CARBURETOR

Original Filed July 21, 1966 3 Sheets-Sheet 1

Fig. 1.

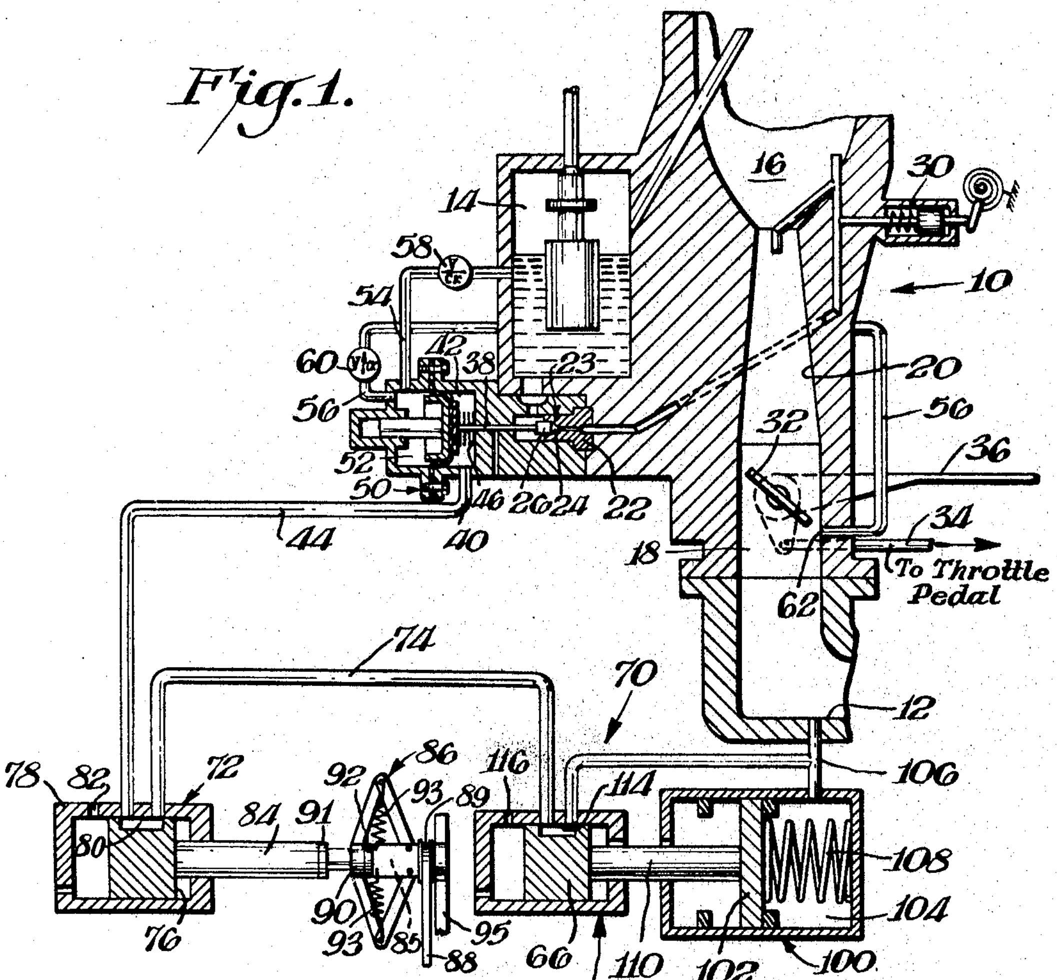
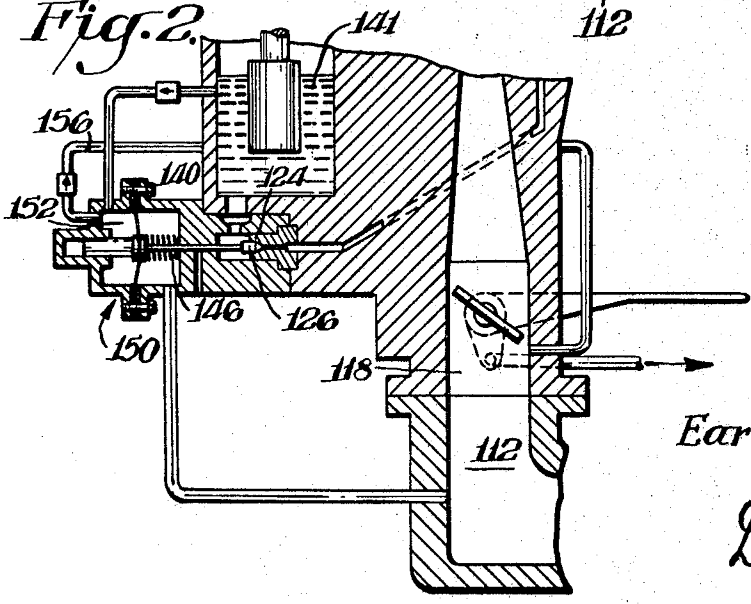


Fig. 2.



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CARBURETOR

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Fig. 4.

