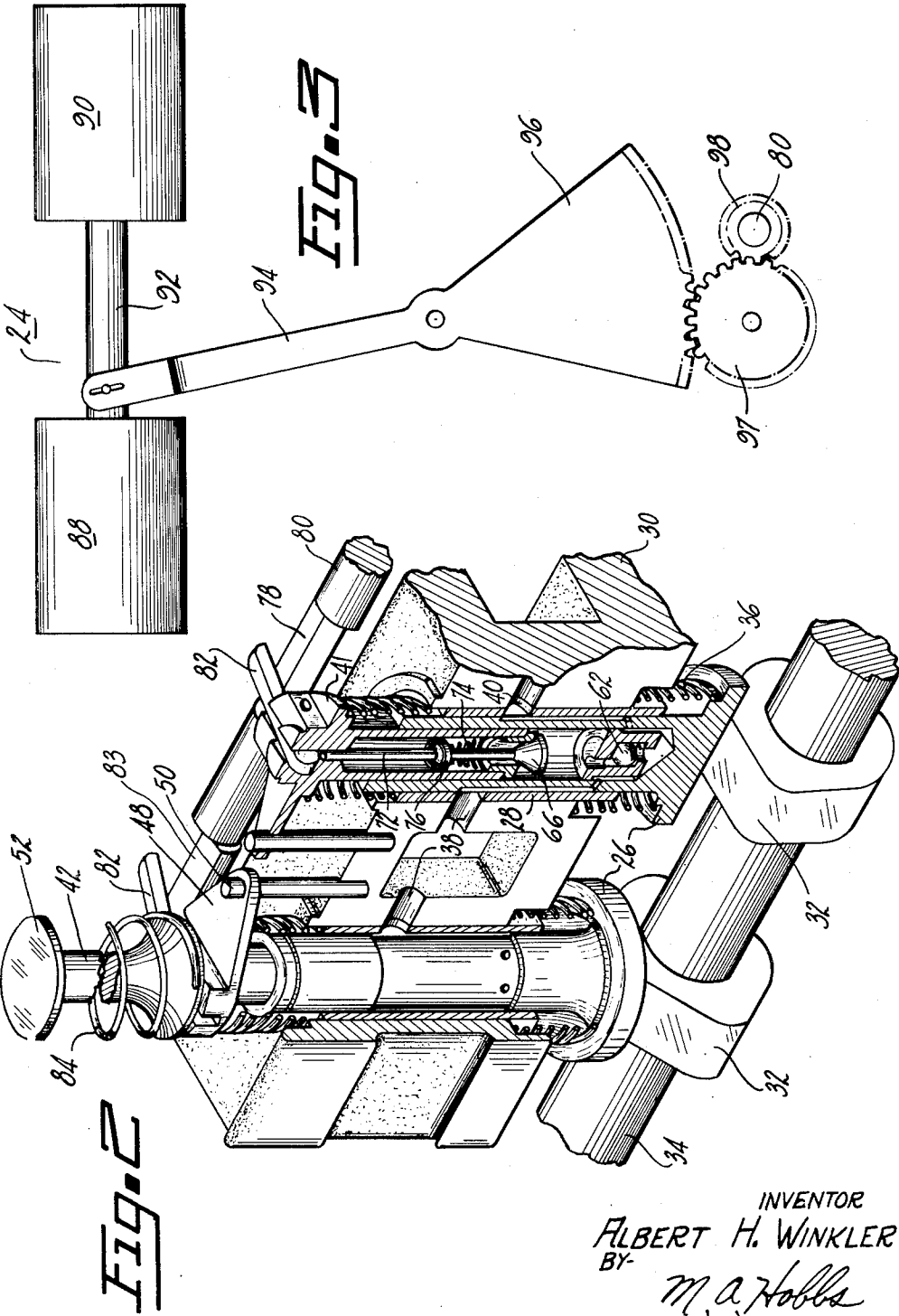
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6 Sheets-Sheet 4

