

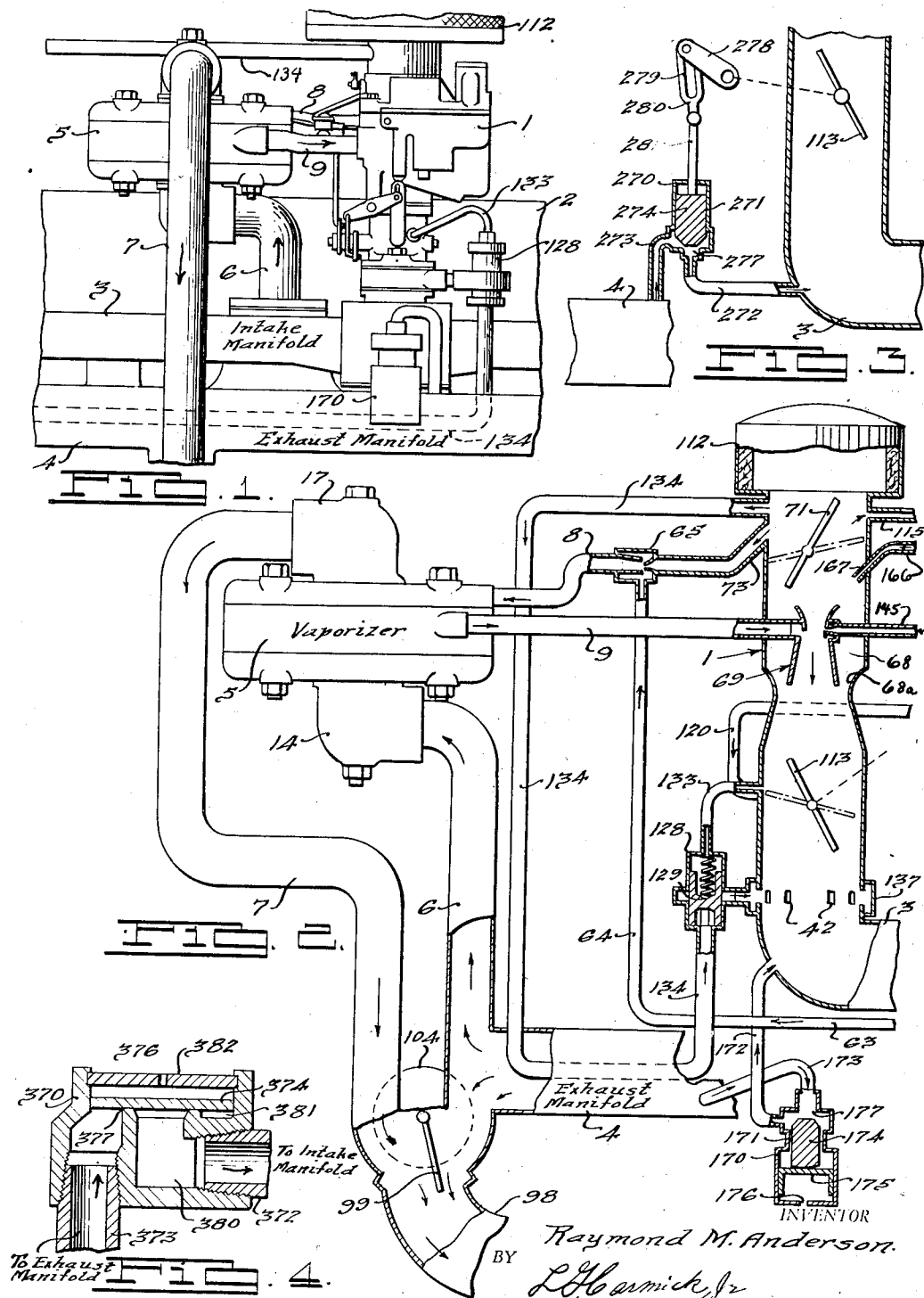
May 15, 1945.