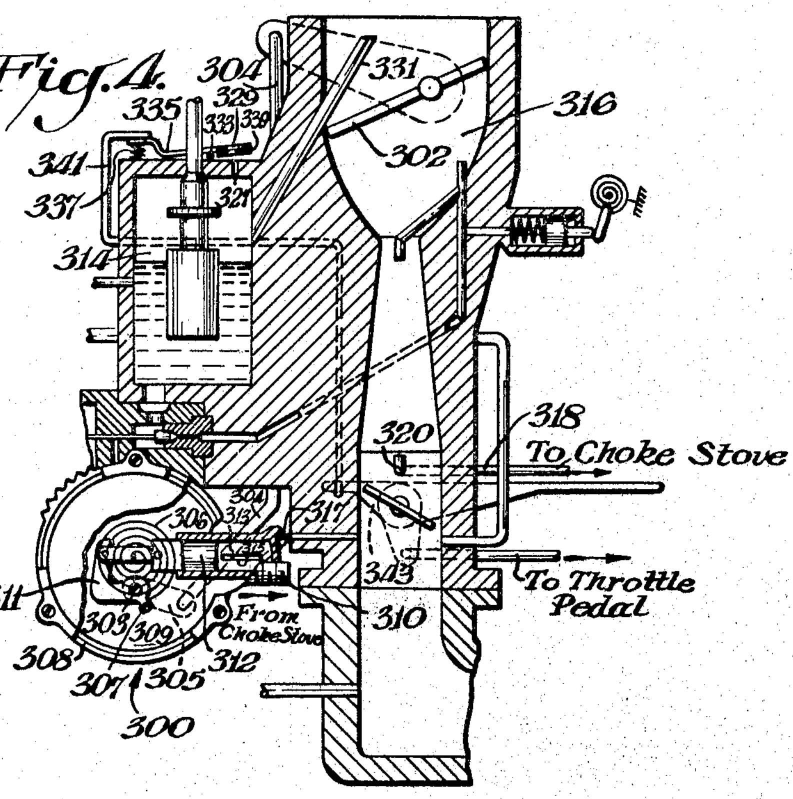

Fig. 3.

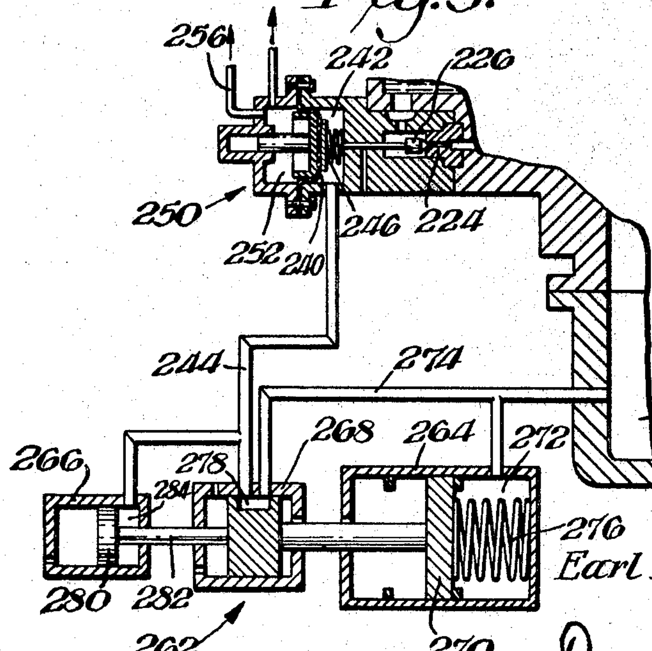

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Fig. 6.

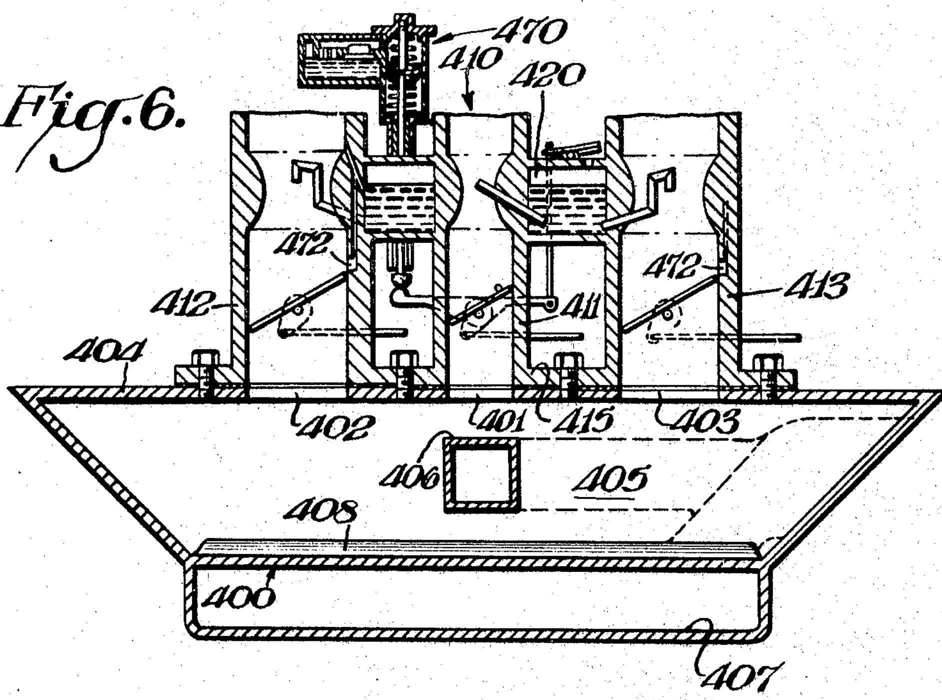
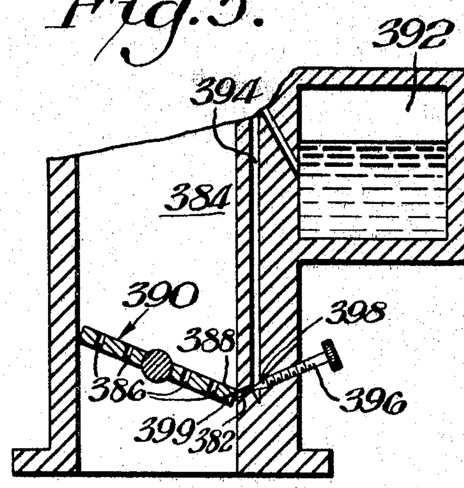


Fig. 5.