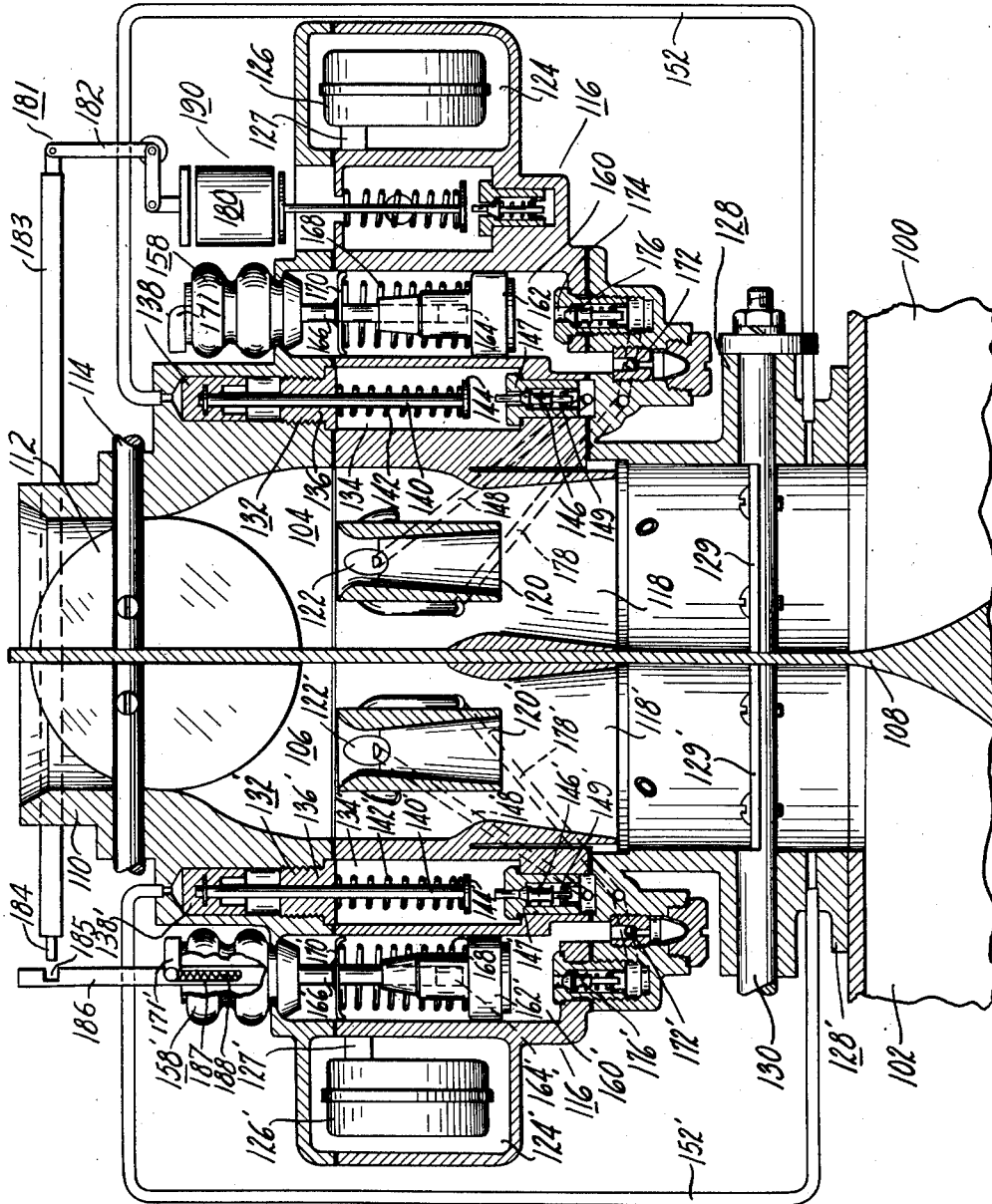


FIG. 4

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6 Sheets-Sheet 5

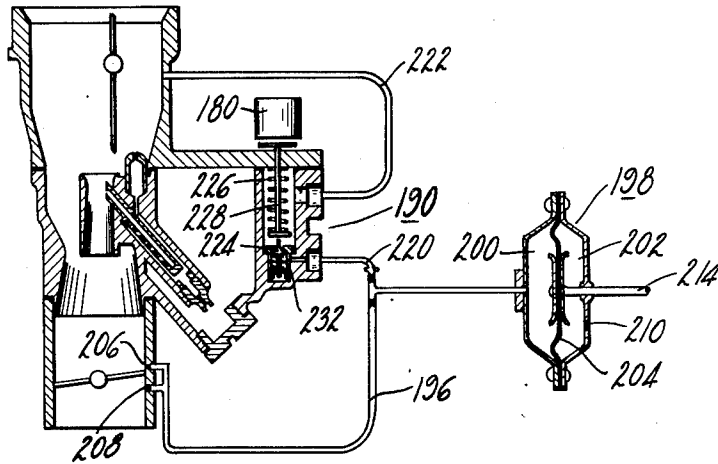


Fig. 9

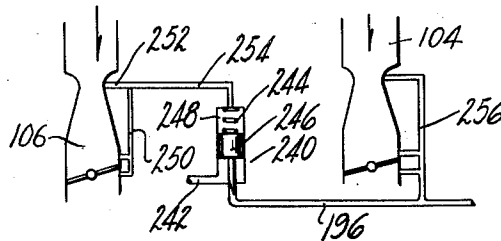


Fig. 10

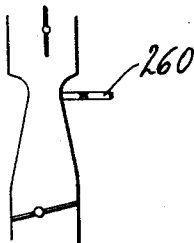


Fig. 11

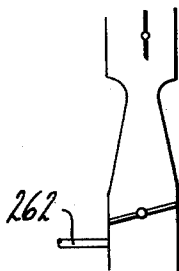


Fig. 12

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6 Sheets-Sheet 6

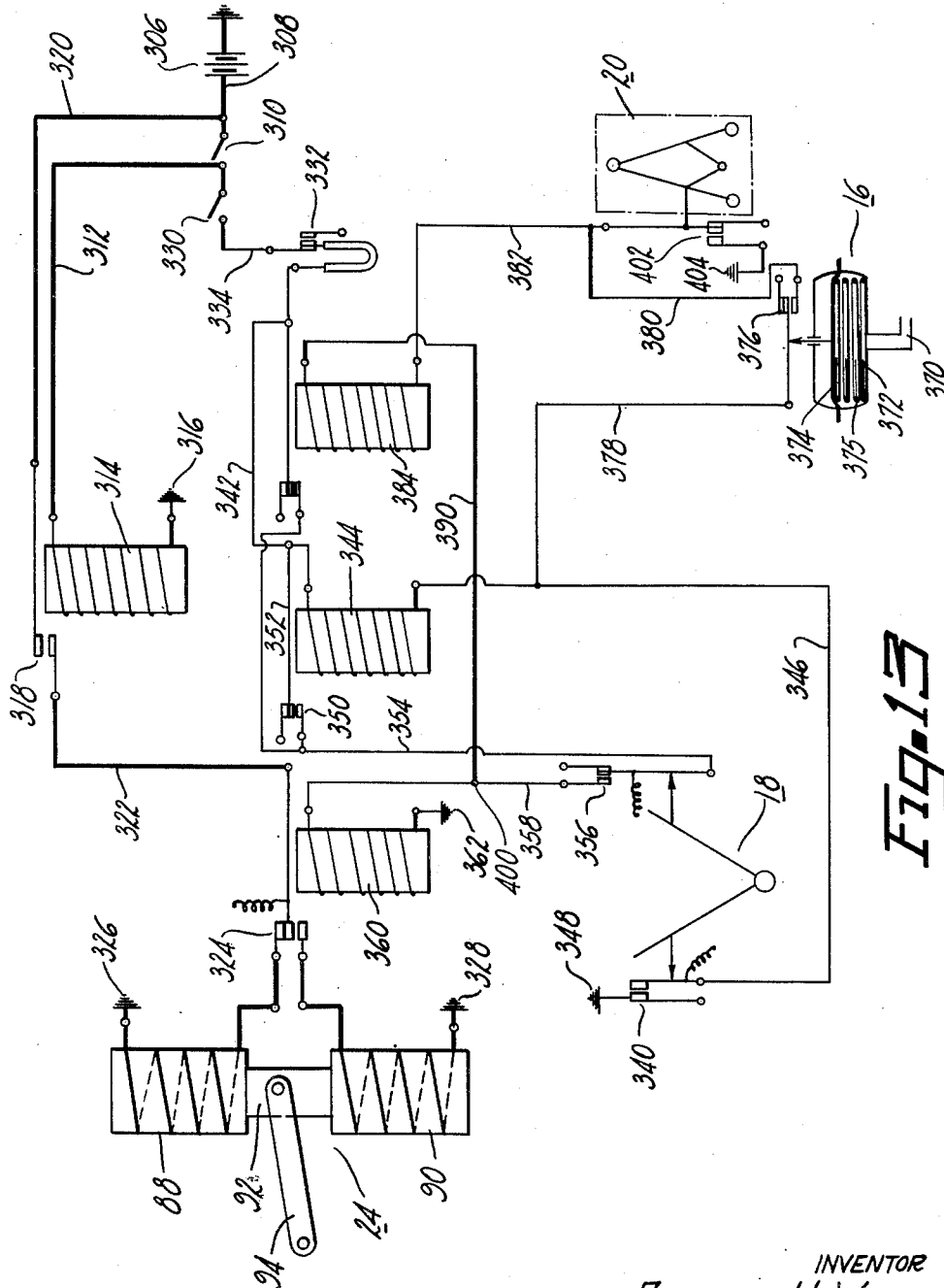


Fig. 13

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UNITED STATES PATENT OFFICE

2,652,038

MULTIPLE CYLINDER INTERNAL-COMBUSTION ENGINE

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Application May 29, 1947, Serial No. 751,282

10 Claims. (Cl. 123—52)

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The present invention relates to internal combustion engines and more particularly to a multiple cylinder internal combustion engine in which less than the full number of cylinders may be used to deliver power during certain stages of engine operation.

One of the principal objects of the present invention is to provide a multiple cylinder internal combustion engine in which the effective number of power cylinders varies in accordance with engine power output requirements.

Another object of the present invention is to provide an internal combustion engine for giving high economy during certain stages of engine operation and for giving high power output in other stages of operation.

Another object is to provide a multiple cylinder internal combustion engine wherein less than the full number of cylinders may be employed during idling and cruising and the full number of cylinders employed for starting, during power pick-up and high power output.

Another object of the invention is to provide an internal combustion engine which gives high economy for low power engine output.

Still another object is to provide in a multiple cylinder internal combustion engine a mechanism for rendering a portion of the cylinders inoperative during certain stages of engine operation and for rendering said cylinders operable for other stages of engine operation.

Still another object of the present invention is to provide a mechanism for rendering a portion of a multiple cylinder internal combustion engine inoperative and simultaneously therewith decreasing the source of available fuel and air mixture for said engine.

A further object is to provide a mechanism for automatically cutting in or cutting out a portion of the cylinders of a multiple cylinder internal combustion engine as the requirements of the engine shift between low and high power operation.

A further object is to provide a mechanism for rendering a portion of the cylinders in a multiple cylinder internal combustion engine inoperative, which may be readily installed in or removed from standard automobile engines.

A still further object of the present invention is to provide in the aforementioned multiple cylinder engines a mechanism for rendering a portion of the cylinders inoperative wherein the power loss through said inoperative cylinders is reduced to the minimum.

Additional objects and advantages will appear

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from the following description and accompanying drawings, wherein one specific embodiment of my invention is disclosed. The engine construction and control mechanism therefor comprising the subject matter of the present invention are not limited to the embodiment disclosed herein nor to any particular type of internal combustion engine, but are understood to be generally adaptable to any of the aforesaid engines having a plurality of cylinders with lift-type intake and exhaust valves. The invention in its broadest aspects contemplates the use of a valve tappet construction and cooperating control mechanism for a portion of the cylinders, which will render the valves for said cylinders and consequently said cylinders inoperative, except during starting, acceleration and high power output. The high economy of engine operation obtained by the present construction results not only from the use of less than the full number of cylinders for low power requirements but also from the complete sealing of the inoperative cylinders by the closing of the intake and exhaust valve to prevent said cylinders from pumping air and thereby placing an undue drag on the operable cylinders. The construction and operation of one means for accomplishing this will be fully described hereinafter.