R. M. ANDERSON

2,375,883

INTERNAL-COMBUSTION ENGINE CHARGE FORMING APPARATUS

Original Filed June 16, 1939



ATTORNEY

UNITED STATES PATENT OFFICE

2,375,883

INTERNAL COMBUSTION ENGINE CHARGE
FORMING APPARATUS

Raymond M. Anderson, Detroit, Mich., assignor
to Evans Products Company, Detroit, Mich., a
corporation of Delaware

Original application June 16, 1939, Serial No.
279,394, now Patent No. 2,323,639, dated July
6, 1943. Divided and this application November
20, 1942, Serial No. 466,275

14 Claims. (Cl. 123—119)

The present invention relates to internal combustion charge forming apparatus and this application is a division of applicant's copending application Serial No. 279,394, filed June 16, 1939, now Patent Number 2,323,639 for Internal combustion engine charge forming apparatus and relates to such apparatus and particularly to devices combined with an engine to reduce detonation or knocking by admitting an anti-knock fluid such as exhaust gas under certain conditions, such as under heavy loads.

Various other charge forming features and combinations and such anti-knock devices are claimed in this parent application, but the anti-knock apparatus or devices to supply exhaust gas only at full load conditions are claimed therein in combination with a particular engine fuel supplying means, namely, means to supply the intake conduit with a high temperature super rich mixture of oil and a small part of the total air supply, whereas the invention of this divisional application relates to such anti-knock devices per se or in combination with ordinary engines without regard to such special fuel supplying means.

The objects of this invention are to provide improved internal combustion engine charge apparatus, including simple and dependable means to prevent or reduce knocking of the internal combustion engine under heavy load conditions. Other and more specific objects, features and advantages will be apparent from the following specification, the corresponding drawing, and the appended claims.

In the drawing, in which like numerals are used to designate like parts in the several views throughout;

Figure 1 is a general view showing in elevation part of an embodiment of the whole specific charge forming and regulating apparatus of the above identified parent application as it appears installed on or applied to a conventional, present-day, automotive vehicle, gasoline engine, with conduit 39 shown diagrammatically and showing a first form or embodiment of my anti-knock device applied to such an engine;

Figure 2 is a wholly diagrammatic and spread out view of some of the major portions of the whole specific charge forming and regulating apparatus of my above identified parent application and corresponding to Figure 1, this view showing generally or schematically the connections between the several parts but not accurately showing relative positions or the relative vertical levels of the parts and also showing in

more detail the first embodiment of my anti-knock device as applied;

Figure 3 is a partly diagrammatic view showing a modified form or a second embodiment of an installed anti-detonation unit according to my invention; and

Figure 4 is a sectional view of still another modified form or a third embodiment of an anti-detonation unit, according to my invention.

In general, the anti-detonation unit of this invention may be applied to or used in combination with any of various sorts of internal combustion engines for vehicle, marine or stationary use having spark ignition, exhaust and an intake manifold or conduit means with a carburetor or the like to supply any desired fuel in the proper mixture ratios into this intake conduit and more particularly to conventional or present-day types of gasoline engines, such as are now commonly used in trucks and passenger automobiles. In order to completely disclose one particular application of my improved anti-detonation apparatus as specifically disclosed in parent case and to give a better understanding of its use and interrelation and combination with the other parts of an internal combustion engine, I have included herein those portions of the specification and drawing of my above identified parent application, which relate more directly to my anti-knock device, and have briefly summarized the rest of the equipment of the parent application, yet I intend to include by reference herein the balance of this parent application, in order to give the desired and complete understanding of this specific embodiment.

However, as indicated above, it is to be understood that this division application is not intended to be in any wise limited to this particular type of engine or fuel feeding system since it will be generally apparent and will appear from the present application that the improved anti-detonation device of the present invention may be of general utility and used in combination with various conventional sorts of internal combustion engines, as indicated above.

As shown as a whole in Figure 1 and as shown schematically in Figure 20, the improved charge forming and regulating apparatus is applied to a conventional type gasoline engine 2 having an induction intake conduit including the intake manifold 3 and an exhaust conduit including the exhaust manifold 4. The intake conduit includes a carburetor unit 1 which, as illustrated herein, may be of the down draft type. The engine is provided with the usual air cleaner 112 mounted

above the carburetor. A compact, flat, vaporizer-heater unit or heat exchanger 5 is jacketed and heated by exhaust gases conveyed thereto from the exhaust manifold by a pipe 6, the used exhaust gases being carried back to the exhaust conduit by pipe 7. Pipes 6 and 7 may be used to support this vaporizer-heater unit.