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CARBURETOR

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Original application July 21, 1966, Ser. No. 572,635, now Patent No. 3,447,516, dated June 3, 1969. Divided and this application Jan. 29, 1968, Ser. No. 725,243.
Int. Cl. F02m 1/08, 11/06
U.S. Cl. 261—23 3 Claims

ABSTRACT OF THE DISCLOSURE

Gasoline engine induction system for automobile and the like provides less emission of undesirable exhaust products by having (1) fuel cut-off valve connected to cut off fuel flow from carburetor when vehicle is decelerating from speeds of at least about 30 mp.h. and to restore fuel flow when speed reaches about 22 m.p.h.; (2) carburetor without an idle jet so that engine idles on the main jet and fuel mixture is then more closely controlled over entire range of operation. Mixture enrichment is preferably arranged for idle as against off-idle operation, as by having the closing of the throttle open an external vent in the carburetor bowl or having a supplemental fuel jet opening in throttle barrel alongside idle position of downstream tip of throttle blade; (3) automatic choke operated by mixture taken downstream from carburetor venturi, heated, and delivered to thermally responsive choke actuator. Above features can be incorporated in a single small primary carburetor that is combined with one or two large secondary carburetors used for high power operation. Supplemental heating can be provided for mixture delivered by primary carburetor.

This application is a division of application Ser. No. 572,635, filed July 21, 1966 (now U.S. Pat. 3,447,516, granted June 3, 1969. Said parent application is a continuation-in-part of applications Ser. No. 408,135, filed Nov. 2, 1964 (now U.S. Pat. 3,282,261, granted Nov. 1, 1966) and Ser. No. 443,956, filed Mar. 30, 1965 (now U.S. Pat. 3,310,045, granted Mar. 21, 1967), the first of which is in turn a continuation-in-part of applications Ser. No. 301,249, filed Aug. 12, 1963 (now abandoned), and Ser. No. 314,814, filed Oct. 12, 1963 (now U.S. Pat. 3,198,187, granted Aug. 3, 1965), and the second of which is in turn a continuation-in-part of said application Ser. No. 314,814 and of application Ser. No. 445,856, filed Mar. 29, 1965 (now U.S. Pat. 3,250,264, granted May 10, 1966).

The present invention relates to internal combustion engines of the type used to power vehicle such as automobiles. In operation the exhausts of such engines emit undesirable materials such as unburnt and partially burnt hydrocarbons and excessive carbon monoxide.

Among the objects of the present invention is the provision of novel induction systems for such engines, to help reduce their undesirable emissions.

The foregoing as well as other objects of the present invention will be more fully understood from the following description of several of its exemplifications, reference being made to the appended drawings in which:

FIG. 1 is a somewhat diagrammatic sectional view of a portion of an engine induction system pursuant to the present invention;

FIG. 2 is a view similar to FIG. 1 but with additional parts broken away, showing a modified induction system representative of the present invention;

FIG. 3 is a view similar to FIGS. 1 and 2 showing another modified induction system representative of the present invention;

FIG. 4 is also a somewhat diagrammatic sectional view of portions of another induction system typical of the present invention;

FIG. 5 is a diagrammatic sectional view of a portion of an induction system representative of the present invention; and

FIG. 6 is also a somewhat diagrammatic sectional view of portions of another induction system typical of the present invention.

According to the present invention an induction system of an internal combustion engine propelling a vehicle has a fuel cut-off control for interrupting the flow of fuel to the engine when the vehicle decelerates, the control has a first control element shiftable between an actuated and a deactuated position in response to vehicle speed, and a second control element connected to respond to a severe drop in pressure in the intake manifold of the engine by causing fuel cut-off so long as the first control element is then in its actuated position, and the first control element is connected (a) to be shifted to its deactuated position when the vehicle speed is less than about 22 miles per hour, and (b) to be shifted to its actuated position when the vehicle speed is at least about 30 miles per hour.

The fuel cut-off valves of the induction systems of the present invention are also desirably arranged to act as pumps and discharge into the intake manifold a quantity of fuel when cut-off is terminated so as to provide extra fuel and thus help the engine run smoothly as it resumes operation after the cut-off.

Another feature of the present invention is the provision of a fuel cut-off valve operator arranged to move the valve into cut-off position in response to a suction at least about 23 inches of mercury below atmospheric pressure, the operator having sufficient hysteresis to keep the valve in cut-off position as the suction is diminished in intensity until it reaches about 21.5 inches of mercury below atmospheric pressure, and to then open the valve.

To simplify the provision of accurately proportioned fuel-air mixtures for combustion, the induction systems of the present invention preferably has a venturi-containing air supply throat for providing suction to draw gasoline for operating the engine under part-throttle conditions with a relatively lean fuel mixture such as one having an air-to-fuel ratio at least as high as 15:1, said system having an automatic choke assembly including a conduit that draws a gaseous stream through an engine-heated stove to heat the gas and then deliver the gas to a temperature-responsive choke valve bias. For accurate maintenance of the proportioning the gas conduit is preferably connected to withdraw gas from a point in the throat downstream of the venturi, and to ultimately deliver the gas to the intake manifold.

The improvements of the present invention are shown with greater clarity in the drawings. In FIG. 1 a carburetor **10** is illustrated as mounted on an intake manifold **12** and as including a fuel bowl **14**, an air horn **16**, a throat **18**, and a venturi **20** connecting the horn with the throat. The carburetor can have a conventional arrangement for supplying a flow of fuel to mix with the air that passes through the venturi, and in FIG. 1 only a main fuel jet **22** is illustrated. Jet **22** communicates with the lower portion of fuel bowl **14** by way of a cut-off valve **23** having a fixed seat **24** and a movable plug **26**. The jet may also have special provision indicated at **30** for receiving a variable quantity of air, depending upon the ambient temperature, as more fully explained in application Ser. No. 445,856.

In the throat of the carburetor there is a throttle valve **32** shown as operated by means of a linkage **34** extending to a throttle pedal or the like. The throttle valve can also be provided with a delaying or checking mechanism to keep the throttle from closing rapidly through its last few degrees of closing movement, and such checking mechanism can include a checking arm 36 that cooperates with pneumatic, hydraulic or other type of delay structure as shown for example in the various parent applications.

The cut-off valve plug 26 has a shank 38 by which it is connected to the diaphragm 40 of an operating head 50. The head includes a suction chamber 42 connected to a suction line 44 and arranged so that the application of sufficient suction through that line will cause the diaphragm 40 to be pulled to the right as shown in FIG. 1, against the resistance of a return spring 46. Relieving of the suction permits the spring to return the diaphragm to the left-hand position.