In the drawings,

Figure 1 is a side elevation of a multiple cylinder internal combustion engine showing schematically the several elements comprising the present invention, the position of said elements being rearranged to more advantageously show the functional relationship thereof;

Figure 2 is an isometric partial cross-section through the valve control mechanism for rendering a portion of the cylinders inoperative;

Figure 3 is an elevation of the actuating means for the valve control mechanism;

Figure 4 is a cross-section through a tappet showing said tappet in operative position when the valve operated thereby is closed;

Figure 5 is a cross-section through a tappet showing the tappet in operative position when the valve operated thereby is opened;

Figure 6 is a cross-section through a tappet showing the tappet in inoperative position;

Figure 7 is a cross-section of a valve tappet similar to Figure 6 showing the tappet in inoperative position when the valve operated thereby would normally be opened;

Figure 8 is a vertical cross-section of a carburetor for use on the aforementioned engines wherein the several component parts are rear-

ranged to more clearly show the full relationships thereof:

Figure 9 is a vertical cross-section of a carburetor showing one embodiment of a spark advance mechanism connected therewith;

Figure 10 is a schematic view of another embodiment of a spark advance mechanism;

Figure 11 is a schematic view of a carburetor showing a spark advance connection;

Figure 12 is a schematic view of a carburetor similar to Figure 11 showing another arrangement of a spark advance connection; and

Figure 13 is a diagram of the electrical control system of the present invention.

The present invention may be readily understood by referring to the accompanying drawings in which Figure 1 shows a multiple cylinder internal combustion engine in combination with the present engine control mechanism wherein numeral 12 designates a conventional spark distributor, 14 a carburetor, 16 a spark advance mechanism, 18 a vacuum actuated switch for the split engine control, 19 a manually actuated switch for said control, 20 a speed responsive switch for said control and 22 a tappet assembly for controlling the operation of a portion of the cylinders, said tappet assembly being actuated by a solenoid mechanism 24 in response to the aforementioned control switches. The several switches are connected by leads to relays in box 25 which in turn control solenoid mechanism 24. With the exception of the mechanism for rendering a portion of the cylinders inoperable and the control system for said mechanism, the present engine is a conventional multiple cylinder internal combustion engine. The one shown in Figure 1 is a standard six cylinder, L head motor with lift-type valves. Of the six cylinders, three are part time operating cylinders. For convenience in description throughout the specification and in the appended claims, the cylinders which remain in operation the entire time that the engine is running will be referred to as the "normal" cylinders and the cylinders which are operable only during starting acceleration and high power output will be referred to as the "power" cylinders. In the engine shown in the drawings, the normal cylinders are the front three and the power cylinders are the rear three, although any other suitable arrangement of the power and the normal cylinders may be used, as for example the cylinders of the two sets may be alternated. The tappets for the valves of the power cylinders are shown schematically at numeral 22. The running of the engine on all six cylinders will be referred to as "standard engine operation" and the running of the engine on only the three front cylinders will be referred to as "split engine operation."

