July 6, 1943. R. M. ANDERSON 2,323,639

INTERNAL COMBUSTION ENGINE CHARGE FORMING APPARATUS

Filed June 16, 1939 5 Sheets-Sheet 1

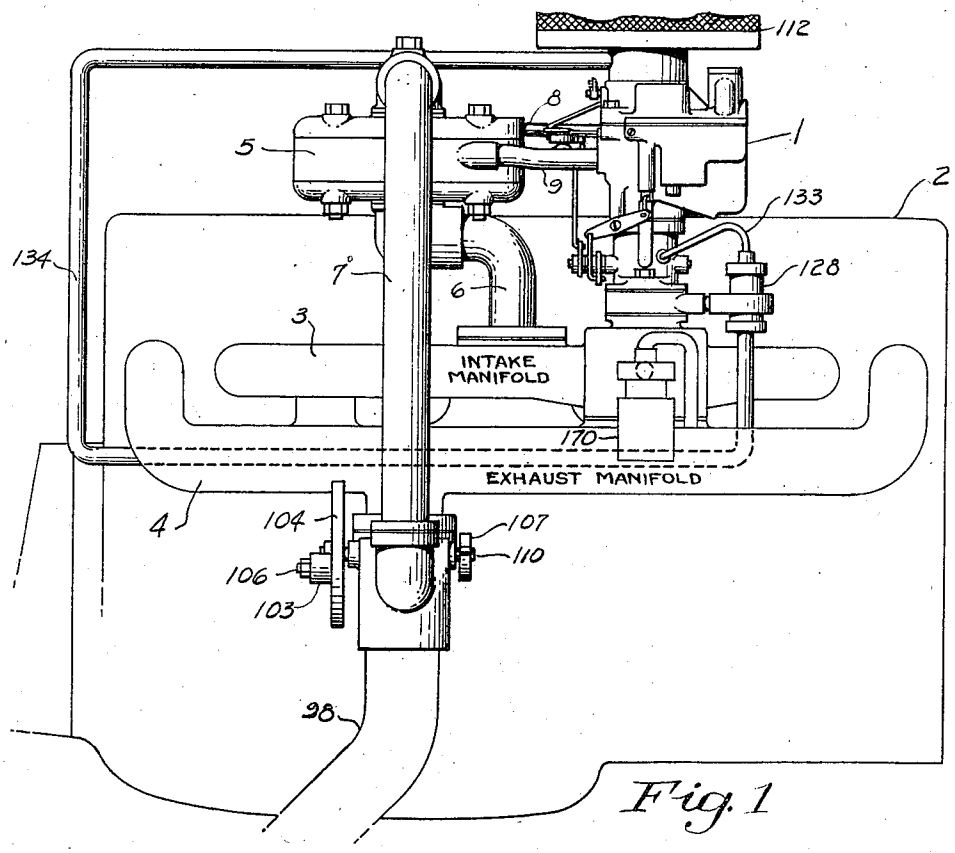


Fig. 1

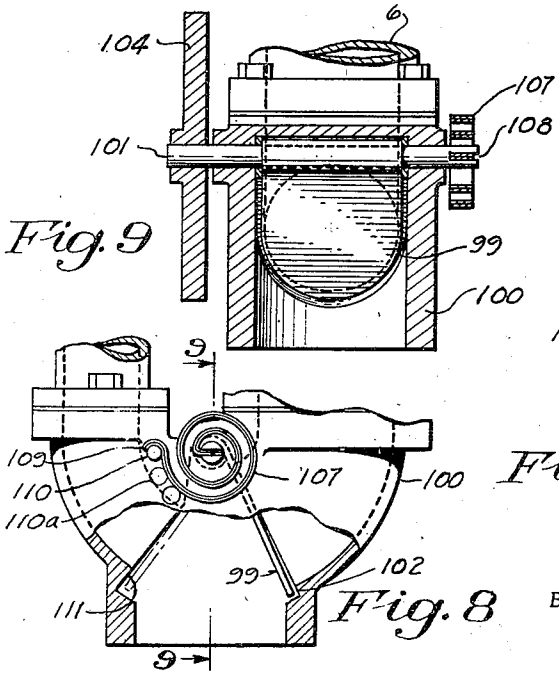


Fig. 9

Fig. 8

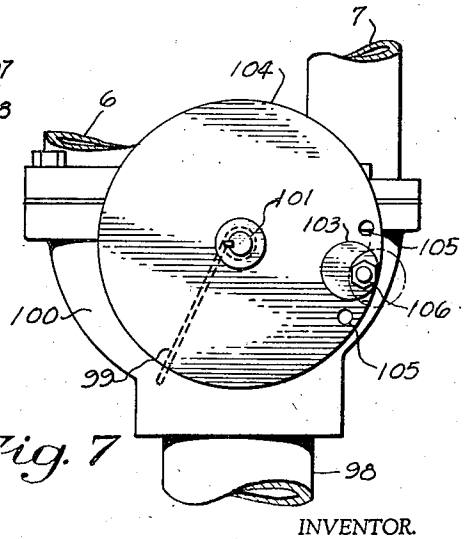


Fig. 7

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July 6, 1943. R. M. ANDERSON 2,323,639

INTERNAL COMBUSTION ENGINE CHARGE FORMING APPARATUS

Filed June 16, 1939 5 Sheets-Sheet 2

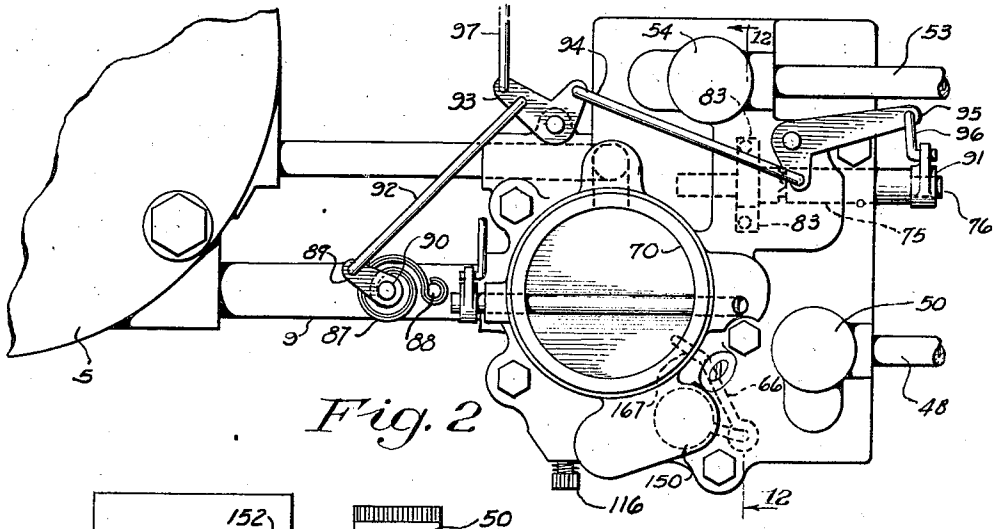


Fig. 2

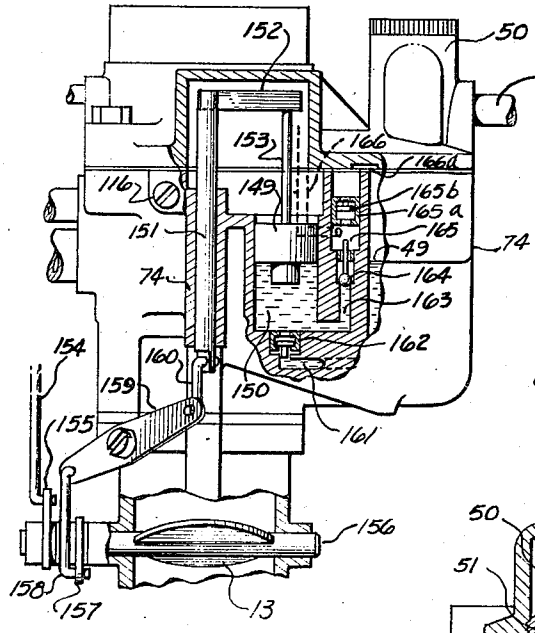


Fig. 10

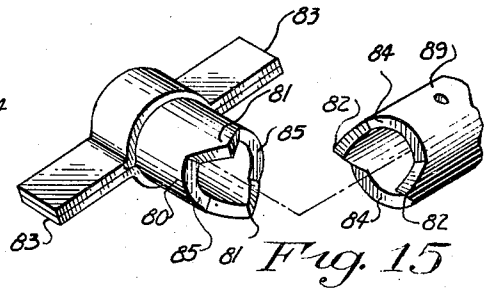
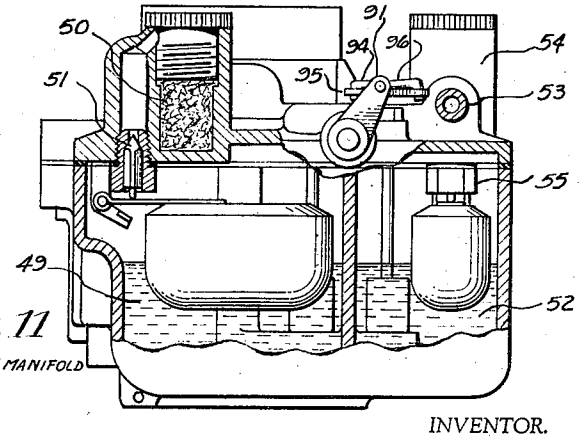