Head 50 is also arranged to operate as a pump. To this end a space 52 on the side of the diaphragm opposite suction chamber 42 is sealed and provided with fuel inlet and outlet tubes 54 and 56 which contain appropriate check or one-way valves 58 and 60. Inlet tube 54 communicates with fuel bowl 14 to receive fuel from that bowl, while outlet tube 56 leads to a discharge opening 62 in carburetor throat 18, downstream of throttle valve 32. A complete cycle of fuel cut-off valve operation will accordingly first draw fuel into pump space 52 as the diaphragm moves to the right, and when the diaphragm returns to the left-hand position will cause that fuel to be discharged into the carburetor throat.

The application of suction to suction line 44 is effected by cut-off control 70 which includes a control valve 72 and a suction line 74. Valve 72 is of the sliding spool type, having a spool 76 shiftable in a housing 78, a recess 80 in the spool providing communication between suction lines 74 and 44 when the spool is appropriately positioned, as illustrated. This is the right-hand position of the spool which can also be moved toward the left, thereby breaking the connection between the two suction lines. A vent 82 can also be provided to rapidly vent suction line 44 when the spool is in its left-hand position.

The spool is secured to a rod 84 which has a reduced extension 85 that pivotally receives a centrifugal operator 86 rotatably fitted over the rod and held by a fixed support mount 95. The centrifugal operator is rotated by the vehicle or engine, as by means of belt 68 and pulley 89 formed on the operator, and has a rotatable collar 90 slidable along the reduced portion 85 of spool rod 84 between two collars 91, 92 fixed on that rod. Springs 93 may be provided to urge the rotatable collar 90 toward collar 91.

The cut-off control 70 further includes a vacuum cylinder 100 having a piston 102 and a suction chamber 104 connected to the intake manifold by a suction supply line 106 arranged so that the application of sufficient suction through that line will cause the piston 102 to move to the right against the influence of a coil spring 108, as shown in FIG. 1. The piston 102 has a piston rod 110 connected to a slide valve 66 so that movement of the piston to the right also causes the recessed portion 114 of that valve to connect the suction line 74 to the supply line 106. A vent such as 116 can be provided to rapidly vent the supply line 74 when the recessed slide valve 112 is in its left-hand position.

In use, the induction system of FIG. 1 operates to supply fuel to the carburetor throat when the engine in which it is incorporated is running at any speed, and is not abruptly decelerating. When the vehicle driven by such engine begins rapid deceleration, the intake manifold suction will be sufficiently intense to cause the piston 102 to move to the right compressing coil spring 108. The coil spring may be preloaded so that the piston moves to the right at a manifold vacuum slightly above the highest vacuum developed when there is no deceleration. When the piston 102 shifts to the right, the recessed portion 114 of the slide valve 66 connects the vacuum supply line 106 with the line 74. At speeds of 30 miles per hour or over the governor control 86 moves the spool 76 to its right-hand position so that manifold suction is supplied to the cut-off valve operating head and fuel flow is cut off.

As deceleration proceeds, the intensity of the manifold suction will diminish and the centrifugal operator will gradually move its collar 90 toward fixed collar 91. When deceleration proceeds to about 22 to 25 miles per hour, the centrifugal operator moves the valve spool 76 to the left, breaking the suction connection to the cut-off valve and permitting spring 46 to open the cut-off valve and restore the fuel flow.

The centrifugal action of the control 86 is much more accurate and dependable than intake suction variations in determining when the fuel flow is to be cut off and restored. It is accordingly preferred to have the centrifugal action govern the cut-off valve operation in accordance with engine or automobile speed, as by arranging for the suction head 50 of that valve to close the cut-off valve in response to a degree of suction not quite as intense as will be developed during the desired deceleration. In this way whenever the spool valves 76 and 66 are both moved to their right-hand positions the manifold suction will always be sufficiently intense to effect shut-off. Correspondingly, some dropping off of suction intensity during deceleration will not open the cut-off valve until the spool valve 72 moves to its left-hand position. As indicated above, the apparatus can accordingly be adjusted to prevent fuel cut-off unless the deceleration starts from at least 30 miles an hour, and restoration of fuel flow can be adjusted at 22 to 25 miles per hour. At any time during the deceleration, opening of the throttle, as by depressing the throttle pedal, will cause the manifold vacuum to decrease which then causes the spring 108 to move its piston 102 to its left-hand position, terminating the fuel cut-off so that the engine is immediately available for doing whatever work is called for. Preferably, the centrifugal operator is responsive to automobile speed rather than engine speed to minimize the possibility of fuel cut-off during gear shifting.

Along with the foregoing, every fuel cut-off termination will be accompanied by the pumping of additional fuel into the induction system from pump space 52 through outlet tube 56 and discharge opening 62 so that engine firing commences immediately and does so smoothly whether the resumption of firing is merely for idling the engine or for the beginning of a violent acceleration.

It has been discovered that best operation with exceedingly low levels of undesired exhaust emission is obtained when the fuel flow resumption is at a vehicle speed only slightly below the 30 miles per hour minimum speed at which cut-off is effected. The difference in the two speeds is so small that manifold suction cannot be depended upon to accurately provide the sole control.

The construction of FIG. 1 involves a very small number of components and can be further simplified by having its centrifugal operator 86 combined with the conventional type of centrifugal ignition advancing mechanism operated by the distributor shaft. An extra set of fly-weights on such shaft can be provided for this purpose although it is also possible to use for the cut-off mechanism the same weights that are relied on to advance the timing.