The tappets or valve lifters of assembly 22, which are claimed in a divisional application Serial No. 361,694, filed June 15, 1953, are shown in detail in Figures 2 and 4 to 7, inclusive, in various steps of operation are of the hydraulic type. They consist of a reciprocable sleeve 26 mounted in a bushing 28 of housing 30 and urged against the periphery of cam 32 on shaft 34 by spring 36, said housing being a hollow casting which forms a conduit for supplying fluid to said tappet through orifices 38 and 40 of housing 30 and bushing 28. Sleeve 26 slips over a hollow piston 41 and during split engine operation is adapted to move axially relative to said piston. Piston 41 butts against the lower end of a valve stem 42 and is constantly urged into engagement

therewith by a spring 44 reacting between the lower side of piston head 46 and the top end of bushing 28, said piston being prevented from rotating in sleeve 26 by arm 48 secured to piston head 46 and a guide pin 50 on which said arm is adapted to slide. During normal engine operation, piston 41 moves in unison with sleeve 26 to actuate valve 52 mounted on the upper end of stem 42. The interior of housing 30 communicates with the interior of sleeve 26 through orifices 38 and 40, annular recess 54 in the periphery of said sleeve and one or more ports 55 connecting said recess with chamber 56. This chamber communicates with a second chamber 57 in said sleeve through a fluid passageway having a ball check valve 62 consisting of a small cylindrical chamber having a lower port 58 and an upper port 60 and a freely movable ball 62 adapted to seat over port 58 to prevent backflow of fluid in chamber 57. In standard operation, the volume of chamber 57 will vary as the tappet automatically adjusts its length to that required to properly seat the respective intake or exhaust valve.

The hollow interior of piston 41 forms a conduit for fluid flowing from chamber 57 back to the fluid source, the upper end of said piston communicating with the interior of the tappet chamber 63 (Figure 1) through one or more ports 64. In the lower end of piston 41, a conical valve 66 seats over orifice 68 of insert 70 and under certain operating conditions is adapted to retain the fluid in chamber 57. Valve 66 is supported by a valve stem 72 and is urged to its closed position over orifice 68 by a coil spring 74 reacting between the upper end of orifice insert 70 and the lower side of collar 76, said collar being rigidly secured to the central portion of valve stem 72. During split engine operation, valve 66 is opened by a cam 78 on shaft 80 actuating pivoted lever 82 which engages the upper end of stem 72 and urges said stem and valve 66 downwardly against the force of spring 74, thus opening said valve to permit the fluid to flow from chamber 57. A separate cam is provided for the intake valve and one for the exhaust valve. The tappet controlled by cam 78 actuates an exhaust valve. The cam for controlling the tappet of the intake valve is shown at numeral 83 and is positioned one quarter of a revolution ahead of the cam operating the exhaust valve. With this arrangement, the exhaust valve is rendered inoperable after the intake valve so that the combustion products of the last explosion before the cylinders become inoperative will be expelled. This is important since, as previously mentioned, the valves of the power cylinders are completely closed during split engine operation, and the entrapment of combustion products from an explosion would cause undue drag on the engine during split engine operation. In the change from standard to split engine operation, cam 78, controlling the tappet shown in Figures 4 to 7, follows in sequence of time the one shown partially in broken lines. The tappet shown in these figures, therefore, controls an exhaust valve; however, the construction and operation of the tappet for an intake valve are the same as the construction and operation for an exhaust valve so that the description of the tappet shown in said figures is equally applicable to a tappet for an intake valve. A conventional valve spring 84 which reacts between a portion of the cylinder block and collar 86 of valve stem 42 constantly urges valve 52 toward its closed position.

The tappets in the assembly are directly con-

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trolled by two solenoids 88 and 90, shown clearly in Figure 3, arranged diametrically opposite to one another and connected by a reciprocable rod 92. The central portion of rod 92 is connected by a lever 94 with a sector gear 96 which meshes with gear 97 which in turn meshes with small gear 98 mounted on the end of shifter rod 80. Movement of the rod 92 to the right by solenoid 90 causes shifter rod 80 to rotate clockwise 180 degrees and to cause cam 78 to actuate lever 82 which opens valve 66, thus rendering the cylinders controlled by said tappets inoperative, as will be more fully explained hereinafter.

In the present embodiment of the invention, the intake manifold 100 supplying the normal cylinders is functionally independent from intake manifold 102 supplying the cylinders rendered inoperative during split engine operation. These two intake manifolds are preferably supplied with the fuel-air mixture from two independent carburetors or from a single carburetor having two separate induction passages with a main discharge nozzle, power enrichment jet and accelerating pump for each of said induction passages. A carburetor having two separate induction passages suitable for the present invention is shown in Figure 8 of the drawings. The several conventional elements of the carburetor have been rearranged to more clearly show the functional relationships of said elements to one another. The right and left sides of the carburetor, as shown in the drawing, are substantially the same with the exception that on only the right side is included a spark advance mechanism. The carburetor consists of induction passage 104 leading to the normal cylinders and induction passage 106 leading to the power cylinders, said induction passages being separated by a vertical partition 108 which, as shown in the drawing, extends from the entrance of the air horn 110 to the lower side of the intake manifold. A choke valve 112 mounted on shaft 114 is disposed near the air entrance of air horn 110 and is adapted to be actuated by either an automatic choke mechanism or by the operator through any suitable linkage connected to one end of shaft 114. The choke valve is divided equally into two separate sections by partition 108, though they function in unison during the operation of the engine. Since the elements comprising one-half of the carburetor are substantially the same as those of the other half, the same numerals with primes will be used for designating the elements for the carburetor half supplying the power cylinders as those used for the half supplying the normal cylinders.