Fig. 15



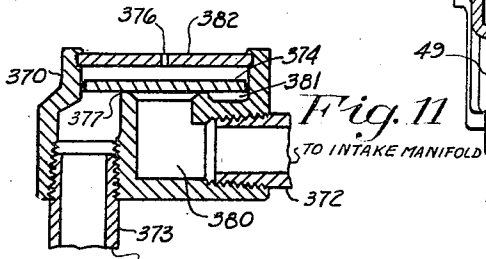


Fig. 11

Fig. 22

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INTERNAL COMBUSTION ENGINE CHARGE FORMING APPARATUS

Filed June 16, 1939 5 Sheets-Sheet 3

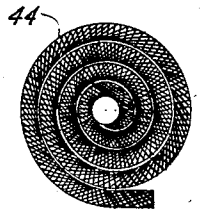


Fig. 3

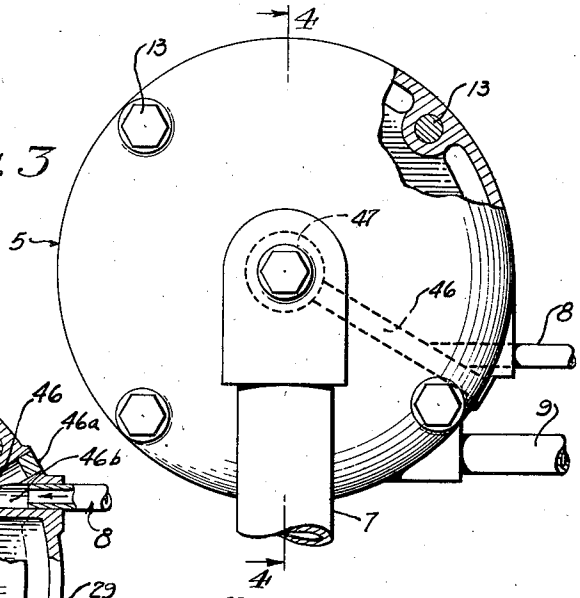


Fig. 4A

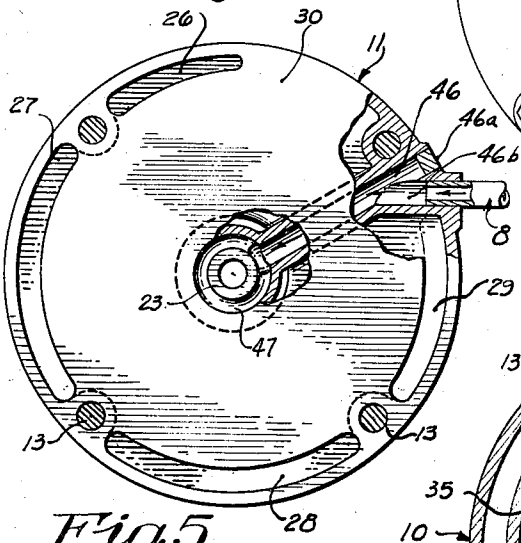


Fig. 5

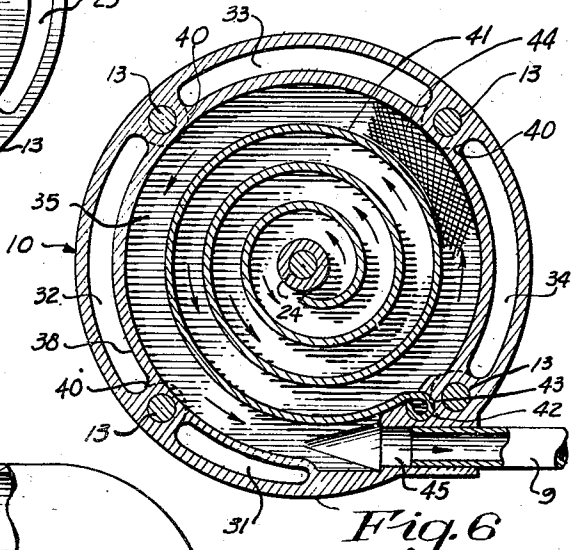


Fig. 6

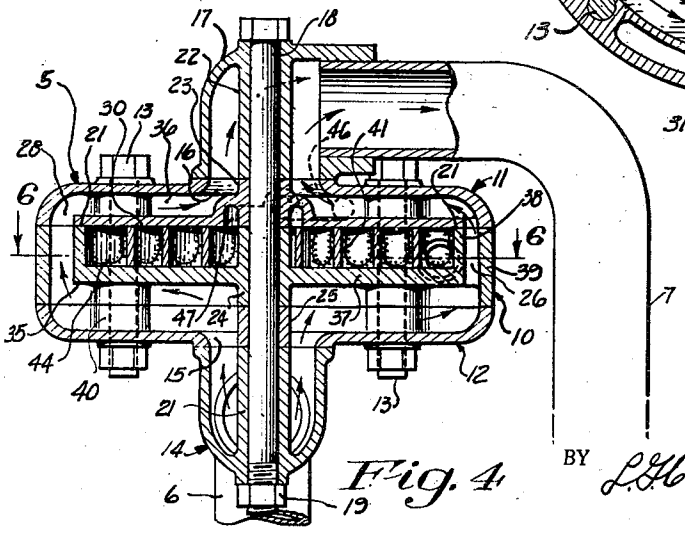


Fig. 4

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INTERNAL COMBUSTION ENGINE CHARGE FORMING APPARATUS

Filed June 16, 1939 5 Sheets-Sheet 4

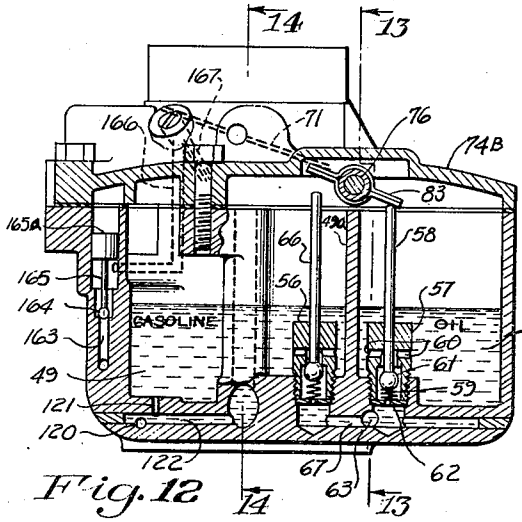


Fig. 12

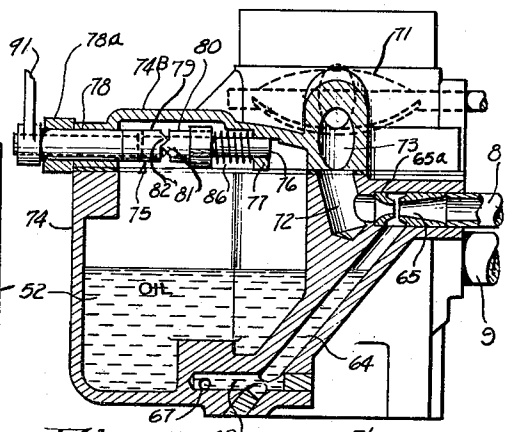


Fig. 13

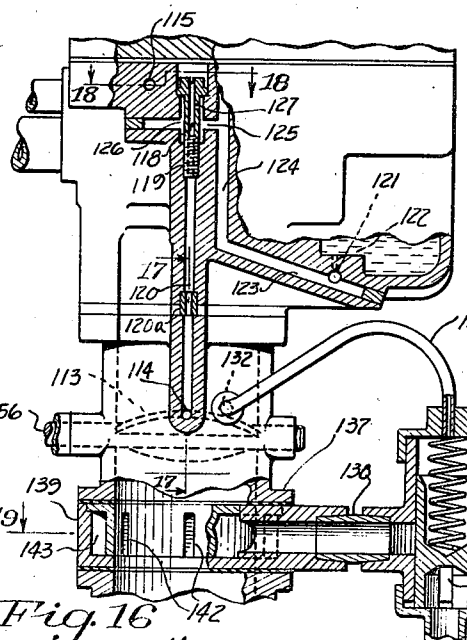


Fig. 16

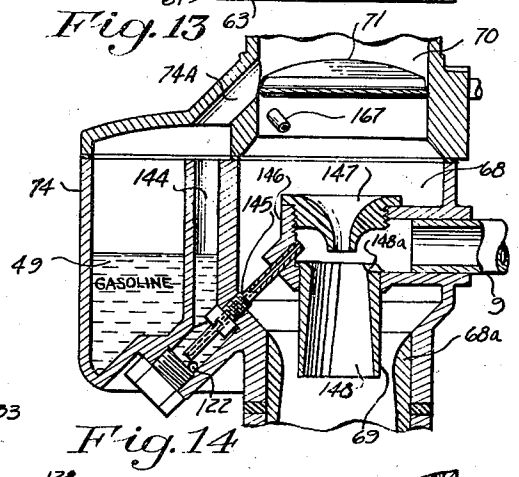


Fig. 14

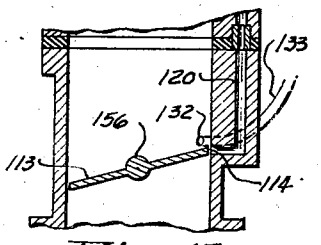


Fig. 17

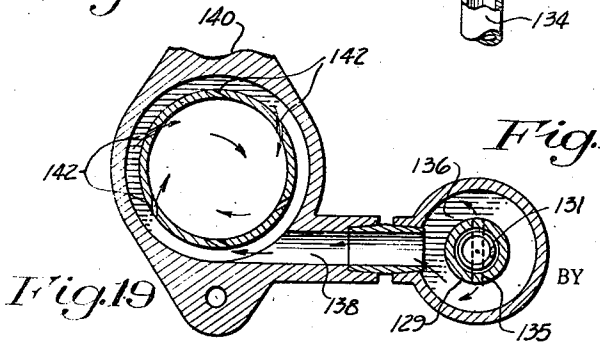


Fig. 19

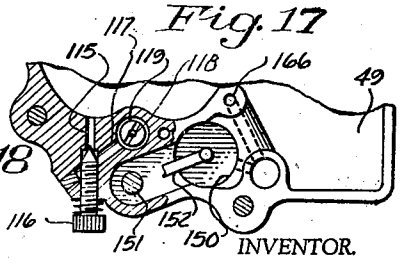


Fig. 18

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INTERNAL COMBUSTION ENGINE CHARGE FORMING APPARATUS

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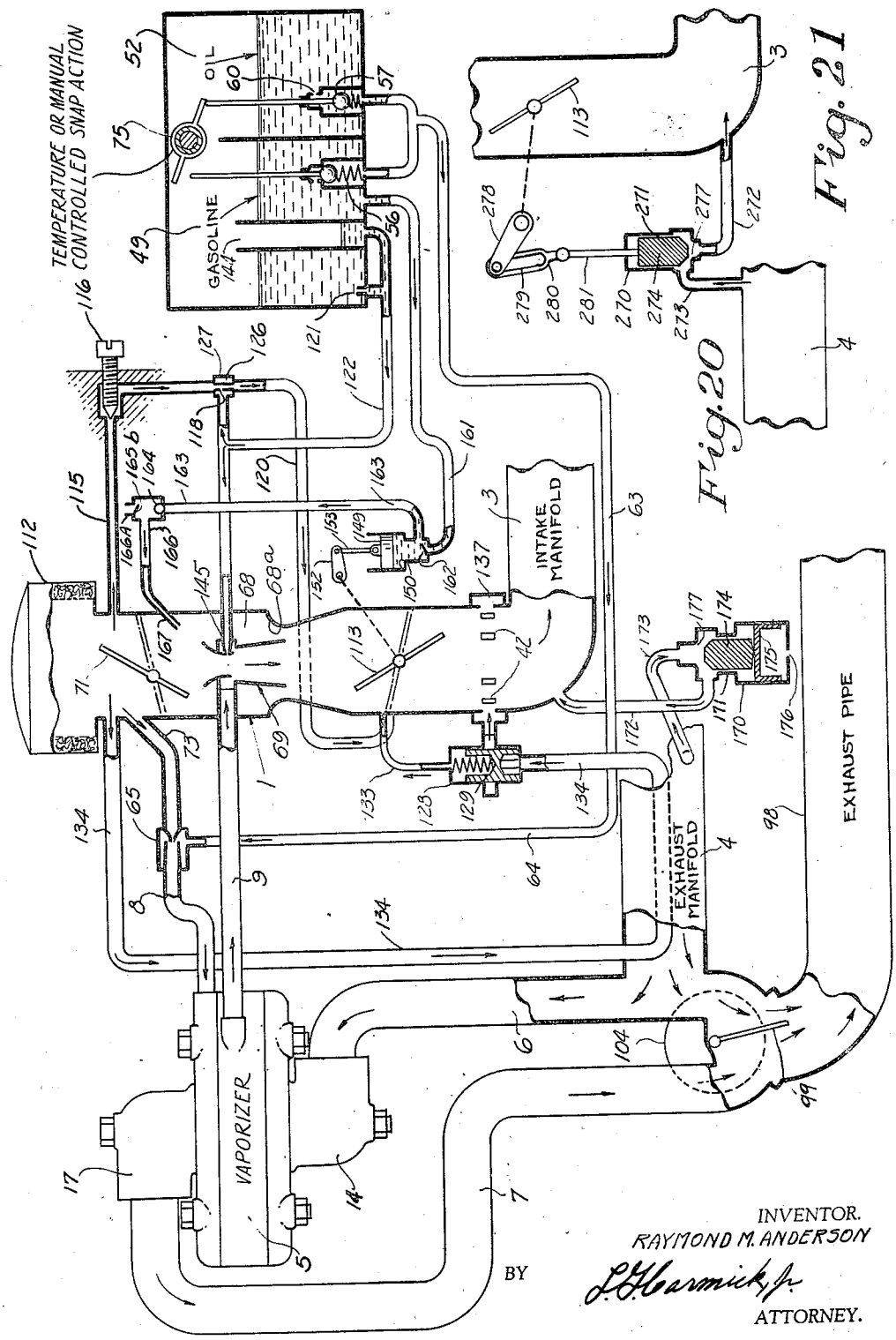


Fig. 21

Fig. 20

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Patented July 6, 1943 2,323,639

UNITED STATES PATENT OFFICE

2,323,639

INTERNAL COMBUSTION ENGINE CHARGE FORMING APPARATUS

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

Application June 16, 1939, Serial No. 279,394

28 Claims. (Cl. 123—127)

This invention relates broadly to internal combustion engines, particularly of the gasoline spark ignition type, and more specifically to certain improved charge forming and regulating apparatus for such engines to materially increase fuel economy and to make possible the use of heavy or cheap fuel without objectionable sacrifice of the several desirable performance or operation characteristics, such as flexibility, full power including high volumetric efficiency, anti-knocking, easy starting, and lack of objectionable carbonization, crankcase dilution, and smoking.

Many extensive and expensive efforts have been made heretofore to use heavy or low grade fuel, such as oil, in conventional types of spark ignition, Otto cycle, gasoline engines, particularly for vehicles or similar uses. In fact, since the early days of the gasoline automobile engine there have been more than several thousands of such proposals or attempts, but, insofar as is known, none have been so made as to be commercially acceptable or successful.

Today the requirements for such apparatus are even more exacting in view of the present relatively high compression engines and the higher standards of performance. Although the systems taught in this crowded art are too numerous and too varied to discuss here, it may be noted generally that these prior systems are in large measure impractical or undesirable in failing to satisfy the major conditions set forth above, and also that they would be expensive to build and difficult to apply to existing engines.