The construction of FIG. 2 is a still further simplified embodiment of fuel cut-off arrangement in accordance with the present invention. In this construction no centrifugal or speed-responsive control is used, and the intake manifold suction directly effects the cut-off and restoration of fuel flow by means of a snap action valve operator 150. Operator 150 is similar to operator 50 of the construction of FIG. 1, but has a snap disc 140 made of spring sheet metal that has been given a permanent deformation to form a bulge with a perforated center. The metal of the disc is thin enough so that some force applied to the outside bulge will cause it to snap into inside-out position forming a reverse bulge. Because of the springiness of the metal the removal of the foregoing force will permit the disc to snap back into its original position. Both snaps take place abruptly and the snapped disc does not show any tendency to remain in any position intermediate between the extremes to which it snaps.

In many respects the fuel cut-off arrangement illustrated in FIG. 2 operates in a manner similar to the arrangement shown in FIG. 1 to supply fuel to carburetor throat **118** when the engine in which this arrangement is utilized is running at any speed and is not abruptly decelerated. Compression spring **146** then functions to keep the cut-off valve plug **126** away from its seat **124** because there is insufficient suction in the manifold **112** to draw the snap disc **140** to its right-hand position where it would cause the cut-off valve to close. When the vehicle driven by the engine in which this arrangement is incorporated begins rapid deceleration, the intake manifold suction will be sufficiently intense to snap the disc **140** to the right and thereby terminate the supply of fuel.

The cut-off valve plug **126** remains in the closed position until the manifold suction diminishes to a predetermined intensity at which the disc **140** snaps back to its original position which in turn unseats the valve plug. Since the force required to hold the snap disc inside out is less than that needed to initially move the disc to that position, it accordingly follows that the cut-off valve plug **126** will remain seated over a range of manifold suctions in a manner similar to the way the speed-responsive device of FIG. 1 keeps the cut-off valve closed over a range of engine speeds. Thus, for example, the snap disc can be so made that it moves the valve to fuel cut-off position when subjected to a suction of at least 23 inches of mercury below atmospheric pressure, and to have sufficient hysteresis to keep the valve closed as the suction is diminished in intensity until it reaches about 21.5 inches of mercury below atmospheric pressure, at which point the disc will snap back and open the valve to thereby terminate fuel cut-off.

Along with every fuel cut-off termination additional fuel is pumped into the induction system from pump space **152** on the side of snap disc **140** opposite the suction chamber through outlet tube **156** in the same manner as described above in conjunction with the cut-off arrangement illustrated in FIG. 1.

Another simplified embodiment of a fuel cut-off arrangement in accordance with the present invention is shown in FIG. 3. As is in the construction of FIG. 2, no centrifugal or speed-responsive device is used to control the operation of the valve, and the intake manifold vacuum effects the cut-off and restoration of fuel flow by means of a control assembly **262** having a pair of vacuum cylinders **264**, **266** with pistons **270**, **280** linked together through a slide valve **268**.

The first vacuum cylinder **264** includes a suction chamber **272** connected to intake manifold **212** by a suction line **274** arranged so that the application of sufficient suction through that line will cause the piston to be pulled to the right as shown in FIG. 3, against the resistance of compression spring **276** in the same manner as explained in conjunction with FIG. 1. Movement of the piston **270** to its right-hand position also causes the recessed portion **278** of the slide valve **268** to connect tube **244** to suction line **274**. Manifold suction is then applied to the flexible diaphragm **240** of the operating head **250** by way of line **244** to thereby cause the valve plug **226** to cut off the fuel flow as explained above in conjunction with FIG. 1.

Vacuum cylinder **266** also includes a suction chamber **284** which communicates with tube **244**. Accordingly when the suction in line **274** is above a predetermined intensity, piston **270** is drawn to the right, slide valve **268** and piston **280** moving along with it so that intake manifold suction is also applied to chamber **284**.

In operation, the second vacuum cylinder **266** serves as a holding or hysteresis device to prevent the piston **270** from shifting back to its left-hand position until the manifold suction diminishes to a predetermined lower intensity corresponding to that at which the fuel flow is to be restored.

By way of example, vacuum chamber **272** may be so dimensioned that a manifold suction of at least 23 inches of mercury below atmospheric pressure is required to create a force on the piston great enough to cause it to compress spring **276**. This suction would then be applied to the diaphragm **240** by way of the slide valve **268** and the line **244** to close the cut-off valve, and it will also bring vacuum cylinder **266** into action. The combination of cylinders **264** and **266** then requires less intense suction to hold valve **268** in its right-hand position. Fuel cut-off termination would not occur until the manifold suction reached, for example, 21½ inches of mercury below atmospheric pressure at which time the spring **276** would urge the piston **270** to the left, thereby causing the slide valve **268** to break the suction connection to the cut-off valve and permitting the spring **246** to open the valve and restore the fuel flow.

As in the construction of FIGS. 1 and 2, along with every fuel cut-off termination additional fuel is pumped into the induction system from pump space **252**. Moreover, as in the construction of FIG. 1, the suction chamber **242** is only exposed to manifold vacuum when fuel cut-off is desired. This is particularly important with the fuel cut-off valve of the continuous travel type which can move back and forth with small pressure fluctuations in the manifold, thus causing small amounts of unwanted fuel to be pumped into the induction system through line **256**.

The induction systems illustrated in FIGS. 1–3 may include an automatic choke assembly of the type illustrated at **300** in FIG. 4 which operates to bias a choke valve **302** toward a closed position during cold engine starting and warm-up. The choke valve **302** is connected through linkage **304** to an arm **305** fixed to one end of a rotatable shaft **303**. The end of shaft **303** opposite the one connected to linkage **304** carries an arm **311** connected to a piston **312** loosely fitted in a pneumatic cylinder **313**, and arm **311** has an extension **307** connected to a free end of bimetallic or similarly thermally-responsive coil spring **306**, the other end of which is fixed and which is calibrated to resiliently urge the choke valve closed when the engine is cold. The coil is enclosed by a suitable housing **308** that defines a compartment **309** having an inlet port **310** connected to the outlet of a choke stove (not shown). The compartment **309** communicates with the cylinder **313** by way of the clearance around its loosely fitted piston **312**, and the cylinder in turn has a longitudinally extending discharge port **315** leading to an intake manifold conduit **317**.