In the main carburetor body 116, the induction passage 104 leading to the normal cylinders contains a large venturi 118 formed integrally with the main body and a small venturi 120 axially aligned with said large venturi and held concentrically in the throat of said large venturi by the end of the main discharge jet 122. Said main discharge jet extends from the throat of small venturi 120 into the float chamber 124 and contains a metering jet (not shown) in the lower end thereof. The float chamber 124 shown in part on each side of the schematic view of the carburetor consists of a single chamber in which are disposed a pair of floats 126 and 126' connected to each other by an arm 127 so arranged as to regulate the fuel inlet valve (not shown) in accordance with the quantity of fuel in chamber 124. The main body 116 is mounted on throttle body 128 in which are disposed throttle valves 129

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and 129' mounted on throttle shaft 130. The throttle body is mounted on an intake manifold having two separate branches 100 and 102, the former leading to the normal cylinders and the latter to the power cylinders.

In main body 116 adjacent the float chamber is a vacuum actuated power enrichment means 132 consisting of a cylinder 134 separated into an upper and lower section by insert 136. The upper section of cylinder 134 contains a reciprocable piston 138 secured to the upper end of rod 140 which is adapted to move axially through insert 136. A spring 142 reacting between the lower side of insert 136 and the top side of shoe 144 urges rod 140 downwardly and shoe 144 into engagement with the valve stem of a conical valve 146 controlling the flow of fuel from the float chamber 124 through power enrichment jet 147 and conduit 148 to the main discharge jet 122 posterior to the main fuel metering jet located therein. When shoe 144 engages the stem of valve 146, it urges said valve in the opening direction in opposition to spring 149. The upper end of cylinder 134 is connected by conduit 152 with the induction passage for the normal operating cylinders on the engine side of the throttle valve. Engine suction is thus transmitted through said conduit to the upper end of cylinder 134 and lifts piston 138, rod 140 and shoe 144 in opposition to spring 142, when the vacuum in the intake manifold becomes sufficiently high to overcome the force of said spring. It is thus seen that when the intake manifold vacuum is relatively high as when the throttle valve is closed, piston 138 is held in the upper end of cylinder 134 and shoe 144 is held in its lifted position, as shown in the drawings, disengaged from the stem of valve 146, thus permitting said valve to remain closed so that only the normal supply of fuel is discharged through the main discharge jet. When the vacuum in the induction passage on the engine side of the throttle valve becomes so low that spring 142 can overcome said vacuum above piston 138, as when the throttle valve is moved to wide open position, shoe 144 is moved into engagement with the stem of valve 146 and opens said valve to admit additional fuel into the main discharge jet for high power output of the engine. On certain types of engines it may be desirable to omit the power enrichment jet or it may be necessary for satisfactory operation to rearrange the actuating means so that the jet will be open at times other than at high power output.

The power enrichment means for the power cylinders is the same in construction and operation as the one described in the preceding paragraph, but it is adapted to operate only during the time its respective cylinders are in operation.

A manually actuated accelerating pump 153 is provided for each induction passage and, in reference to the one supplying the normal cylinders, consists of cylinder 160, a piston 162 adapted to reciprocate therein secured to the lower end of sleeve 164, said sleeve being adapted to slide on the end of rod 166 to form a lost motion connection between piston 162 and said rod. The piston and sleeve are urged downwardly relative to rod 166 by a coil spring 168 reacting between the top side of piston 162 and the bottom side of spring retainer 170 rigidly secured against axial movement on said rod. The upper end of cylinder 160 is sealed with a corrugated rubber capsule or the like adapted to permit the free movement of rod 166. The upper end of rod 166 is connected by

a suitable linkage, shown in part at numeral 171, with a throttle valve actuating means. In the operation of the accelerating pump, when the throttle valve is moved to closed position, piston 162 is lifted to the position shown in the drawings and fuel flows from the float chamber through check valve 172 into the lower end of cylinder 160 beneath said piston which is held in this raised position so long as the throttle valve remains in closed position. When the throttle valve moves in the opening direction, rod 166 is moved downwardly, causing spring retainer 170 and spring 163 to urge piston 162 toward the lower end of cylinder 160, thus forcing the fuel in that end of the cylinder to flow through orifice 174 of valve 176 into conduit 178 and thence from the discharge end of said conduit adjacent small venturi 120 into the induction passage 104. The accelerating pump 150 for the power cylinders is rendered inoperative during split engine operation by a solenoid 180 through a suitable linkage that prevents the throttle valve actuating mechanism from moving piston 162'. A linkage 184 for preventing operation of said piston is shown schematically in Figure 8 and consists of a bell crank 182 and a longitudinal movable rod 183 provided with a pin 184 which is adapted to slide into slot 185 of an extension 186 of pump rod 165' when solenoid 180 is energized. The linkage connecting rod 166' with the throttle valve, shown in part at numeral 171', is yieldably connected to said rod by a slot 187 and spring 188 so that said linkage can move with the movement of the throttle valve even though piston 166' is held inoperative by pin 184 in slot 185.

While a double barrel carburetor having a separate discharge nozzle, accelerating pump and power enrichment jet for each induction passage is included in this embodiment of the invention, a single barrel carburetor mounted on a conventional intake manifold may be used, provided the various elements of the carburetor are so modified that the fuel delivered by the carburetor will be properly adjusted as the engine shifts between split and standard operation.

In the present engine, the operating conditions under which the spark is maintained at various advanced positions are the same as those for a conventional internal combustion engine. For standard operation of the engine, an extreme retardation of the timing is required for smooth idling, but on slight opening of the throttle, an appreciable immediate advance of the timing should be made. Following this, a further gradual advance should be made as the speed increases until a predetermined speed and load are attained, after which the effect of the vacuum spark advance is reduced as the manifold vacuum is decreased. In the present engine, the manifold vacuum, for actuating the spark advance mechanism, varies substantially from standard engine to split engine operation for any given engine speed. For example, while the engine is running at a given R. P. M. and load on standard engine, the throttle valve would be more nearly closed than when the engine is running at the same R. P. M. and load on split engine. Thus, the manifold vacuum would be lower during split engine operation than during standard engine operation since the position of the throttle determines the degree of manifold vacuum for any given speed. In order to adjust the spark advance mechanism automatically for either standard or split engine operation, an electrically actuated regulator has been provided for modify-

ing the operation of a suction responsive spark advance mechanism.