The main unheated air-fuel mixture is carried from the carburetor unit 1 to the heater by horizontal pipe connection 8, and the hot super rich mixture is conducted from the heater to the carburetor mixing chamber by the slightly lower horizontal pipe connection 9, which is preferably made of aluminum, aluminum alloys or the like, as discussed hereinafter.

In the present invention, the major part of the engine's air supply is sucked down through the intake conduit (comprising the riser, the mixing chamber, and the intake manifold) in the usual fashion, while a small proportion (preferably about 5% and less than 10%) of the total air supply is drawn through a separate passage, the hot mixture-contacting portions of which are all of aluminum or the like, and which includes connections 8 and 9 and the substantially horizontal, tortuous, mixture-heating passage in the heater 5.

In general, I have provided a suitable Venturi means 65 located near the entrance 8 to this passage, together with suitable light and heavy fuel jets (not shown) to supply either light or heavy fuel from the adjacent two reservoirs of a suitable multi-fuel carburetor 1, thus either of the two fuels is metered and mixed with the air stream in passage 8, and this super rich mixture is heated to a high temperature so that the sprayed fuel is partly gasified, partly vaporized, and the balance finely divided. For the sake of simplicity, this condition is hereinafter referred to as "vaporized."

It is believed impractical to thoroughly gasify all of the oil or to really crack all of the heavy hydrocarbons in an apparatus of this type. Only enough air is used in this rich mixture to effectively carry the fuel and to hold enough heat to effectively vaporize the main fuel supply and to keep it in this condition in the intake manifold. It is important that only a small portion of the total air supply is heated to a predetermined temperature so that the volumetric efficiency of the engine will not be materially reduced. Such a reduction in volumetric efficiency, with its attendant decrease in power and torque, would occur if it were attempted to heat sufficiently all of the engine's air supply to permit the use of low grade fuel, or if even a small proportion of the total air were heated to too high a temperature. Also, too high a temperature, tending to distill or crack the heavy fuel, will produce carbon and gum deposits; while, on the other hand, too low a temperature will cause crankcase dilution from the unvaporized globules of heavy fuel.

It may be noted in connection with the use of heavy fuel, such as oil, in a conventional gasoline type engine, that it has been previously proposed to heat the liquid oil (without any appreciable quantity of air) in a small passage or elsewhere and then to spray it into the intake conduit where it is supposed to be vaporized and mixed in a venturi or the like. Such systems are impractical, if not commercially impossible, since it is not possible to get enough heat into the liquid oil itself so that it will vaporize sufficiently when discharged into the intake mixing

chamber. On the other hand, if sufficient heat is added to this liquid oil so that it is partly gasified or vaporized in its heating passage, then the metering will vary widely with small temperature changes and as alternate charges of liquid and vaporized oil come along the passage.

Any sudden increases in the richness of the fuel mixture from the vaporizer-heater 5, and particularly the collection or trapping of a pool of liquid fuel which is later sucked into the intake conduit at a period of high vacuum (for example, when the throttle is suddenly opened), are highly objectionable since they cause smoking, carbon and gummy deposits, tend to choke the engine, to produce crankcase dilution, and reduce economy. Hence the uniform vaporization and supply of the rich, heated air-fuel mixture and the provision of a proper vaporizer-heater and connections therefor which have no traps or the like, are particularly desirable.