The choke stove, which is conveniently mounted on the exhaust system, has an inlet running to a conduit **318** that opens at **320** inside the carburetor throat in a direction that points upstream. Aside from this location of the choke stove inlet, the entire choke system can be of conventional construction, with the tension of the thermostatic coil **306**, when cold, urging choke valve **302** closed until the engine is started and the air then entering the air horn **316** causes the valve which is unbalanced to open somewhat against the bias of the temperature-responsive thermostatic coil. At the same time intake manifold suction is applied by means of conduit **317** to the choke piston **312** and also tends to pull the choke valve **302** open.

The manifold suction also sucks gas from the compartment **309**, causing some of the fuel-air mixture to be drawn from the carburetor throat through stove inlet **318**. Heating of this mixture as it passes through the choke stove warms up the spring coil **306** so that it relaxes its tension.

As the engine warms up, the choke piston moves farther and farther to the right, as seen in FIG. 4, reducing but not completely cutting off the flow through the choke stove. This assures the maintenance of the spring coil **306** in fully warmed-up condition during further operation of the engine.

By drawing the warm-up medium from the carburetor throat downstream of the venturi, the variations in warm-up flow of this medium with engine operating changes will not change the fuel-to-air proportion in the mixture delivered to the cylinders. All the air in such mixture must necessarily pass through the venturi (except for very slight leakage through throttle valve shaft journals or the like) so that the mixture can be more accurately metered. No excessive richening of the mixture is therefore needed to make up for the variable air leakage through the choke system ordinarily experienced where the choke stove inlet is upstream of the venturi.

The foregoing choke improvement is particularly effective where the carburetor venturi is used to provide idle combustion mixture as well as the combustion mixture for operating the engine at higher speeds and powers, that is "off-idle". It will be noted in this connection that the construction of FIG. 4 has no idle fuel jet such as is conventionally used in engines. As explained in application Ser. No. 443,956, the idle fuel jet can be omitted where the venturi is made small enough to operate effectively with the low air flow rate developed at idle, and this is conveniently accomplished by having the throttle arranged to provide when closed a minimum mixture flow passageway with a cross-sectional area at least about 6 to 10% that of its maximum passageway when wide open. As in that application the throttle plate in the construction of FIG. 4 can be perforated.

Inasmuch as the carburetor of FIG. 4 is, by reason of the absence of the usual idle mixture, readily adjusted to provide accurately proportioned fuel-air mixtures over the entire range of its operation, such adjustment can be made to give stoichiometric mixtures which result in extremely low exhaust emission. Leaner mixtures such as a 17:1 air fuel ratio will produce further reductions in exhaust emission and these leaner mixtures can be used in dual intake manifold systems such as described in application Ser. No. 408,135. Combining the carburetor structure of FIG. 4 with the fuel cut-off features of FIGS. 1–3, and if desired also adding a throttle-closing delay as described in the present applications, gives an extremely efficient induction system and one that has a strikingly low emission of carbon monoxide as well as of unburnt and partially burnt hydrocarbons.

For best operation the fuel-air mixture metered by the carburetor is preferably slightly richer at idle than under load. Such an arrangement enables smoother and more stable idling as compared to having the same mixture ratio for both types of operation.

In the construction of FIG. 4 a very small idle enrichment is provided by a vent **327** that opens to the atmosphere directly from the fuel bowl **314**, when the throttle is in idle position, but is closed by flap **329** under all other throttle positions. When closed the fuel bowl is vented through vent tube **331** to the carburetor air horn **316** where the pressure is slightly below atmospheric during engine operation.

Flip **329** is shown as pivoted at **333** and as having a lever arm **335** biased upwardly by spring **337** to urge the flap toward vent-closing position. A soft gasket **339** below the flap helps assure effective vent closing. A link **341** connected between flap lever **335** and the throttle control is vertically reciprocable and is moved downwardly by a crank arm **343** mounted on the throttle shaft when the throttle moves into idle position, thus causing vent **327** to open. Opening of the throttle releases the link **341** and permits spring **337** to close the flap over the vent.

The extra idle enrichment of the present invention can be provided by other arrangements such as a very small idle port, and can amount to only a small fraction of an air-to-fuel ratio. The idle ratio can accordingly be 14:1 with the operation ratio 15:1. In very warm climates, however, the idle mixture can be leaned down to 14.5:1.

FIG. 5 shows a particularly desirable idle enrichment technique. In this figure a relatively small fuel port **382** is positioned within the throat **384** of a carburetor such as that of FIG. 4. The port opens into the throat alongside the downstream tip **388** of a throttle plate **390** suitably journaled in the induction passage. The plate is perforated as indicated at **386** to permit the passage of idle fuel mixture even though the plate is in fully closed position. During such idle operation a small amount of fuel is sucked into the throat from the fuel bowl **392** through the line **394** and the port **382**. By locating the port opening alongside the downstream tip of the throttle plate below the upper edge of the tip and preferably as illustrated between the upper and lower edges of the tip, fuel flow through the port is cut off quickly whenever the throttle is opened even a small amount. As little as 5° of opening will leave the port effectively exposed to the ambient pressure above the throttle, which is not low enough to suck the fuel up from the fuel bowl.

Such a 5° limit on on the enrichment operation is particularly desirable when operating with lean mixtures, that is mixtures having air-to-fuel ratios at least as high as 15:1. The idle enrichment is then essential to smooth idling so that the idling speed can be set to a relatively low value, generally not over 600 r.p.m., and the engine can then make full use of the fuel economy and low exhaust undesirables of the lean mixtures.

Permitting the enrichment to continue to 10° throttle opening (above idle) would carry the enrichment into a large portion of the engine's low speed operations when used to power an automobile. Most present-day automobile engines are so powerful that in city traffic they need never have their throttle opened more than about 10°.

The need for idle enrichment diminishes as the idle engine speed increases. At 700 r.p.m. idle enrichment is still desirable, but at 800 r.p.m. it can be completely dispensed with.