In general, the objects of the present invention are to provide an improved charge forming and regulating apparatus for conventional types of gasoline engines (particularly for use in automotive vehicles including trucks, boats, etc.) permitting the use of a large proportion or all heavy or cheap fuels, such as oil or cheap or low octane rating gasoline or the like, to lower fuel costs and at the same time materially increase efficiency (particularly the over-all fuel consumption as represented by tank miles per gallon); all either increasing or without objectionable sacrifice of the desirable performance or operating characteristics, such as high torque, high volumetric efficiency, flexibility, good distribution, easy starting, and without entailing objectionable operating conditions, such as knocking, crankcase dilution, carbonization, or smoking.

Other objects are to provide an apparatus for these purposes which includes or makes use of standard present-day carburetor parts and units, which is cheap to build, and which is easy to install and service.

The numerous other and more specific objects and advantages, and the manner in which all the various objects are realized, will appear in the following description which, considered in connection with the accompanying drawings, sets forth a preferred embodiment of the invention.

As indicated below, certain divisible units or sub-combinations disclosed herein are claimed in my four divisional or continuation-in-part applications, all entitled: Internal combustion engine charge forming apparatus.

My divisional application Serial No. 466,275, filed November 20, 1942, claims the three anti-knock or anti-detonation units hereof shown in Figures 20, 21 and 22; these units being claimed per se or in combination with ordinary internal combustion engines without regard to the super-rich mixture or the special charge forming apparatus of this parent application.

My divisional application Serial No. 466,276, filed November 20, 1942, claims the fuel selecting valves, their arrangement in a multi-fuel carburetor and their operating or snap action control means as shown in 2, 11, 12, 13 and 15 hereof; these features being claimed per se or in combination with an ordinary internal combustion engine, carburetor, or multi-fuel carburetor without regard to the particular charge forming apparatus of this parent application.

My continuation-in-part application Serial No. 466,835, filed November 25, 1942, has claims to the exhaust gas flow regulating valve unit or the automatic control for the fuel mixture heater as shown in Figures 1, 7, 8 and 9 hereof, this unit being claimed in combination with an ordinary engine or mixture heater, without regard to the special form of mixture heater or the other features of the particular charge forming apparatus of this parent application.

My divisional application Serial No. 467,848, filed December 4, 1942, claims the vaporizer-heater unit of Figures 3, 3A, 4, 5 and 6 hereof, this unit being claimed per se or in combination with an ordinary internal combustion engine, without regard to the rest of the particular charge forming apparatus of this parent application or the features, as claimed herein, that the whole hot, rich mixture supplying means, including the connection into the main mixing chamber, is flat and free from liquid fuel collecting traps or bends.