One embodiment of a regulator for the spark advance mechanism is shown generally at 190 in Figure 8 mounted on the carburetor body adjacent the accelerating pump and is shown schematically in Figure 9 in combination with a carburetor and a suction responsive spark advance actuating mechanism. In the embodiment shown in the latter figure, a conduit 196 connects the induction passage of the normal cylinders with a suction responsive element 198 consisting of two compartments 200 and 202 separated from one another by a fluid impervious flexible diaphragm 204. Conduit 196 communicates with the induction passage through port 206 so disposed in relation to the throttle valve as to be on the engine side thereof on all throttle positions except closed throttle and through port 208 disposed in such a position as to be on the engine side of the throttle valve in all throttle positions. Port 208 is substantially smaller than port 206 and is provided primarily for the purpose of producing a preliminary lowering of pressure in conduit 198 so that the pressure responsive diaphragm 204 will respond immediately to engine suction transmitted through port 206 as the throttle valve is opened. The engine suction transmitted through conduit 196 urges diaphragm 204, in opposition to a spring, not shown, in the direction to advance the spark. The compartment 202 is vented to the atmosphere through port 210.

A rod 214 secured at one end to the center of diaphragm 204 and at the other end to the distributor is adapted to be moved axially by the diaphragm in response to variations in engine suction as transmitted to compartment 200. In split engine operation, the engine suction is transmitted without modification to compartment 200. In order to obtain the desired spark advance for any given speed, an air bleed is provided for decreasing the effect of the manifold vacuum in compartment 200 when all the cylinders are in operation. The bleed consists of a conduit 220 connecting conduit 196 with regulator 190 and a conduit 222 connecting said regulator with the air intake of the carburetor. Preferably, conduits 196 and 220 are provided with removable restrictions so that the effective capacity of said conduits can be accurately adjusted relative to one another. The passageway through the regulator is controlled by a conical valve 224 which is held in open position during standard engine by a coil spring 226 urging stem 228 into engagement with the upper end of said valve, thus permitting air to flow from the induction passage through conduits 222 and 220 into conduit 196. During split engine operation, stem 228 is withdrawn from and held in spaced relation to said valve by a solenoid shown schematically at numeral 180, thus permitting spring 232 to close said valve. This solenoid performs an additional function in the control of the split engine operation which has been discussed hereinbefore.

It is seen that during the operation of the engine when the throttle valve is closed, the port 208 below the throttle valve causes a slight lowering of the pressure in compartment 200 so that the actuating mechanism will be more responsive to further increase in engine suction transmitted through port 206 as the throttle valve is opened. The effect of the suction transmitted through port 208 has no substantial effect on the advancement of the spark. As the throttle valve is opened, the suction immediately effects an ad-

vancement of the spark and maintains the spark in the advanced position until there is a substantial decrease in manifold vacuum which results when the engine is operating under load with the throttle valve open. When the power cylinders are inoperable, the solenoid holds stem 228 in its lifted position and the bleed 220 is closed by valve 224 so that the desired effect on the spark is obtained during split engine operation.

Another modification of the spark advance regulator is shown schematically in Figure 10. In this embodiment, the air bleed for conduit 196 is controlled by the pressure in the induction passage for the power engine cylinders and includes a pressure responsive valve 240 for controlling the flow of air through bleed 242. The valve is urged to its closed position by a spring 244 reacting between the upper end of piston 246 and the upper end of cylinder 248 and is urged toward open position by engine and venturi suction transmitted through conduits 250, 252 and 254 to the upper end of cylinder 248. While the power cylinders are in operation, piston 246 is held in the upper end of cylinder 248 and the valve carried by said piston is held in open position so that air may flow through the conduit 242 into conduit 196. In this modification, a conduit 256 connects conduit 196 with the throat of the venturi for the normal cylinders so that the spark is advanced with increasing air flow even though the manifold vacuum is low. During high manifold vacuum operation and relatively low air flow the manifold vacuum acting through the holes adjacent the throttle valve produces the required spark advance. In split engine operation, there is no air flow through nor engine suction in the induction passage 106 since the valves of the power cylinders are completely closed. Thus, valve 240 remains in its lower position completely closing the air bleed so that the full effect of the suction created in induction passage 104 of the normal cylinders is transmitted without modification to chamber 200. When the power cylinders cut-in for standard engine operation, the suction created in induction passage 106 lifts piston 246 and valve 240 to open the air bleed and thus cause a partial decrease in the vacuum transmitted from induction passage 104 to chamber 200.

In Figure 11, the spark advance mechanism is actuated solely by the suction at the throat of the venturi in induction passage 104 as transmitted through conduit 260 to chamber 200. A regulator similar to the one shown at 190 may be provided to adjust the suction for either split engine or standard engine operation. It is seen that the spark would be advanced substantially in accordance with engine speed. In Figure 12, the spark advance mechanism is actuated entirely by intake manifold vacuum transmitted through conduit 262 to compartment 200. This modification also includes a regulator such as that shown at 190 for adjusting the suction for either split or standard engine operation.

Figure 13 shows a circuit plan of an arrangement particularly adapted for shifting the operation between split and standard engine throughout the operating range of the engine. The main circuit for energizing the two solenoids 88 and 90 of tappet control mechanism 22 includes a grounded storage battery 306 from which the current flows from lead 308 to ignition switch 310, thence through lead 312 to the winding of relay 314 to ground 316. Completion of this

circuit by closing the ignition switch in the conventional manner energizes relay 314 which closes switch 318 and completes a second circuit consisting of battery 306, lead 320, switch 318, lead 322, double bolted switch 324, either solenoid 88 or 90, and the respective grounds therefor 326 and 328. The particular solenoid energized depends upon the energization of one or more of the cooperating control circuits to be presently described.

In the control circuit for the main solenoid actuating circuit, there are six separate control elements which cooperate with one or more of the remaining control elements to shift the engine between standard and split engine operation. The mechanism for shifting the operation between standard and split engine may be manually controlled by the operation of switch 330 which when open renders the remaining control elements inoperative and prevents the solenoid from shifting to split engine or if on split engine, causes said mechanism to shift to standard engine.