As pointed out in the parent applications, the use of lean mixtures calls for a carburetor venturi of relatively small cross-sectional area. Thus for 16.5:1 mixtures (before idle enrichment) the venturi (or venturi's where more than one is used) should have a combined cross-sectional area at their minimum point of about 0.1 to 0.2 square inch per hundred total cubic inches displacement.

Although the port **382** of FIG. 5 may simply be a non-adjustable metered orifice in view of the very small amount of fuel it passes, it can be made adjustable by providing for, for example, a threaded screw **396** having a tapered end portion **398** that coacts with the port passageway to adjust its effective size. Additionally, the underside of the throttle plate may be recessed as at **399** to enable the port to be as high as possible and not have it obstructed too much by the throttle plate. A recess of this type is essential where the plate tip, instead of being rectangular, has its edge face tapered so that essentially the entire edge face engages the throat wall.

Vent **327** of the construction of FIG. 4 may also be made adjustable as by having flap **329** bendable to positions in which it partially blocks the vent even when the flap is lifted as far as it will go.

The line **394** is preferably provided with an air bleed so that the fuel supplied through the port **382** is in the form of an emulsion. Alternatively the bleed can be omitted and the port made somewhat smaller in cross-sectional area.

Where the throttle plate is held open during idle, as for instance when the perforations **386** are not present, the enrichment port still preferably opens at a level between the upper and lower edges of the plate tip when the plate is in idle position. However the recessing of the lower face of the plate is then not needed.

In conventional carburetor systems where idle fuel is normally supplied by one or more fuel ports located under the upstream tip of the throttle valve, a small fuel port positioned under the downstream tip of the valve can be provided to improve the operation of the carburetor. The fuel port positioned alongside the downstream tip of the valve provides a portion of the idling fuel which can be cut off abruptly and much more quickly than the fuel from the conventional ports when the throttle valve moves away from idling position. Such an arrangement reduces over-rich conditions at slightly off-idle positions which in turn reduces undesirable exhaust emissions.

The choke and enrichment features of the construction of FIGS. 4 and 5 are particularly valuable when used together and also when used with primary carburetion barrels in a multiple carburetion system. Such an arrangement is shown in FIG. 6 which illustrates an intake manifold **400** for a V–8 engine, the manifold being equipped with a unitary three-barrel carburetor **410** having barrels **411**, **412**, **413**. The combination is shown in sectional view, the section taken transversely of the engine crank shaft direction. The manifold has an upper wall **404** with three openings **401**, **402**, **403** very close together and they are shown as only separated by a sufficient amount to allow for locating securing bolts between them. They can be spaced even closer together by shifting the mounting bolts to other locations and can in fact be spaced apart as little as a half inch if desired, or even less. The space between the barrels is conveniently used to provide room for a common float chamber **420** so that this chamber can be essentially confined within the outer limits of the three barrels themselves. This greatly reduces the space occupied by the carburetor.

Mixture-receiving openings **401**, **402**, **403** are shown as opening downwardly into a transverse distributor section **405**. Each transverse end may be branched to provide four outlets for the respective four cylinder intake ports at each bank of the V–8 engine. The usual heating duct cross-over between opposing exhaust ports in the two banks is shown as having branches **406**, **407**, branch **406** penetrating through distributor section **405** to provide more direct heating for the intake mixture passing through the section particularly from barrel **411**. Branch **407** runs beneath the floor of distributor section **405** to provide further heating of the intake mixture. Heating the fuel mixture in such a manner provides better distribution of the fuel to the engine. Heat-transfer ribs **408** can also be provided on the floor to further improve heat transfer.

Carburetor barrel **411** is the primary barrel on which the engine is operated under low power and cruising conditions, and it is relatively small as compared to the cross-sectional area made available by the intake manifold for carrying the mixture to all cylinders. As pointed out in application Ser. No. 408,135, a primary barrel with a venturi area only about 1/10 that of the total venturi area when all carburetor barrels are in use, operates surprisingly well under part-throttle conditions with a mixture ratio of 16:1, which is leaner than heretofore considered practical. Such operation produced a hydrocarbon emission of only 112 parts per million in a standard V–8 engine that had its intake manifold modified to permit running on a small primary carburetor barrel with a venturi-throat-cross-sectional area of 0.16 square inch per 100 cubic inches of total piston displacement. The manifold was originally of the standard two-barrel carburetor type and was modified by removing its common wall, a partition 1 7/16 inch deep by 1 5/8 inch long known as the riser partition. Thus, the manifold was converted to one in which a common passageway branched to all cylinders. By contrast a standard four-barrel induction system on this engine produced hydrocarbon emission of 240 parts per million when operated with a 16:1 fuel ratio.

Similar results have been obtained on a large V–8 engine that had its intake manifold modified to take three carburetor barrels. The manifold was originally of the standard four-barrel type with four intake openings, two for primary barrels and two for secondary barrels. Each of the primaries was paired with a different secondary, and each pair led through a longitudinal runner and then through lateral branches to half the cylinders of the engine, two in each bank. The half not supplied by one runner was supplied by the other. The modification consisted of milling out a section 1 5/8 inches deep by 1 1/4 inches long in the web between the manifold halves at the primary intake openings. A primary carburetor barrel was mounted over the center of the common chamber formed by this operation and the two secondary carburetor barrels were attached concentrically with the two secondary openings in the manifold. The primary carburetor had a venturi throat which was 15% of the combined cross-sectional area of the three venturi throats and 0.15 square inch per 100 cubic inches of total piston displacement. A vehicle having an engine with this type of induction system has emitted only 160 parts per million hydrocarbons and 0.4% carbon monoxide during a test commonly used to evaluate automobile exhaust emissions, as opposed to 476 parts per million hydrocarbons and 2.7% carbon monoxide emitted by the same car with a standard induction system. The car with the modified induction system has proved to be driveable with mixture ratios of 17 pounds air per pound fuel.