Referring to the drawings which illustrate a

preferred embodiment of the invention, including three modifications of the anti-detonation unit—

Fig. 1 is a general view showing in elevation an embodiment of the charge forming and regulating apparatus of the present invention as a whole as it appears installed on or applied to a conventional, present-day, automotive vehicle gasoline engine, with the economizer air supply conduit 134 being shown somewhat schematically or diagrammatically to simplify this figure;

Fig. 2 is a fragmentary plan view of the apparatus shown in Fig. 1, the air cleaner being removed;

Fig. 3 is a top plan view of the vaporizer-heater unit, a portion being broken away to show underlying parts;

Fig. 4 is a vertical sectional view of the same unit taken on the line 4—4 of Fig. 3;

Fig. 4A is a reduced scale plan view of the screen coil used in the vaporizer-heater unit;

Fig. 5 is a view of the under side of the upper cap of said vaporizer-heater unit, portions being broken away to show underlying parts;

Fig. 6 is a transverse view taken on the line 6—6 of Fig. 4;

Fig. 7 is a detail end elevation view of the exhaust gas regulating unit as viewed from the left in Fig. 1;

Fig. 8 is a fragmentary end elevation of the other side of this exhaust gas regulating unit with portions being broken away;

Fig. 9 is a vertical sectional view of this valve unit taken on the line 9—9 of Fig. 8;

Fig. 10 is a fragmentary view of the main carburetor unit as seen in Fig. 1, with portions being broken away to show the accelerator pump;

Fig. 11 is a fragmentary view of the main carburetor unit as seen from the right in Fig. 1, with portions being broken away to show the floats and interior parts;

Fig. 12 is a fragmentary sectional view of the main carburetor unit taken on the line 12—12 of Fig. 2;

Fig. 13 is a fragmentary sectional view taken on the line 13—13 of Fig. 12;

Fig. 14 is a fragmentary sectional view taken on the line 14—14 of Fig. 12;

Fig. 15 is a fragmentary perspective view of portions of the fuel selecting snap-action unit;

Fig. 16 is a fragmentary view as seen in Fig. 1, with portions being broken away to show underlying parts, including the idling assembly and the economizer structure;

Fig. 17 is a fragmentary sectional view taken on the line 17—17 of Fig. 16;

Fig. 18 is a fragmentary sectional view taken on the line 18—18 of Fig. 16, with a portion of the view being in plan;

Fig. 19 is a fragmentary sectional view taken on the line 19—19 of Fig. 16;

Fig. 20 is a wholly diagrammatic and spread out view of the major portions of the whole charge forming and regulating apparatus, showing generally or schematically the connections between the several parts, but not accurately showing relative positions or the relative vertical levels of the parts;

Fig. 21 is a partly diagrammatic view showing a modified form of anti-detonation unit; and

Fig. 22 is a sectional view of still another modified form of anti-detonation unit.

As shown as a whole in Fig. 1 and as shown schematically in Fig. 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 (see also Figs. 3–6 inc.) 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 novel features of which are hereinafter more fully described.

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. Venturi means 65, preferably located near the entrance to the passage, with the heavy or light fuel jets 62 and passage 64, meters and mixes the main fuel supply into its air stream. 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 pre-determined 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 or 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 grades 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 pre-determined 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 62 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 particularly to the schematic Fig. 20, it will be seen that, for starting and until the engine has come up to temperature, only gasoline or the like will be supplied to the vaporizer-heater unit's venturi 65 for discharge into the annular space in the composite inner venturi 69 of the multi-venturi set 69, 68a of the main mixing chamber 68. Manually operated or automatically controlled valves 56, 57 may control the change over from gasoline to heavy fuel, or vice versa at starting or at other times, as is well known in this art. The novel features of the valve actuating snap-action unit 75 are described hereinafter.

An important feature of this invention is the provision of auxiliary fuel supplying means to supply volatile unheated fuel directly into the intake conduit concurrently with the varying supply of the high temperature, super-rich, air-fuel mixture into the intake conduit. It is particularly desirable to supply a compensating or limited flow of volatile fuel (which is relatively constant at normal running speeds) in conjunction with the hot rich oil-air mixture so that the proportion of volatile fuel to the total fuel is large at low speeds and small at higher speeds and loads. Similarly, it is desirable to have an idling supply of volatile fuel only.

A compensating jet assembly 145, 144, 122, 121, which is shown in Figs. 12 and 14, and the later described details of which are entirely conventional so that this assembly per se forms no part of the present invention, discharges liquid gasoline or other like fuel into the annular space in the composite smaller venturi 69 of the main mixing chamber 68 as shown. This supply of fuel is limited to a substantially constant rate, as is well known in connection with the Zenith carburetor. In addition, volatile idling fuel is supplied by the conventional idling organization (see Figs. 20, 16, 17 and 18) by opening 114 adjacent the throttle 113. Thus at lower engine speed this idling supply will constitute all of the fuel supply and, as the speed increases, the idling supply cuts out and the compensating jet then supplies volatile fuel at a substantially constant and limited rate. Thus, considering these two auxiliary volatile fuel supplying means together, at low engine speeds the supply of unheated volatile liquid fuel increases with engine speed to a relatively constant limited value under normal running conditions so that the unheated volatile fuel is a large proportion of the total fuel supply at these low engine speeds, with this proportion decreasing at the higher engine speeds to a small proportion of the engine fuel. It may be noted that this direct supply of idling and compensating unheated volatile fuel substantially matches or generally corresponds to the oppositely varying curve for the heat conditions for the vaporizer-heater unit since there is a small and insufficient amount of exhaust heat available to the vaporizer-heater unit at very low engine speeds, which amount of available heat increases with engine speed and load until it is sufficient, beyond which point it is limited or regulated by the automatically controlled exhaust gas regulating valve 99. Also, it is noted that the quantity of fuel supplied through the vaporizer-heater 5 substan-

tially matches the amount of heat available to this heater unit from the exhaust as the speed or load increases.

An accelerating pump unit **150** (see Figs. 20, 10 and 13), which is conventional per se, discharges unheated liquid volatile fuel through nozzle **167** directly into the main mixing chamber **68** ahead of the first or smaller venturi **69** to give rapid acceleration on this quickly vaporized gasoline which will supplement the main fuel charge supplied through the vaporizer-heater unit **5**.

In normal mixed city and cross country driving of an installation of the invention as disclosed on a loaded truck, the engine used up to one-fourth to one-third gasoline and the remainder oil. Of course, much less auxiliary fuel or gasoline is used in straight away or highway type driving.

The main air-fuel supply through this vaporizer-heater unit **5** will vary in accordance with the suction in the mixing chamber **68** or, more accurately, in accordance with the suction at the throat of the inner venturi **69**.

The economizer unit **130** meters a pre-determined amount of air or other diluent into the intake manifold at each part-throttle part-speed condition to thin the mixture down to the desired point for each condition. This later described unit is responsive to and meters in accordance with throttle position and engine speed-load conditions, and is particularly useful in connection with the long mixture-heating passage in the heater **5**.

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.

The present invention is peculiarly adapted for use on cold running or heavy duty type engines. In such installations the limitations of detonation or knocking at or near full loads when using heavy or low octane rating fuel are much less severe, and appreciable increases in power output or torque, coupled with higher efficiency, have been obtained with oil and low grade fuels having octane ratings below 40. For example, in marine engine installations, for which this invention is well adapted, certain units hereof, such as the anti-detonation unit, the accelerator pump, etc., may be omitted if desired.

It will be apparent that the present invention can be simplified to use only one fuel, such as cheap or low grade gasoline or other relatively volatile fuel. In such case, the two bowls, the change over valves and the like can be omitted and a much cheaper and simpler apparatus can be made.

Referring to Figs. 3–6 inc., the vaporizer-heater unit comprises an intermediate section **10** which is tightly clamped between a cap portion **11** and a base portion **12** by means of through bolts **13**. An elbow **14** is mounted on the base **12** and serves as a connection between the exhaust intake pipe **6** and the interior or exhaust gas jacket portion of the heater through annular port **15** formed in the base. The exhaust gases are discharged from the heater through an annular port **16** in cap **11** into a similar elbow **17** communicating with the exhaust discharge pipe **7**. Tie rod or through bolt **18** with nut **19** draws the two elbows **14** and **17** together to clamp them to the cap and base **11** and **12**, but this clamping is limited by hollow bosses **21** and **22**, integral with elbows **14** and **17** respectively, acting through the sleeve or boss **23** integral with cap **11**, sleeve or boss **24** integral with intermediate section **10**, and sleeve or boss **25** integral with the base **12**. Cap **11** is provided with ducts **26**, **27**, **28** and **29** adjacent its periphery and extending through its lower wall **30** to form the upper portion of the exhaust jacket passage. Ducts **31**, **32**, **33** and **34** formed in section **10** have the same contour and are positioned to register with the ducts **26**, **27**, **28** and **29** of the cap when these parts are assembled to form jacket passages for the flow of exhaust gases from the space beneath and around the mixture-heating chamber **35** upwardly and around this chamber to the similar space **36** above it.

The mixture-heating chamber **35** comprises a lower wall **37** extending out from the sleeve **24** to an annular lateral wall **38** which is joined to the outer shell wall **39** of the section **10** by webs **40** around the through bolts **13**. This chamber **35** is closed by an upper wall **30** which is integral with the sleeve **23** and the cap **11**, the whole being otherwise generally similar to the structure of the base **12**.

The interior of the mixture-heating space in **35** is partitioned or separated into a long tortuous mixture-heating passage by a partition or separator **41** which may be formed in various ways but which preferably comprises a flat, spiral, coiled steel spring which is substantially equal to the depth of the annular chamber in member **35** so that it is more or less tightly received between the walls **30** and **37** to form with these walls a flat, spiral, mixture-heating passage. The outer end of the spring **41** is beaded at **42** for removable anchorage in a notch **43**, and its inner end abuts against sleeve portion **24**.