As is well known, the actual temperatures of the exhaust gas in the manifold of ordinary gasoline engines vary within wide limits (about 600 degrees F. to nearly 1450 degrees F.) under different speed and load conditions so that the amount of heat available to the exhaust heater for the super rich air-fuel mixture varies widely. Accordingly, it is important that the quantity of exhaust gas made available to the heater unit be regulated not only in accordance with temperature but in accordance with engine speed-load conditions, which may be represented by exhaust gas flow rate. If the rich heated mixture of air and heavy fuel is not heated to a high enough temperature, there will be excessive and objectionable crankcase dilution due to lack of vaporization of the heavy fuel condensation. Also, too low a temperature is apt to cause smoking. On the other hand, too high a temperature for this mixture will reduce the volumetric efficiency, as noted above. It has been found that a mixture temperature of about 400 degrees F. is best when using oil or similar heavy fuels, although this temperature may be varied from about 375 to 500 degrees F. When using gasoline, even the cheaper, poorer grade with low octane rating, in this super rich heated mixture, good results may be obtained with lower mixture temperatures. For example, a temperature as low as 280 degrees F. can be used, with best results at about 350 degrees F. However, the above mentioned 400 degrees F. temperature will be found satisfactory for either type of fuel.

It has been found that the better distribution obtained because of the predetermined amount of heat added with this rich heated mixture more than offsets the expected slight decrease in volumetric efficiency so that higher torques have been obtained. Also, this better distribution tends to reduce detonation.

Another reason why it is important to regulate the temperature of the mixture in the vaporizer-heater unit 5 is that it is necessary in order to secure proper over-all air-fuel ratios under different load conditions and the corresponding temperatures of the exhaust gas in the exhaust manifold 4. For example, an increase in temperature of the vaporizer-heater will cause an expansion of the air in the mixture passage therein and an even greater expansion of the fuel particles, which will tend to reduce the vacuum in this passage and thus reduce the suction on the main fuel jet (not shown here) so that the mixture will become leaner. The converse

will, of course, occur if the temperature drops suddenly. Thus it will be apparent that changes in temperature will affect the metering adversely and, accordingly, the over-all fuel ratio and the economy.

Referring again to the more specific, complete disclosure in the parent application, it will be apparent that the flow of the exhaust gas from the exhaust manifold 4 to the exhaust pipe 98 may be all or in part diverted through a by-pass circuit consisting of a pipe 6, connection 14 through the jacket surrounding the vaporizer-heater 5, through connection 17 and pipe 7, this diversion being controlled by a suitable thermostatically regulated valve unit comprising the unbalanced valve 99, which is on a shaft which also carries the inertia weight wheel 104 carrying the offset and adjustable weight 103 to bias valve 99 toward its closed or heating position, this weight 103 being secured in any one of several adjusted positions by bolt 106 which may be received in one of several holes (not shown here). The valve 99 is also actuated toward open or closed position by a suitable bi-metallic element, as will be well understood in this art.

Referring further to Figure 1, the carburetor 1 is of the multi-fuel type and in addition to supplying either light or heavy fuel, such as gasoline or oil, to the intake to the vaporizer 5. This carburetor 1 also embodies means to support gasoline for acceleration, for idling, and for the conventional compensating flow. It will be noted that these are always on gasoline and will operate concurrently with the main super rich air fuel mixture from the vaporizer which discharged into the throat of a multiple-Venturi set 68 through pipe 9. These more detailed features will be seen more clearly in the incomplete schematic Figure 2 which also shows the exhaust gas inlet 14 and discharge fitting 17 for the vaporizer 5, the conventional air cleaner 112, the entrance to the intake conduit above the carburetor, the conventional choke 61 and, above the choke, but below the air cleaner, the pipe 134 to supply air to a special form of economizer 128, the pipe 73 to supply air to the venturi, the entrance pipe 8 and the pipe 115 to bleed air to the non-illustrated but conventional gasoline idling system, which as usual supplies the idling gasoline into the manifold adjacent the throttle plate 113 through conduit 120.

Just below the choke and upstream from the multiple Venturi set which includes the parts 68, 69—A and 69, I have shown the conduit means 167 to inject gasoline for acceleration and this conduit 167 is periodically supplied with gasoline by wholly conventional means which are well known in present day carburetors and include a suitably actuated pump supply by gasoline from the reservoir in the two bowl carburetor 1. This metered oil or metered gasoline is supplied through jets from one of the two valves in carburetor units 1 through conduit 63—64 to the Venturi unit 65.

The suitably metered compensating flow of gasoline is led into the Venturi set 69 by conduit means 145.