In order to prevent the engine from shifting to split operation before the motor has reached normal operating temperatures, a thermostatically controlled switch 332 is placed in lead 334 through which the current flows to the remaining control elements. As the engine becomes warm, switch 332 closes and remains closed as long as the temperature of the engine remains above a predetermined point. The thermostatically controlled switch is preferably located on the cylinder head or in a conduit carrying water from the jacket around the combustion chambers. It is seen that this thermostatically controlled switch will prevent the engine from shifting to split engine operation while the engine is cold and thus prevents undue strain from being placed on the standard cylinders.

While the engine is idling, i. e. when the throttle valve is in closed or substantially closed position, it is preferable to operate on split engine unless the engine is cold as explained in the preceding paragraph. A switch 340 is actuated by the closing movement of the throttle valve to close the circuit consisting of battery 306, switches 310 and 330, lead 334, switch 332, lead 342, relay 344, lead 346 and ground 348. When this circuit is closed, relay 344 becomes energized and closes switch 350 so that the current flows through leads 352 and 354, switch 356, lead 358 and relay 360 to ground 362, energizes relay 360 and completes the main circuit to solenoid 90, thus shifting the engine to split operation. While the throttle valve is closed or nearly closed, the intake manifold vacuum is relatively high. This lower pressure is transmitted through conduit 370 to chamber 372 of unit 16 and moves diaphragm 374 downwardly in opposition to spring 375, closing switch 376. The closing movement of switch 376 by manifold vacuum completes the circuit consisting of battery 306, switches 310 and 330, lead 334, switch 332, lead 342, relay 344, lead 378, switch 376, leads 380 and 382, relay 384, lead 390, relay 360 and ground 362. With the main conduit controlled by switches 340 and 376, it is seen that the split engine phase becomes effective by the closing movement of the throttle valve or by high manifold vacuum, and remains effective as long as the throttle valve is closed or the manifold vacuum remains above a predetermined value.

The operation of the solenoids is also controlled

by engine speed. The speed controlled switch 29 is preferably regulated by a fly-ball governor driven from the drive shaft through the speedometer cable. During operation, when the engine reaches a predetermined speed, switch 29 closes, thus closing the circuit beginning with the connection 400 and consisting of lead 399, relay 384, lead 382, switch 402 and ground 404. This circuit will not energize relay 384, however, unless the circuit controlled by switch 340 or the circuit controlled by switch 376 is first closed since the current for the circuit control by switch 402 flows from the circuit for energizing relay 360. After switch 402 has been closed by the governor while either switch 340 or 376 is closed, relay 384 for maintaining the engine on split operation remains energized until all three switches have been opened or until switch 356 has been opened, the latter switch being opened by overtravel of the throttle valve lever for manually shifting the engine to standard operation. The circuit for energizing relay 360 thereafter remains open and the engine remains on standard operation until the throttle valve is moved to closed position, closing switch 340, or until the manifold vacuum is sufficiently high to close switch 376. When the engine is on split operation with the throttle valve open, though not in the overtravel position, and the manifold vacuum low, the engine remains on split operation as long as the speed remains above a certain predetermined value. When the speed decreases to a point below the predetermined rate, switch 402 is opened and relay 384 is de-energized and the engine shifted to standard operation. The return of the speed to a point above a predetermined rate, however, does not again energize relay 360 unless either switch 340 or 376 has been closed.

While in the present electrical system the closing of either switch 340 or 376 will energize relay 360 and thus shift the engine to split engine operation, it may be desirable to so arrange the system that the vacuum actuated switch 376 cannot alone close the circuit to energize relay 360. One way of accomplishing this is to provide relays at 344, 360, and 384 which have electrical characteristics such that the voltage required to operate two or more in series would be greater than the maximum line potential of the electrical system. By this arrangement, the vacuum actuated switch would be unable to energize the circuit for split engine operation unless either switch 356 or 402 were first closed.

Some of the controls included in the present system are optional and may be omitted without seriously affecting the operation and control of the engine. For example, the circuit controlled by the throttle switch 340 for shifting the engine to split operation could be omitted since the manifold vacuum is usually sufficiently high when the throttle is closed to actuate switch 376 and shift the engine to split operation. Further, omission of the speed controlled switch would not seriously affect the operation of the control system since the degree of manifold pressure in general follows the speed of the engine for any fixed position of the throttle valve. Many more modifications of the control system are possible without causing any substantial overall change in the operation of the present engine.

Operation

In starting the present engine, the operator closes the ignition switch 310 which automatically places a cold engine in position for standard operation, that is, with all six cylinders being oper-

able. After the engine begins to run on its own power, it operates on all six cylinders regardless of speed, manifold vacuum or throttle position until the engine becomes warm enough to close the thermostatically controlled switch 332. While the engine is on standard operation, a fluid such as oil flows from housing 30 through orifices 38 and 40 into chamber 56 and thence through ball check valve 42 into chamber 57 below valve 66, said latter valve being held in closed position during standard operation by spring 74. It is thus seen that the fluid in chamber 57 is prevented from flowing in either direction by the two valves 42 and 66. With the fluid entrapped in chamber 57, sleeve 26 is unable to move relative to piston 41 so that as cam 32 rotates, said sleeve and piston move in unison to operate the inlet or exhaust valve of the engine. Throughout the time valve 66 remains closed, the tappets operate in the conventional manner to open and close the valves for their respective cylinders. This operation is illustrated in Figures 4 and 5 of the drawings.

While the engine is on standard operation, solenoid 160 remains de-energized so that accelerating pump 158 may be actuated by the movement of throttle valve. Thus, all the elements of the carburetor, i. e. elements of the carburetor supplying fuel to the normal cylinders and those supplying fuel to the power cylinders, are in operation and function the same as the elements of any conventional carburetor.

When the engine has reached normal operating temperatures, thermostatically controlled switch 332 closes and renders the remaining control circuits operable. After switch 332 has been closed, closing the throttle valve completes the circuit controlled by switch 340 which energizes solenoid 360 and causes solenoid 90 to shift the engine to split operation. The circuit controlled by manifold vacuum responsive switch 376 is generally completed when the throttle valve is moved to closed or nearly closed position since at this time the manifold vacuum is usually relatively high. As the throttle valve is moved in the opening direction during acceleration, the circuit controlled by switch 340 is broken, but solenoid 90 remains energized unless the manifold vacuum decreases sufficiently to permit switch 376 to open.