The horizontal pipe **8** supplies air-fuel mixture to the horizontal, flat, spiral passage in the heater through passage **46***b* communicating with the radial passage **46** having its end closed by a cap **46***a*. This arrangement permits easier coring in the casting of this member. The passage **46** in turn communicates with the annular space **47** about the sleeve **23** which opens into the center of the space in the unit **35** and into the inner end of the spiral passage between the turns of the spring **41**. The heated air-fuel mixture leaves through port **45** which communicates with the substantially horizontal aluminum pipe **9**.

As shown in Fig. 14, the other end of pipe **9** is fitted into a passage member **146** cast in the main carburetor unit and leading directly into the annular space formed about the throat of the inner venturi **69** which is formed of the upper and lower portions **147** and **148** secured into member **146** as shown. Note that member **148** is cut away at **148***a* to remove even the slight dam which would otherwise be present.

As noted above, it is important that there be no upward bends, dams, or the like in the whole length of the rich mixture-carrying passage from its fuel venturi **65** to and past its point of discharge into the throat of venturi **69** to form traps collecting pools of liquid fuel.

It is also desirable that this whole length of

this tortuous mixture-carrying passage be substantially flat or horizontal. It may, of course, include several slight downwardly extending portions as shown. If this passage or the vaporizer-heater unit extends downward vertically or on a steep slope, the heavier liquid fuel particles tend to run through too fast and escape vaporization. On the other hand, if the passage extends upwardly, it will necessarily form or include a trap to collect liquid fuel. Also, the passage will require a much greater lift or suction to pull the mixture through. Further, the compact and flat or substantially horizontal vaporizer-heater unit has a height or difference of level between its intake and discharge connections 8 and 9 which corresponds to the difference in height between the throat of the inner venturi 69 and the fuel lift distance (about 5/8") above the fuel level in bowls 49 and 52. Hence such a flat heater unit cooperates with the use of a one or two bowl carburetor carried by or integral with the mixing chamber 68 and also supplying the auxiliary fuel directly to this mixing chamber 68.

It is desirable that there be an appreciable or rather large mass of metal in the heater unit 5 to give a leveling or fly wheel effect to take care of variations in the exhaust heat or in the amount of heat extracted by the mixture. For the same reason it is desirable that the metal be such that it would store a large amount of heat per unit weight. Also, it should, of course, be a good heat conductor. Preferably, the entire heater unit 5, including the sections 10, 12, 11, 14, 17, and pipe 9, or at least a part of its hot mixture-contacting portions, is formed of aluminum or the like (including predominantly aluminum alloys) for the above reasons, and particularly since it has been found this causes the heater to be more efficient in gasifying and vaporizing the fuel in the rich hot mixture and reduces carbon formation. The reason for this last is not entirely understood, although it may involve some type of catalytic action.

In addition, it has been found desirable to have a series of spaced wires extending throughout all or a substantial portion of the length of this tortuous mixture-heating passage to aid in breaking up the rapidly moving globules of oil and to act as additional heat transferring surfaces. Preferably, this is achieved by the spirally coiled tube 44 formed by winding a length of bronze screen to form a tube which is then bent into the flat spiral form so that it can be readily positioned in the flat spiral heating passage where it will lie adjacent the side walls of each turn of the passage. It has been found that copper or the like, including copper alloys, also increases the efficiency of the gasifying or vaporizing, possibly by some type of catalytic action. The screen should be rather fine in order to have a large area exposed. However, it is preferably formed of a medium weight (for example .022") bronze wire so that it will not readily burn out. Aluminum or aluminum alloy screen or mesh is more apt to burn out rapidly, and even copper is corroded more rapidly than the copper alloys such as bronze. It will be apparent that this gasifying aid of wires or the like may be employed to advantage in other applications and in various forms.

Also, it has been found that the forming of the hot mixture-contacting portions of aluminum or aluminum alloy and the use of the mesh unit 44 aid in reducing carbon deposits or gummy deposits in the heater unit and in the mixing chamber and its venturi.

It will be apparent that this complete vaporizer-heater unit is separate from the exhaust conduit or manifold or from the other parts of the organization so that it can readily be mounted in the correct position in various types of engines and so that it will be readily accessible for service, including cleaning.

It will also be apparent that this vaporizer-heater unit 5, including its connections, can be readily disassembled by the operator and that the screen member 44 can be removed for cleaning by brushing or bending it. The cheap mesh unit 44 can be readily replaced if corroded or burned.

Partitioning spring 41 is readily removable and can be cleaned when necessary by striking it against a hard object to knock off deposits or by scraping if necessary. The flat inner surface of the upper and lower walls 30 and 37 may be readily cleaned by scraping or the like upon the removal of 44 and 41.

Figs. 2, 10–14 inclusive, 16 and 17 give a disclosure of the details of the main multi-fuel carburetor unit. Gasoline or the like is conveyed from any suitable source of supply such as the usual fuel pump drawing from a gasoline supply tank through the supply pipe 48, suitable filter 50 and float regulated valve 51 to the float chamber 49. Similarly, heavy fuel, such as oil or the like, is conveyed to a float chamber 52 through pipe 53, a suitable filter 54 and float controlled valve unit 55. The conventional floats are shown in Fig. 11. The two float chambers 49 and 52 are formed in a common casing 74 which is integral with the mixing chamber section of the intake conduit, and these two chambers are divided by an upright partition 49a which does not extend to the top of this casing. As shown in Fig. 12, duplicate valve units 56 and 57 selectively shut off the flow of either the light or heavy fuel to the passage 67. The oil valve unit has a valve body 57 guiding a valve stem 58 which carries a valve member 61 biased to close ports in the valve body 57 by the spring 59. The valve body 57 is removably screwed into a corresponding socket formed in the bottom of the float chamber casing.

The above mentioned ports in the valve seat shut off the communications with the ports 60—60 communicating with the float chamber. The lower end of the spring 59 is retained by a plate 62 having a metering jet or orifice therethrough which is calibrated as the main jet for the viscosity of the oil or other heavy fuel used in this float chamber. The gasoline float chamber has valve body 56 with guided valve stem 66 and other portions which may be identical with those used in the oil float chamber. However, the jet or orifice in the gasoline float chamber is differently calibrated on account of the different viscosity of the lighter fuel.

As shown in Fig. 14, passage 67 communicates through the passage 63 and upwardly inclined passage 64 with an annular space about the throat of the primary venturi formed by the two Venturi portions 65 and 65a respectively in a suitable recess in the carburetor unit casing. It is desirable that a multiple or double venturi be used to produce sufficient suction to effectively pull the rich mixture and fuel particles through the high resistance, long, mixture-heating passage. This multiple venturi in the mixing chamber 68 comprises the composite inner venturi 69

and the outer venturi 68a. The inner venturi consists of the upper or inner Venturi portion 147 threaded into the portion 146 which also forms an enclosed annular space about and opening into the throat of the inner venturi 69. The lower Venturi portion 148 is also suitably secured in the portion 146. Further, it is advantageous, and more thoroughly mixes all the fuel from both sources, to have the compensating nozzle 145 discharge into this same inner venturi 69.

Another advantage gained by drawing the rich mixture passage discharge into the inner venturi 69 is that any unvaporized or liquid particles will run down and be drawn off the lower end of the lower portion 148 out in the air stream to be carried along instead of running down the walls of 68a or the like. To avoid any trap or dam for any of these unvaporized or heavy liquid particles, the top edge or lip of Venturi portion 148 is cut away at 148a to form a horizontal and unobstructed passage. It will be apparent that a trap or dam in this passage would, at times, collect a pool of oil which would then be sucked into the venturi at the next period of high vacuum, thus causing smoking, etc.

The lift from the level of the oil or gasoline to the throat of this primary venturi 65, 65a is a somewhat greater lift than that used in conventional present-day automobile carburetors so that fuel will not start to be drawn through the separate mixture-heating passage until the engine has reached a slightly higher speed and the heater has come up to temperature. Until then, the fuel is supplied by the idle and compensating jets. In the embodiment illustrated, this lift is about 5/8". This lift is sufficient so that no fuel will be drawn into the heating passage when the throttle is closed or nearly closed and the venturi 69 exerts little suction. Thus, in coasting with the throttle closed or nearly closed, little or no fuel comes through the vaporizer-heater, since the inner venturi 69 of the multiple venturi set will not be exerting sufficient suction to lift fuel from the bowl.

The two valve units 56 and 57 are either positively on or off and the fuel to be supplied to the primary venturi 65 is selected by depressing the valve stem for the fuel desired (permitting the other valve to be closed by its spring) by the swinging arms 83 of the snap-action mechanism hereinafter described.

Air is drawn from the intake conduit 70 through sloping passage 73 formed in the carburetor unit cover 74b and opening above the choke 71, through communicating passage 72 formed in the carburetor unit body 74, and thence through the primary venturi 65—65a, as described above.

The valves 56 and 57 are actuated by an improved snap-action unit 75 which is best seen in Figs. 2, 12, 13 and 15. This unit includes a rock shaft 76 journaled at its inner end in a lug 77 formed on the cover 74b and also journaled in a bushing 78 carrying a bracket 78a, all fixed in the cover 74b above the partition 49a. An actuating sleeve 79 is pinned to the shaft 76 in abutment with the bushing 78. Snap sleeve 80 is rotatably and slidably mounted on a shaft 76 adjacent the sleeve 79. This sleeve 80 has axially extending cams 81—81 cooperating with a pair of similar opposed and axially extending cams 82—82 on the sleeve 79. A pair of arms 83—83 extend radially from opposite sides of the sleeve 80 to actuate one or the other of the valve stems. Normally the cam points or lobes 81—81 rest against the flat surface 84—84 between the cam lobes 82—82, the sleeve 80 being biased towards the sleeve 79 by the compression spring 86 mounted on the shaft between the lugs 77 and the sleeve 80. As the shaft 76 is rocked about its axis, its cams 82—82 engage the cams 81—81 and rotate the sleeve 80, thereby opening one or othe other of the valves 56 and 57 against the action of the spring tending to hold the valve seated.