It will also be noted that Figure 2 shows certain details of the economizer 128, including pipe 133, to supply vacuum to actuate the piston valve 129 which controls the admission of air into the intake manifold through the annular passage 137 and the ports 142. This feature in particular may, of course, be eliminated, if desired, and in general will be understood as emphasized above

that the above described details or specific parts are not to be considered as part of this invention, except insofar as they supply one specific installation.

Referring now to the operation of this particular embodiment, as shown in the parent application, it will be seen that for starting, as disclosed in the parent application, I have provided entirely the conventional carburetor units or parts, including an accelerator pump, the idling system and a compensator metering system and jet to supply the intake manifold or its mixing chamber with these auxiliary flows of gasoline concurrently with a supply of the super rich mixture of a small part of the air with either oil or gasoline as delivered into the mixing chamber venturi 69 by pipe 9. Obviously, these particular details are not essential to the present invention.

In order to reduce detonation or knocking at high load and speed conditions, particularly where operating temperatures are high, a novel anti-detonation unit (of which three forms are hereinafter described) may be employed, which may admit a small amount of exhaust gas into the intake manifold at the time of detonating conditions under the control of the throttle itself or in response to exhaust manifold and intake manifold pressures, which are a measure of the engine load-speed conditions.

One form of anti-detonation unit is shown more or less schematically in Figures 1 and 2 in which the housing 170 has a narrow valve guiding portion 171, the enlarged upper end of which is connected by pipe 172 to the intake throttle, and which also has the pipe or conduit 173 connecting its end to the exhaust conduit on the engine side of the control valve 99. The valve element 174 has a loose or sloppy fit in the guide portion 171 so that gases can readily leak or flow past it to act upon the piston element 175. The lower end of the housing on the other side of the piston is vented at atmosphere at 176. The valve element 174 is quite heavy so that it will be inertia damped to prevent flutter. When the valve is closed it will be up against the valve seat 177 and close off communication from the exhaust connection 173. Generally speaking, this valve unit is either on or off, and it will be apparent that the piston 175 is actuated by and is responsive to the algebraic sum of the exhaust pressure and the intake manifold pressure when the valve 174 is off its seat 177; that is, the exhaust pressure is aided by the weight of the valve in holding it open while the intake manifold vacuum is tending to lift the piston 175 up to close the valve. No springs or the like are used for biasing a valve of this type since it would be difficult, if not impossible, to make a spring which would stand up under the very high temperature and hard service encountered in a unit of this type. It will be apparent that by properly proportioning the weight of the valve, the piston area, and the size of the connections, this valve can be made to open only at full load conditions of the engine; and it will be responsive to the load-speed conditions of the engine since at full load conditions the intake manifold vacuum is quite low and the exhaust pressure is high. In addition, the exhaust pressure will increase with the speed of the engine. Pipe connections 172 and 173 and the valve housing 170 itself will cool the exhaust gas which is carried from the exhaust manifold to the intake manifold to reduce the loss of volumetric efficiency due to the highly expanded

high temperature exhaust gases. If additional cooling is desired, it will be obvious that a suitable heat exchanger or cooler can be added to this unit.

It will be apparent that the heavy valve 174 will normally be held on its seat 177 to shut off any exhaust gas flow by the intake manifold vacuum action on the piston 175 and overcoming the weight of parts 175 and 174.

With a valve unit of the types disclosed herein, it has been found desirable to admit inert gas up to about 10% of the volume of the air-fuel charge for full or nearly full loads only. This will eliminate or greatly reduce the knocking which is more of a problem when the hot engine is running on all or nearly all oil or heavy fuel having a low octane rating.

Figure 3 shows another modification of this anti-detonation unit in which the heavy valve unit 274 is biased to closed position on its seat 277 by its own weight to close off exhaust gases coming from the pipe 273 from going into the pipe 272 communicating with the intake manifold 3. The valve guiding portion 271 of the housing 270 has a loose fit about valve unit 274, and the upper end of this housing 270 has an opening for the valve actuating rod 281 which carries a pivoted member 280 which contains a slot 279 cooperating with a pin 278 which is fixed on or with respect to the throttle 113. This pin-and-slot lost motion connection is so arranged that the valve is lifted from its seat only at or near full load throttle openings so that exhaust gas will be admitted only at these conditions when detonation would be apt to occur.