In another embodiment a standard four-barrel manifold with two separate longitudinal runners was modified to take three carburetors in a transverse arrangement. The partition betwen the two runners at the primary openings was milled away to a depth of one inch and separate outwardly directed lateral passageways were added to each longitudinal runner adjacent the intake openings, with a large secondary carburetor fitted on each lateral. The original secondary intake openings were covered and a primary carburetor fitted over the four intake openings. The roof of the heat cross-over for the standard manifold was used as a floor for the lateral passageways to provide a heated surface under each secondary carburetor.

The primary carburetor had a bore 1.1 inches in diameter and a venturi 0.88 inch in diameter, while the two secondary carburetors each had a bore 1 3/4 inches in diameter and a venturi 1 5/8 inches in diameter. The primary venturi area was 0.12 of the combined cross-sectional areas of the two longitudinal runners, and 0.16 square inch per 100 cubic inches of total piston displacement, which piston displacement corresponds to about 70 horsepower of maximum power output. The net venturi area of the primary carburetor was about 11% of the total net venturi area of the three carburetors.

The modified assembly operated very well with primary barrel mixture ratios as rich as 15:1, only began to misfire when the ratio reached about 20:1 or leaner and over this entire range showed very little hydrocarbon emission.

Similar results are obtained when only one secondary barrel having twice the throat and venturi areas of one of the foregoing secondary barrels, is substituted for both of the secondary barrels in that combination. Such substitution is preferred for use with in-line engines such as the more conventional six-cylinder automobile engines inasmuch as it materially simplifies the induction system without detracting from its efficiency. On the other hand for V-type engines and particularly V-8's, it is preferred to have a pair of secondary barrels because they provide better induction and take up less space than a single larger secondary barrel.

The ratio of primary venturi area to total venturi area or to total cross-sectional area of manifold passageway can be as low as 5%, and the primary venturi area can be as low as about 0.1 square inch for every 100 cubic inches of total piston displacement or for every 70 horsepower of maximum engine output, and still give very good operation, particularly with large engines such as used in large trucks and buses.

Increasing the relative size of the primary venturi beyond about 0.2 square inch for every 100 cubic inches of total piston displacement reduces the effectiveness of the operation with lean mixtures. At this proportion the primary venturi area is about ⅛ the combined area of all venturis.

It is preferred that the primary barrel be so small that the air velocity through the most restricted portion of its venturi be about 200 to 300 feet per second when the engine is operating under road load cruise at 1100 r.p.m. Conventional 4-barrel carburetors generally provide an air velocity of only about 60 feet per second in such operation.

Because of the relatively small size of the primary barrel as compared to the intake manifold dimensions, it is helpful to provide additional heating for the mixture supplied by that barrel. In FIG. 6 an extra shelf **406** is provided directly under opening **401**, which shelf is the upper surface of the exhaust crossover **405**. By having this shelf only about ¾ to 1 inch below opening **401**, fuel droplets delivered by barrel **411** will impinge directly on the shelf and volatilize as well as break up, to be carried away by the mixture movement with very little tendency to accumulate as a liquid pool on the floor of the manifold.

Instead of having the intake manifold arranged with its trunk passage or distributor section **405** running transversely of the engine, it could also run longitudinally of the engine as in conventional V–8 manifolds, with branches running to the individual cylinders from the longitudinal ends. With either arrangement it is preferred to have the throtle plates pivot about axes that are longitudinally directed, that is parallel to the crank shaft. Such an orientation gives better distribution of mixtures to the cylinders in both banks of the engine.

The fuel-metering arrangements of primary barrel **411** are essentially like those shown in applications Ser. No. 408,135 and Ser. No. 443,956, but the secondary barrels have auxiliary ports **472** that supply fuel when the secondary throttles are only slightly opened and not enough air is passed to operate their venturis.

The throttle of the primary carburetor barrel is also provided with a throttle-closing delay shown in FIG. 6 in the form of a dash-pot **470** that causes the throttle to close slowly in the event the throttle control is abruptly closed after the throttle-closing movement gets to the point that the air or mixture flow in the barrel reaches about $\frac{4}{10}$ pound per hour per cubic inch displacement. The delayed rate of closure then can be about 5 to 10% per second, as described in Ser. No. 408,135, and the dash pot construction can be the same as there described.

In addition, the throttle check is arranged to hold the minimum air flow rate somewhat above the idle limit for as long as possible, generally up to about 25 seconds after the beginning of a deceleration from about 50 miles per hour for an automobile driven by the engine of FIG. 6. The extra air of the mixture flow provided by the last few seconds of checking can be such that about 20 to 60% more flows through the barrel than the minimum for idling at no road load with 6° ignition advance before top center. After the throttle checking is completely terminated the throttle returns to the usual idle setting with the engine running at about 600 r.p.m. or somewhat less, and the ignition timing about 6° before top center.

The constructions of FIGS. 1, 2, 3 and 6 are particularly effective when used with automobiles having all mechanical transmissions, that is the type called "manual." Such all-mechanical transmissions rigidly connect the engine to the automobile's wheel and such connections give the greatest concentration of undesired exhaust emissions during deceleration of the automobile. Automobiles that have fluid-coupled transmissions such as those called "automatic," permit the engine to slow down much more abruptly than the vehicle does during deceleration and for this reason give much lower concentrations of undesirable exhaust emission during deceleration.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed:

1. In an internal combustion engine carburetor having a venturi-containing throat and an automatic choke responsive to engine-heated intake, the improvement according to which means are provided to withdraw the gaseous stream supplied to said automatic choke from downstream of said venture whereby the venturi is connected to receive the entire intake of the carburetor, and said venturi being constructed and arranged to meter all the fuel supplied by the throat for off-idle operation of the engine, as well as all or almost all of the fuel supplied by the throat for idle operation.

2. The combination of claim **1** in which the venturi is connected to meter all the fuel supplied by the throat.

3. The combination of claim **1** in which there is a throttle plate downstream of the venturi, the plate is tiltable between an idle closed position and a full throttle open position, and fuel supply means is connected to supply all fuel for the throat to the venturi so long as the plate is tilted more than about 5° away from its idle closed position.

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