At a certain amount of valve depression, a balance is reached between the upward spring pressure exerted on the valve stem and the action of the spring 86 through the cooperating cam or wedge surfaces 81 and 82, the reaction of which causes an inward sliding movement of the sleeve 80 on the shaft 76 to compress the spring 86. Further rotation of the rock shaft 76 beyond this balance point permits the sleeve 80 to slide back far enough to allow the cam lobes 82—82 to pass the corresponding cams 81—81 so that the depressed valve spring forces its stem upwardly and helps to rotate the sleeve 80 in the opposite direction. This action is enhanced by the spring 86 acting through the cooperating sides or cam surfaces of the cam lobes 81—81 and 82—82.

It will be noted that this snap-action mechanism, which will positively open one valve and close the other, is quite compact. Particularly, it is of small height or diameter so that it may be readily mounted in the cover or upper part of the carburetor casing above the partition 49a where it is completely shielded and housed against dirt and the like. Its control shaft 79 is journaled in and extends out through the side of the carburetor casing lid where it carries a pinned arm 91 which may be actuated by any suitable manual or automatic control linkage. It is desirable to have manual control available at all times, and if automatic control is used it may be made responsive to various engine conditions, as is well known in the art.

As shown in Fig. 2, a bi-metallic coil spring thermostat 87 having one end anchored by pin 88 is mounted on or above the vaporizer-heater mixture discharge conduit 9 so that it will be actuated responsive to the temperature of said mixture. The inner end of this bi-metallic coil actuates an arm 89 pivoted about pin 90. The action of this arm is transferred through a link 92 to a pivoted bell crank lever 93 which is in turn connected by a link 94 to a second pivoted bell crank lever 95 which is connected by a link 96 to the arm 91. The inner end of a suitable manual control linkage, which may be held in either position by conventional means, is connected to the bell crank lever 93 by a link 97, and it will be apparent that manual control can over-ride the automatic control through deflection of the bi-metallic spring element in either direction or by other known means.

As noted above, it is quite important that the temperature of the super-rich heated mixture be maintained within reasonably close limitations. In the present embodiment it has been found that although better results are obtained the more closely the mixture temperature is regulated, satisfactory results are obtainable with variations up to 50 degrees F. In the present embodiment a close regulation is accomplished by regulating the flow of exhaust gas through the by-pass circuit which includes the vaporizer-heater.

Referring to Figs. 7, 8 and 9, it is seen that the unbalanced exhaust regulating valve 99, which is preferably pivoted at one edge by being fixed on

rockable pin 101 journaled in the side walls of the Y fitting 100, may seat against a shoulder 102 to close this leg of the Y fitting to force all of the exhaust gas around through the vaporizer-heater. When wide open, valve 99 seats against shoulder 111. To prevent fluttering and pounding on its seat, this valve is inertia damped by a comparatively heavy fly wheel 104 fixed on its pin 101. This wheel carries a weight 103 adjacent its periphery to bias the valve toward its closed position against seat or shoulder 102. It will be noted that a bolt 106 secures this weight to the wheel in any one of the plurality of holes 105 so that the weight is adjustable angularly around the periphery of the wheel; and since the bolt hole in the weight itself is eccentric, the weight may be moved in or out radially, both of which movements permit a nice adjustment of the effective lever arm of the weight acting on the valve so that the temperature setting may be varied for different installations, for different fuels, for winter and summer operation, etc. In addition, the pin 101 is fixedly connected to the inner end of a bi-metallic coiled spring 107, the outer hooked end of which 109 is fixed to pin 110 which may be adjustably secured in any one of a plurality of holes 110a to give a further adjustment for the temperature setting or calibration for this valve unit.

Bi-metallic temperature responsive member 107 is set to hold the valve in position against seat 102 to direct all exhaust gas through the heater 5 at low temperatures and at temperatures slightly above the desired setting, which, as noted above, may be about 400 degrees F. to move the valve toward seat 111 to an extent dependent on the temperature and the pressure exerted on the valve. It will be apparent that since this bi-metallic element is mounted adjacent the fitting 100 its action will be responsive to exhaust gas temperatures. The butterfly type valve 99 itself is responsive to the rate of flow of the exhaust gas, which is a function of engine load-speed conditions.

It will be apparent that in normal operation this exhaust gas regulator valve will occupy some intermediate position dependent upon the exhaust gas temperature and flow rate to limit and to regulate the exhaust gas made available to the vaporizer-heater and consequently the mixture temperature.

Referring to Figs. 16, 17, 18 and 20 disclosing further details of the multi-fuel carburetor system, it will be apparent that air entering through the conventional air cleaner 112 is drawn down into the manifold 3 through the separate mixing chamber section of the intake conduit riser 70, there being a conventional butterfly type choke valve 71 above the mixing chamber, which choke may be manually or automatically regulated, as is well known in the art. Below the mixing chamber 68 (which is integral with the two-fuel float bowl unit 74) is a conventional butterfly throttle 113.

The idling mechanism (which is conventional per se) and its passages and connections include the following:

Referring to Figs. 16, 17 and 18, opening 114 is positioned alongside the edge of the throttle when it is in closed position and opens into passage 120 including connecting fitting 120a and having at its upper end a threaded jet member 119. Jet 119 has an axial opening 118 therethrough and has an orifice 127 communicating with an annular space 126 surrounding this member. Space 126 communicates by passage 125 with a downwardly extending passage 124 which, in turn, is connected with the gasoline or light fuel float bowl only through another passage 122 and a conventional calibrated jet 121 which may be removable if desired, as is well known in the art. Passage 115 opens into the intake conduit below the air cleaner 112 and above the choke 71. Its communication with passage 117 is controlled by the adjustable screw 116 to control the air bleed into the upper end of opening 118.

It will be apparent that the details of the idling organization just disclosed are entirely conventional, and consequently these details per se form no part of the present invention. As is well known in the art, when the throttle 113 is nearly closed, the high suction will be transmitted through opening 114 into the several passages, including 120 which sucks gasoline up around the jet member 119, and into the orifice 127 where it may be mixed with air to supply the idling mixture through passage 120 and opening 114. As the throttle is opened, the supply of gasoline through opening 114 will drop off.

The economizer unit designated generally by the numeral 128 and shown in detail in Figs. 16, 19 and 20, may be made in accordance with the disclosure and teachings of my previous United States Patent No. 2,154,417 or the United States patent to Church No. 2,152,028. This economizer unit as illustrated herein comprises the valve piston 129 in the valve housing 130 biased to its downward position by a spring 131, the upper end of the valve housing being closed by a cap 128 which also serves to support the other end of the spring 131. The valve element 129 has a neat working fit in the cylinder or valve housing, and the upper end of this valve unit serves as a piston or a spring-pressed one-way vacuum motor to actuate the valve and place it in any one of a number of positions in accordance with the degree of vacuum exerted on its upper portion. Calibrated opening 132 is located in a particular position inside of the intake conduit so that it will be slightly above the edge of the butterfly throttle valve 113 when it is in fully closed position and so that the edge of the throttle plate sweeps over this opening as the throttle is opened. This opening is conneced to the piston side of the valve element 129 by the pipe 133 so that the position of the valve is determined by or is responsive to the position of the throttle and of the rate of flow of air past the throttle plate and this opening 132.

The lower end of the valve body is closed by a cap including pipe connection 134 which may be heated if desired by having it include any suitable heat exchanger or having it extend through all or a substantial part of the length of the exhaust manifold, as shown in Fig. 1. The pipe then is extended up to the end of the intake conduit so that it takes in air just below the air cleaner, thus eliminating the necessity for an additional air cleaner. This pipe connection from the exhaust manifold up to adjacent the air cleaner 112 is shown schematically only in Fig. 1.

Piston valve 129 has calibrated slots or openings 135 affording a pre-determined area of opening for any particular valve position between pipe 134 and the annular chamber 136 in the valve body and surrounding this valve element. Space 136 is connected by a connection 138 to an annular space 143 which is formed in an insert member 139 held by its ears 140—140 to the top of the intake conduit and between it and the

bottom of the carburetor section casting. As shown, this insert has the usual gaskets above and below it and is made of two portions, each of which is L-shaped in cross section to permit of assembly.

The inner wall of this insert member **139** has a plurality of uniformly spaced slots **142** communicating with the intake conduit and being directed partially or substantially tangentially so that the diluent, comprising hot air or gases which are sucked in through these slots, will set up a swirling in this portion of the intake conduit to promote turbulence, which will assure a more thorough mixing, subdividing and vaporizing of the fuel in the mixture. A more complete disclosure of this type of economizer unit and its advantages will be found in the above mentioned United States Patents Nos. 2,154,417 and 2,152,028, the disclosures of which are intended to be incorporated herein.