A preferred form of this anti-detonation unit is shown in Figure 4 in which the valve housing 370, which may be made in the form of a simple casting or otherwise, is tapped for the exhaust manifold pipe or connection 373 and the intake manifold pipe or connection 372. The upper end of the valve housing 370 is closed by plate 382 which may be secured on suitable shoulders by the upper edges of the housing being peened over or the like. This plate is vented to atmosphere at 376, and a slight amount of gas may leak through this vent 376. The plate or disk valve element 374 may be circular and slightly smaller in diameter than the circular housing 370 so that it has a loose or sloppy fit therein. The disk valve 374 need only be heavy enough to insure its seating when the engine is being started. When in its normal low position resting on the valve seat 377, it will be apparent that this disk valve 374 closes off communication to the central space 380 which is connected to the intake manifold. The annular space 381 which surrounds the central space 380 communicates with the exhaust passage. It will be apparent that when the valve is closed the smaller area at the center of this disk valve will be subjected to the vacuum of the intake manifold and the larger annular area of the valve will be subjected to exhaust pressure, tending to unseat the valve against the action of the intake suction and the slight weight of the valve itself. As noted above in connection with Figure 2, when the intake manifold suction is small and the exhaust pressure is high, the valve will be unseated and will be pushed all the way up against the plate 382 to permit a predetermined flow of exhaust gas into the manifold only at full load conditions of the engine and when it has reached a sufficient speed, which are the conditions when detonation occurs. When the disk valve 374 is in its upper or open position,

it is subjected to the value of the exhaust pressure minus the value of the manifold suction and, in addition, to its own slight weight. Note, however, that when the valve is opened, the resultant of these two pressures acts over its whole area.

The anti-detonation units of both Figures 3 and 4 have one advantage over the unit of Figure 2 in that they will not be open when the engine is first started and thus permit a flow of exhaust gas into the intake manifold, which will make starting more difficult. It is also noted that the units of Figures 3 and 4 may include a cooling fluid, if desired.

Although the foregoing description is necessarily of a detailed character, in order that the invention may be completely set forth, it is to be understood that the specified terminology is not intended to be restrictive or confining and that various omissions and rearrangements or modifications of parts may be employed without departing from the scope or spirit of the invention as claimed herein.

I claim:

1. In combination, an internal combustion engine embodying an exhaust conduit and intake conduit having fuel supply means and anti-knock means admitting a small amount of exhaust gas from the exhaust conduit to the intake conduit only at full load conditions and comprising a gravity biased, normally closed valve arranged to hold itself closed when the engine is not running, a valve housing, and connections so that said valve is responsive to the intake vacuum and the exhaust pressure opposing each other.
2. In combination, an internal combustion engine embodying an exhaust conduit and intake conduit having fuel supply means and anti-knock means admitting a small amount of exhaust conduit to the intake conduit only at full load conditions and comprising a heavy gravity biased and inertia damped valve element, a valve housing, and connections so that said valve is responsive to the intake vacuum and the exhaust pressure acting in opposition.
3. For use with an internal combustion engine embodying an exhaust conduit, an intake conduit, and a throttle, an anti-detonation unit for admitting a small amount of exhaust gas from the exhaust conduit to the intake conduit during knocking conditions and including connections and a normally closed, gravity biased valve, and means including a lost motion connection connecting said valve to be operated by said throttle.
4. For use with an internal combustion engine having an exhaust conduit and an intake conduit, an anti-detonation unit for admitting a small quantity of exhaust gas from the exhaust conduit to the intake conduit during knocking conditions and comprising a heavy, inertia damped valve element gravity biased toward open position and means to hold said valve closed during normal running conditions responsive to and actuated by the intake conduit vacuum.
5. For use with an internal combustion engine embodying an exhaust conduit, an intake conduit, and a throttle, an anti-detonation unit for admitting a small amount of exhaust gas from the exhaust conduit to the intake conduit during knocking conditions and including connections and a normally closed, gravity biased valve and means including a lost motion connection connecting said valve to be opened by said throttle only when moved to its substantially fully open position.