As the speed is increased above a predetermined rate, the governor controlled switch 402 closes. The engine, however, will not shift from standard to split operation unless either throttle controlled switch 340 or vacuum controlled switch 376 is first closed. After the circuit controlled by switch 402 has been closed, the circuits controlled by switches 340 and 376 may be broken without causing the engine to shift from split to standard operation. Therefore, the engine remains in split operation so long as any one of these three switches is closed or until the throttle valve is moved to wide open position, thus opening switch 356 controlling the main circuit to relay 360. After the speed decreases to a point below the predetermined rate while the throttle valve is open and the manifold vacuum is relatively low, relay 360 becomes de-energized and causes solenoid 88 to shift the engine to standard operation.

In the change from standard to split operation, solenoid 90 causes rod 80 to rotate clockwise one-half of a revolution, moving cams 78 and 83 from the position shown in Figures 4 and 5 to the position shown in Figures 6 and 7, in the drawings. Cam 78 rotates lever 82, forcing rod 72 downward-

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ly and opening valve 66 to permit the fluid entrapped in chamber 57 to escape through orifice 63 upwardly through the center of piston 41 and thence through ports 64. Thereafter, as sleeve 26 is lifted by cam 32, it moves axially over piston 41 and consequently is unable to open the exhaust valve. It is thus seen that during split engine operation, the movement of the tappet is confined to sleeve 26.

In the change from split to standard engine operation, solenoid 88 rotates rod 80 counter-clockwise for one-half of a revolution, moving cams 78 and 83 from the position shown in Figures 6 and 7 to the position shown in Figures 4 and 5, thus permitting spring 74 to close valve 66 and entrap fluid in chamber 57 to obtain full operation of the tappet.

When the engine shifts to split operation, the main discharge jet 122' and power enrichment valve 146' which are operated in response to air flow and vacuum in the induction passage 106 do not function since the intake and exhaust valves of the power cylinders remain closed during split engine operation and prevent said cylinders from pumping air through the induction passage. When the power cylinders become inoperative, solenoid 180 becomes energized and through a suitable linkage, such as shown at numeral 181 in Figure 8, renders accelerating pump 158' inoperable and simultaneously permits valve 224 of the bleed or the spark advance mechanism to close and thereby to adjust the pressure in said mechanism to split engine operation.

Although only one embodiment of the invention has been illustrated and described, various changes in the form and relative arrangements of the parts may be made to suit requirements.

I claim:

1. In a multiple cylinder internal combustion engine in which a portion of the cylinders are normal cylinders and a portion power cylinders: an intake manifold for said normal cylinders, an intake manifold for said power cylinders, separate carburetor elements for each manifold including a main discharge jet, a power enrichment jet and an accelerating pump, said carburetor elements of the power cylinders adapted to remain inoperative while said cylinders are inoperative, a vacuum spark advance means having a valve controlled air bleed for adjusting the vacuum for actuating said means to either split or standard engine operation, and a means for actuating said valve and regulating the accelerating pump for the power cylinders.

2. The invention defined in claim 1 wherein the said valve is electrically actuated.

3. The invention defined in claim 1 wherein a solenoid is provided for actuating said valve and for simultaneously rendering said accelerating pump for the power cylinders inoperative.

4. The invention defined in claim 1 wherein said valve is actuated by the manifold vacuum of the power cylinders.

5. In a multiple cylinder internal combustion engine in which a portion of the cylinders are normal cylinders and a portion power cylinders: a separate induction passage for each group of said cylinders, a vacuum spark advance means, a conduit connecting said means with the induction passage for said normal cylinders, a valve for bleeding air into said conduit, and a means for opening said valve when both the normal and power cylinders are in operation.

6. In a multiple cylinder internal combustion engine in which a portion of the cylinders are

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normal cylinders and a portion power cylinders: a separate induction passage for each group of said cylinders, a vacuum spark advance means, a conduit connecting said means with the induction passage for said normal cylinders on the engine side of the throttle, a valve for bleeding air into said conduit, and an electrical means for causing said valve to open for standard engine operation and to close for split engine operation.

7. For use in a multiple cylinder internal combustion engine having at least one normal cylinder, at least one power cylinder, a separate induction passage for each group of said cylinders, and a spark advance mechanism: a carburetor comprising a conduit for connecting the induction passage of the normal cylinders with said spark advance mechanism, an air bleed for said conduit, and a means adapted to become effective when said power cylinders become operative to open an air bleed in said conduit and thereby to adjust the vacuum in said conduit to the requirements for standard engine operation.

8. For use in a multiple cylinder internal combustion engine having at least one normal cylinder, at least one power cylinder, a separate induction passage for each group of said cylinders, and a spark advance mechanism: a carburetor including an accelerating pump for each passage, a conduit for connecting the induction passage of the normal cylinder with said spark advance mechanism, and a means adapted to become effective when said power cylinders become inoperative to adjust the vacuum in said conduit to the requirements for split engine operation and to prevent operation of the power cylinder accelerating pump.

9. For use in a multiple cylinder internal combustion engine having at least one normal cylinder, at least one power cylinder, a separate induction passage for each group of said cylinders, and a spark advance mechanism: a carburetor comprising a main discharge jet for each passage, a conduit for connecting the induction passage of the normal cylinder with said spark advance mechanism, an air bleed port for said conduit, a valve for said port, a chamber, a movable wall for said chamber operatively connected to said valve, and a passageway connecting said chamber to the induction passage of said power cylinders for opening said air port valve when the power cylinders are in operation.

10. For use in a multiple cylinder internal combustion engine having at least one normal cylinder, at least one power cylinder, a separate induction passage for each group of said cylinders, and a spark advance mechanism: a carburetor comprising a main discharge jet, a power enrichment jet, an accelerating pump, a throttle and a venturi for each induction passage, a conduit for connecting the induction passage of the normal cylinder adjacent the throttle valve and at the respective venturi with said spark advance mechanism, an air bleed port for said conduit, a valve for said port, a chamber, a movable wall for said chamber operatively connected to said valve, and a passageway connecting said chamber to the induction passage of said power cylinders adjacent the throttle valve and at the respective venturi for opening said air port valve when the power cylinders are in operation.

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