This economizer unit may, if desired, be used in lieu of the usual power jet or economizer piston valve for opening an additional fuel jet (which open up only at high speeds to richen the mixture for full power). When the power jet is eliminated and this type of economizer is used, the main jet is made larger so that it supplies enough fuel to give the rich mixture necessary for full power at high speeds. The economizer admits a pre-determined quantity of diluent (i. e., hot or cold air or exhaust gas as taught in the above mentioned Church and Anderson patents) for all part-speed and part-throttle conditions to give as lean a mixture for each of these conditions as is consistent with proper operation and performance. It will be noted that this economizer unit is peculiarly advantageous when used in combination with the separate, long, super-rich mixture passage of the vaporizer-heater unit of the present invention since there is a considerable lag or inertia effect because of this long passage. The very quick acting, almost instantaneously operating economizer will tend to keep the mixture on the lean side when the load or throttle positions change. For example, if the vehicle were operating at a high speed using a power jet in lieu of the economizer and the load decreased so that a thinner mixture could be used, the considerable volume of the long tube is still full of a rich mixture and the over-all mixture will not be thinned out until that extra supply of fuel contained in the mixture of the vaporizer-heater unit has been used up. On the other hand, when using the economizer in lieu of the power jet, the mixture in the intake manifold will be immediately thinned down to the desired point, causing material increase in economy with less smoking, etc. Also, when the power jet is used in lieu of the economizer, there will be a lag in reaching the desired richer mixture upon an increase in load, since the whole vaporizer-heater unit volume must be "loaded up" with this richer mixture before it is received by the engine. When using the economizer in lieu of the power jet, the desired rich mixture is achieved almost instantaneously. In addition, where two fuels are used with separate jets for each fuel for the main fuel supply, it will be apparent that the one simple economizer unit may be used in lieu of and to replace two complete power jet assemblies, thus effecting appreciable economy in cost of manufacture and simplifying the apparatus as a whole.

Referring to Fig. 12, the well **144** is supplied only from the float chamber **49** for gasoline or other volatile fuel through the above described passage **122** so that the flow of fuel for the idling and for compensating is controlled by the calibrated jet **121**. As noted above, both float bowls **49** and **52** are in open communication above their partitions **49***a* and both are vented by passage **74***a* in the carburetor casing cover to the intake conduit **70** above the choke and below the air cleaner, to correct for any increase in suction due to a dirty air cleaner, as is well known in the art. A removably screwed-in nozzle or upwardly extending small conduit **145** extends nearly to the bottom of the open well **144** and extends through the side of the central housing member **146** of the inner venturi **69** to discharge gasoline or other light fuel into the annular space about the throat of the inner venturi **69**.

Referring to Fig. 10, the accelerating unit (which is conventional per se) comprises a piston **149** within a cylinder **150**, piston **149** being operated by the throttle operating connections through the slide rod **151**, the bridge member **152**, and the piston rod **153**. The slide rod **151** is connected through a pivoted link **160** to a pivoted lever **159** having its other end connected by link **158** to an arm **157** on the throttle shaft **156**. The throttle shaft is operated by the usual controls acting through the link **154** connected to the arm **155**. Gasoline or the like enters the cylinder **167** having a suitable one-way or check valve unit **162**. Rapid downward movement of the piston **149** closes the check valve **162** and forces gasoline out through passage **163** through the one-way check valve **164** to the chamber or space **165**.

Valve housing **165***a* has a lower opening which serves as a guide for the non-illustrated upper end of the valve stem for valve **164**. A disk valve **165***b* has a serrated outer edge to permit fuel to flow past it when it is in the intermediate or lower position. Upon rapid opening of the throttle, the sudden increase in pressure seats the valve disk **165***b* against its upper seat and closes off the upper part of space **165** so that the fuel is forced up passage **166**. The upper end of space **165** is vented to the gasoline float bowl by a pipe **166***a*. The passage **166** communicates with a removable nozzle **167** (see Figs. 2, 12 and 14) which nozzle extends well out into the upper end of the mixing chamber **68** just below the choke.

It is preferred that this nozzle **167** discharge the accelerating gasoline into the mixing chamber ahead of the Venturi unit **69** so that this stream of accelerating gasoline goes into the air which carries no fuel so that part of it can be more readily vaporized and the remainder will be carried by the air stream into the smaller venturi and there thoroughly mixed with the air and fuel mixture. The mounting of the accelerating gasoline discharge nozzle ahead of the point of entry of the hot mixture into the inner venturi prevents accelerating gasoline from being discharged onto the side walls of the venturi **68***a* or the side walls of the mixing chamber and running down these walls, and permits the use of less gasoline for a given acceleration. It also eliminates stratification which would be apt to occur if the accelerating nozzle discharged beyond or into the inner venturi.

One form of anti-detonation unit is shown more or less schematically in Figs. 1 and 20 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 manifold or to the intake conduit on the engine side of the

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 to 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.

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.

Fig. 21 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 Fig. 22 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 peaned 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 Fig. 20, 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 pre-determined 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 Figs. 21 and 22 have one advantage over the unit of Fig. 20 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 Figs. 21 and 22 may include a cooling fluid if desired.

In extensive tests, including dynamometer runs and installations on various trucks run under varied conditions (including heavily loaded light trucks which run quite hot), the present invention has proved to be flexible in operation, to have high efficiency coupled with full power or torque throughout the operating range, and in general to fulfill the several objects set forth herein.

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 specific 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.

A number of modifications will be obvious to those skilled in this art. For example, as noted herein, the apparatus may be simplified considerably to include one float bowl, etc. to use only one fuel, such as cheap or low grade gasoline or similar relatively volatile fuel. In the two-fuel apparatus, the main fuel supply or float bowl for the vaporizer-heater may be separate from

the auxiliary volatile fuel supply or bowl. Conventional power jets may be used if desired. Other types of accelerating units may be employed for the volatile fuel. Certain units may be omitted if desired, for example, for marine engines. In general it will be apparent that the present disclosure may be modified to suit various types of installations (such as for up draft carburetor systems) and that various features claimed herein may be useful per se or in other engine applications within the scope of the present invention.

I claim:

1. In combination, a carburetor mixing chamber for an internal combustion engine air intake conduit having a posterior throttle, main fuel means supplying said mixing chamber with a highly heated rich mixture consisting of a small part of the total air supply and vaporized and finely divided oil or the like at a rate varying with the mixing chamber suction, and auxiliary compensating fuel means concurrently and always supplying said mixing chamber with unheated gasoline or the like at an automatically controlled and limited rate which is relatively constant during normal running.

2. In combination, a mixing chamber for an internal combustion engine air intake conduit having a main regulatable throttle valve therein beyond said mixing chamber, main fuel means supplying said mixing chamber with a highly heated rich mixture consisting of a small part of the total air supply and vaporized fuel at a rate varying with the mixing chamber suction, and auxiliary compensating fuel means concurrently supplying said mixing chamber with gasoline or the like at an automatically controlled rate which increases to a limited, relatively constant value for normal running conditions.

3. In an internal combustion engine, an induction intake conduit carrying the main air supply and having a mixing chamber including a venturi, main fuel means supplying a hot, super-rich air-fuel mixture into said venturi, and auxiliary fuel means concurrently supplying unheated volatile fuel into said venturi.

4. In combination with an internal combustion engine having an exhaust conduit, an induction intake conduit, means to supply said intake conduit with a high temperature, super-rich mixture of vaporized fuel and air at a rate varying substantially with the intake suction, and including a mixture heater associated with said exhaust conduit to be heated thereby and exhaust gas regulating means to hold said mixture at a substantially constant temperature, and auxiliary fuel means to supply said intake conduit concurrently with volatile fuel at a rate which increases with engine speed to a relatively constant, limited value for normal running conditions so that the volatile fuel is a large proportion of the total fuel supply at low speeds with this proportion decreasing with engine speeds to match substantially the small amount of exhaust heat available at low speeds, and which amount of heat increases with engine speed until it is limited or regulated by said exhaust gas regulating means to a substantially constant value.

5. In combination with an internal combustion engine having an induction intake conduit, main fuel means including a heated passage carrying a small part of the total air supply into said intake conduit and carburetor means to meter and mix fuel in said passage to supply a hot, rich mixture of air and vaporized fuel to said intake conduit at a varying rate, a reservoir for oil or the like, a reservoir for gasoline or the like, means to connect one or the other of said reservoirs to supply said carburetor means, and compensating fuel means connected to said gasoline reservoir concurrently supplying said intake conduit at a substantially constant rate during normal running.

6. In combination with an internal combustion engine, an exhaust conduit, an induction intake conduit having a mixing chamber, a passage carrying a small part of the total air supply to said mixing chamber, carburetor means to meter and mix the principal fuel supply into said passage at a rate varying with suction therein, an exhaust heater operatively associated with said exhaust conduit and with said passage to heat and vaporize the rich fuel mixture therein, auxiliary carburetor means to supply concurrently a relatively small compensating flow of unheated volatile fuel to said mixing chamber at a relatively constant rate, and a single throttle in said conduit regulating both fuel supplies.

7. In combination with an internal combustion engine intake conduit having a mixing chamber and a posterior throttle, means to supply said mixing chamber with light, volatile fuel at a limited and relatively constant rate during normal running, and means to supply said mixing chamber concurrently with a variable flow of high temperature mixture consisting of the main fuel supply of finely divided and vaporized heavy fuel with less than 10% of the total air supply.

8. In combination, an internal combustion engine having an intake conduit having a main regulatable throttle valve therein and operatively associated, multiple fuel carburetor apparatus including jet means to supply said conduit ahead of said throttle valve directly with light, volatile fuel at a limited and relatively constant rate for compensation during normal running and at a variable rate for idling at low engine speeds, and main fuel supply jet means discharging into a separate, long, heated passage communicating with said intake conduit ahead of said throttle valve to mix heavy fuel with a small portion of the total air supply in said passage at a rate controlled by said throttle and varying with intake conduit suction.