6. For use with an internal combustion engine embodying an exhaust conduit and an intake conduit, an anti-detonation unit for admitting a small amount of exhaust gas from the exhaust conduit to the intake conduit only at full load conditions and including cooling connections and a normally closed, gravity biased valve responsive to and actuated by the intake vacuum and the exhaust pressure opposing each other.

7. For use with an internal combustion engine having an exhaust conduit and an intake conduit with a throttle, an anti-detonation unit for admitting a small quantity of exhaust gas into the intake conduit beyond the throttle comprising an on-off type valve and means to hold said valve closed during normal running and to open it only under heavy load conditions.

8. In combination with an internal combustion engine having an exhaust conduit and an intake conduit with a throttle therein, anti-detonation means connected to admit a small quantity of exhaust gas into the intake conduit after the throttle during knocking conditions comprising an on-off type, heavy, inertia damped and gravity biased valve and means to hold said valve closed during normal running conditions and to open it only under heavy load conditions.

9. For use with an internal combustion engine having an exhaust conduit and an induction intake conduit with a throttle therein, an anti-knock unit to admit a small quantity of exhaust gas into the intake conduit beyond the throttle only during knocking conditions comprising an on or off type heavy valve, inertia damped and gravity biased to closed position so that it is closed when the engine is not running and during normal running conditions and means to open said valve only during full load conditions.

10. For use with an internal combustion engine having an exhaust conduit and an induction intake conduit, an anti-detonation unit to admit a small quantity of exhaust gas into the intake conduit under heavy load conditions comprising a casing having valve guide means therein and an upwardly facing valve seat therein, a large area free disk type valve reciprocable in said casing, having a loose fit in said casing and its guide means, and gravity biased to rest on and close off said valve seat when the engine is not running and during normal running conditions, said casing being vented to atmosphere on the other side of said valve, the space within said valve seat being connected to the intake conduit and said casing having means to subject the larger area annular outer portion of the same under side of the valve to the exhaust pressure,

whereby, when closed, the smaller area of the inner portion of the area of the under face of the valve is subject to the intake vacuum and the larger area of the outer portion of the area of the under face is subject to the exhaust pressure modified by the leakage from said loose fit and said vent and, when open, the entire under face of the valve is subject to the algebraic sum of the intake and exhaust pressures modified by the leakage from said loose fit and said vent.

11. For use with an internal combustion engine having exhaust and induction intake conduits, an anti-detonation unit including a free reciprocating valve means biased to closed position when the engine is not running and during normal running conditions, and means to actuate said valve to admit exhaust gas to said intake conduit only during heavy load conditions, including a piston area and connections to expose one part of said area to the intake vacuum when the valve is closed and to expose all of said area to the algebraic sum of these two pressures when the valve is open.

12. For use with an internal combustion engine having an exhaust conduit and an induction intake manifold, an anti-detonation unit, comprising an on or off type valve to admit an anti-knock substance into the intake manifold only during knocking conditions, and means to actuate said valve responsive to the intake manifold vacuum and the exhaust pressure acting in opposition.

13. For use with an internal combustion engine having an exhaust conduit and an induction intake conduit with a throttle therein comprising an anti-detonation unit comprising a valve casing having connections to the exhaust conduit and to the intake conduit beyond its throttle, means including on or off type valve therein to control the admission of an anti-knock substance into the intake manifold beyond its throttle, and quick acting means to actuate said valve to hold it closed during normal running conditions and to open it only during heavy load conditions.

14. For use with an internal combustion engine having an exhaust conduit and an induction intake manifold with a throttle, an anti-detonation unit for admitting a small quantity of exhaust gas into the intake manifold beyond the throttle during knocking conditions comprising passage means to connect to said exhaust conduit and to said intake manifold beyond the throttle, and control means in said passage means to prevent exhaust gas flow therethrough during all normal running conditions and to permit exhaust gas flow therethrough only during heavy load conditions.

RAYMOND M. ANDERSON.