9. An internal combustion engine having an intake conduit Venturi mixing chamber carrying a closely adjacent multiple fuel carburetor unit including a reservoir for volatile fuel and a reservoir for heavy fuel, means including jets for supplying auxiliary volatile fuel from its reservoir to said mixing chamber, means including a heater-vaporizer for supplying a high temperature, super-rich, air-fuel mixture to said mixing chamber, and means to supply fuel from either of said reservoirs to said heater-vaporizer.

10. In combination with an internal combustion engine having an exhaust conduit and an induction air intake conduit having a Venturi mixing chamber, a heat exchanger including a long, heated passage carrying a small part of the total air supply to said mixing chamber, carburetor means to meter and mix the main supply of fuel into said passage adjacent its entrance at a rate varying with mixing chamber suction, said heat exchanger being operatively connected with said exhaust conduit to heat and vaporize the fuel mixture in said passage, and means to regulate the flow of exhaust gases to said heat exchanger in accordance with the exhaust temperature and the exhaust flow rate to maintain

said fuel mixture at a substantially constant temperature during normal running.

11. In combination with an internal combustion engine, an air intake conduit having a mixing chamber venturi, means to inject a highly volatile fuel into the air stream in said conduit ahead of said mixing chamber venturi during periods of acceleration, and means to supply said mixing chamber venturi with a highly heated, rich mixture consisting of a small part of the total air supply and the main fuel supply.

12. An internal combustion engine having an exhaust conduit and an induction intake conduit with a mixing chamber venturi and a following throttle therein, means operated by the opening of said throttle to inject a highly volatile fuel into the intake conduit air stream ahead of said venturi, means including a passage to supply said mixing chamber venturi with a rich mixture of the main fuel supply of heavy fuel, such as oil, with a small part of the total air supply, and means connecting said exhaust conduit to heat the mixture passing through said passage to a high temperature and including exhaust gas flow regulating means to maintain said mixture temperature substantially constant.

13. In combination with an internal combustion engine having an exhaust passage and an induction intake passage, an air cleaner at the entrance to said intake passage, a mixing chamber in said intake passage having venturi means to meter the air supply, a separate passage drawing a small part of the total air supply through said air cleaner, venturi and jet means to meter and mix the main fuel supply into said passage to form a rich mixture, and said passage including a vaporizer-heater connected with said exhaust passage to heat said rich mixture and being connected to discharge into the Venturi means in said mixing chamber.

14. A mixing chamber for an internal combustion engine intake conduit, a multiple Venturi set therein, a separate small conduit discharging a hot, rich mixture consisting of the main fuel supply and a small part of the total air into the throat of a smaller venturi of said set, and means for discharging auxiliary liquid fuel into said throat.

15. In combination with an internal combustion engine having an intake conduit, means including a separate heated passage for supplying said conduit with a rich hot mixture of the main fuel supply with a small part of the total air supply, and means including a different size fixed metering jet for each fuel for alternatively supplying light or heavy fuel to said first means.

16. In an internal combustion engine having an induction intake conduit, means to supply said conduit at a variable rate with a high temperature, super-rich mixture consisting of the main fuel supply and a small part of the total air supply, means to supply said conduit concurrently with liquid volatile fuel during periods of acceleration, means to supply said conduit with a limited flow of liquid volatile fuel for idling of the engine, and a single throttle means for said conduit beyond the entry points for all said fuel supply means.

17. In an internal combustion engine having an induction intake conduit with a regulatable throttle valve, means to supply said conduit ahead of said throttle valve at a variable rate with a high temperature, super-rich mixture consisting of the main fuel supply and a small part of the total air supply, means to supply liquid volatile fuel to said conduit ahead of said throttle valve concurrently for idling of the engine, during periods of acceleration only, and at a limited relatively constant rate for compensation.

18. In an internal combustion engine, means for supplying said engine with its main varying fuel supply of a rich mixture of air and light or heavy fuel, said means including a long heated passage and a jet for each fuel, and a single common economizer for varying the engine's air-fuel ratio comprising means regulating the metered admission of diluent quickly responsive to engine load-speed conditions and calibrated to give the desired lean mixtures for part load conditions and rich mixtures for heavy load or top speed conditions, thus eliminating the need for a power jet for each fuel and correcting for the lag due to said long passage.

19. In an internal combustion engine embodying an intake conduit supplying the major part of the required air and having a throttle, means, including a long heated passage, supplying said conduit with a metered varying main fuel supply comprising a hot super-rich mixture of a small part of the total air and vaporized and finely divided oil, and a quick-acting economizer for varying the engine's air-fuel ratio comprising a calibrated valve regulating a metered admission of small amounts of additional air into said intake conduit, and means actuating said valve responsive to throttle positions and load-speed conditions to quickly give the desired lean mixtures at part throttle and part load conditions and rich mixtures for heavy load or full throttle conditions.

20. The organization set forth in claim 19 in which the economizer supplies its additional air to said intake conduit through a circularly arranged set of tangentially directed openings to cause a swirling in said intake conduit and increase the turbulence therein.

21. In combination, an internal combustion engine embodying an exhaust conduit and an intake conduit, means to supply said intake conduit with a high temperature, super-rich mixture of oil and a small part of the total air supply, and anti-knock means admitting a small amount of exhaust gas from the exhaust conduit to the intake conduit only at full load conditions.

22. For use with an internal combustion engine having an exhaust conduit and an air intake conduit including a mixing chamber; means for supplying said mixing chamber with a highly heated, super-rich air-fuel mixture comprising a separate vaporizer-heater including an exhaust gas passage with inlet and outlet connections therefor and a mixture heating passage with air inlet and mixture outlet connections therefor and carburetor means associated with said mixture air inlet to meter and mix fuel in said passage, said mixture passage being continuously substantially horizontal or slightly downhill from its carburetor to its discharge into the intake conduit mixing chamber so that there are no upward bends, traps, dams, or the like to collect pools of fuel.

23. In combination, an internal combustion engine embodying an induction intake conduit, a mixing chamber section forming a part of said intake conduit and having a venturi therein, a carburetor float bowl unit alongside of and carried by said mixing chamber section, and means including a separate passage for supplying said mixing chamber with a high temperature, super-rich air-fuel mixture comprising a separate vaporizer-heater unit having a tortuous and substantially horizontal mixture passageway there-

in, an air inlet connection, a venturi therein adjacent to and only slightly above the fuel level in said float bowl, means including a jet supplying fuel from said bowl to said passage venturi, and a mixture discharge connection opening into the mixing chamber venturi closely adjacent the fuel level in said float bowl.

24. In combination, an internal combustion engine induction intake conduit having a single main regulatable throttle valve therein, said conduit supplying most of the total air and being substantially unheated to obtain a high volumetric efficiency, main fuel means including a separate pipe supplying said conduit ahead of said throttle with a hot super-rich mixture consisting of the remaining small part of the total air supply and vaporized fuel, and auxiliary fuel means concurrently and continuously supplying said conduit ahead of said throttle with unheated liquid gasoline or the like, both fuel means being controlled by said throttle.

25. In combination with an internal combustion engine having an induction intake conduit including a main Venturi mixing chamber, main fuel means including a separate heated long passage substantially horizontal throughout its length to avoid any liquid fuel-collecting upward bends, traps, dams, or the like, and including a primary Venturi mixing chamber adjacent its entrance to supply said main mixing chamber with a hot, rich mixture consisting of fuel and a small part of the total air supply, and means to supply said primary mixing chamber with either of two types of fuel.

26. In combination with an internal combustion engine having an exhaust conduit and a substantially unheated induction intake conduit carrying a major part of the air supply and including a mixing chamber venturi, means to supply volatile fuel directly to said venturi during normal running, and separate means, including an exhaust heater, to concurrently supply said venturi with a high temperature mixture consisting of less than 10% of the total air supply and carrying the main fuel supply in finely divided and vaporized form.

27. In combination with an internal combustion engine having an exhaust conduit and an air intake conduit including a main mixing chamber, means for supplying said mixing chamber with a highly heated, super-rich mixture consisting of a small part of the engine's total air supply and the main fuel supply, said means including a connection into said mixing chamber, a vaporizer-heater having a long, tortuous mixture heating and liquid fuel vaporizing passage therein and being connected with said exhaust conduit to be heated thereby, and air and liquid fuel supply and mixing means at the entrance to said passage, said first means, including said connection and said mixture heating passage, being substantially horizontal and flat from end to end to avoid any liquid fuel-collecting upward bends, traps, or the like.

28. In combination with an internal combustion engine having an exhaust conduit and an air intake conduit, including a main mixing chamber carrying the engine's main air supply, means for supplying said mixing chamber with a highly heated, rich mixture consisting of a small part of the engine's total air supply, and the main fuel supply in vaporized form, said means including an inlet for air and liquid fuel, a discharge connection into said mixing chamber, and a separate vaporizer-heater having therein a long, tortuous, mixture heating and liquid fuel vaporizing passage, said heater being jacketed and connected with said exhaust conduit to be heated by exhaust gases, and said heater being formed of detachably secured parts so that it may be readily opened to expose the mixture heating passage for cleaning, said means, including said mixture heating passage, being substantially horizontal and flat from end to end so that there are no liquid fuel collecting or trapping upward bends, dams, or the like.

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