O. H. ENSIGN.

METHOD OF AND MEANS FOR PRODUCING EXPLOSIVE MIXTURES OF AIR AND FUEL.

APPLICATION FILED JULY 5, 1917.

1,408,277. **Patented Feb. 28, 1922.**

2 SHEETS—SHEET 1.

Fig. 2.

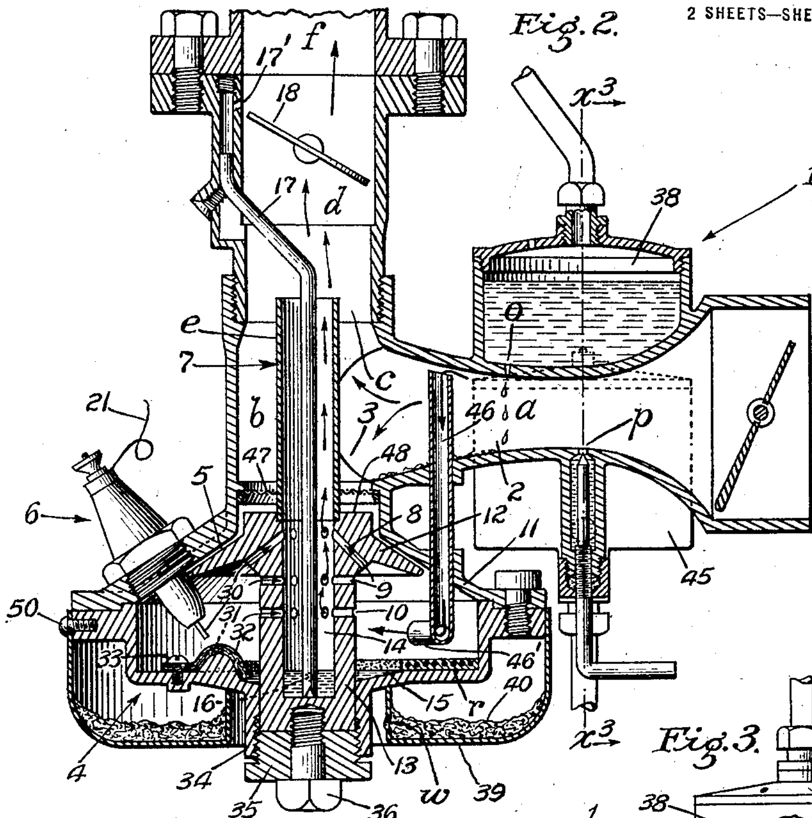
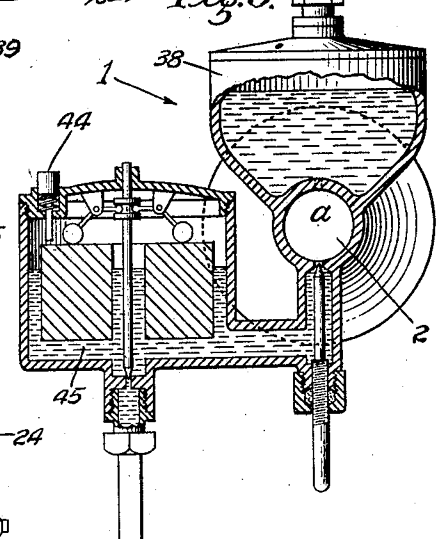


Fig. 3.



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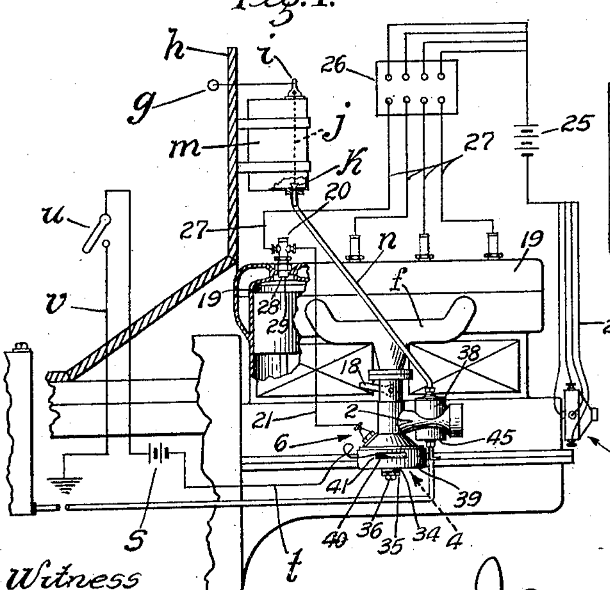

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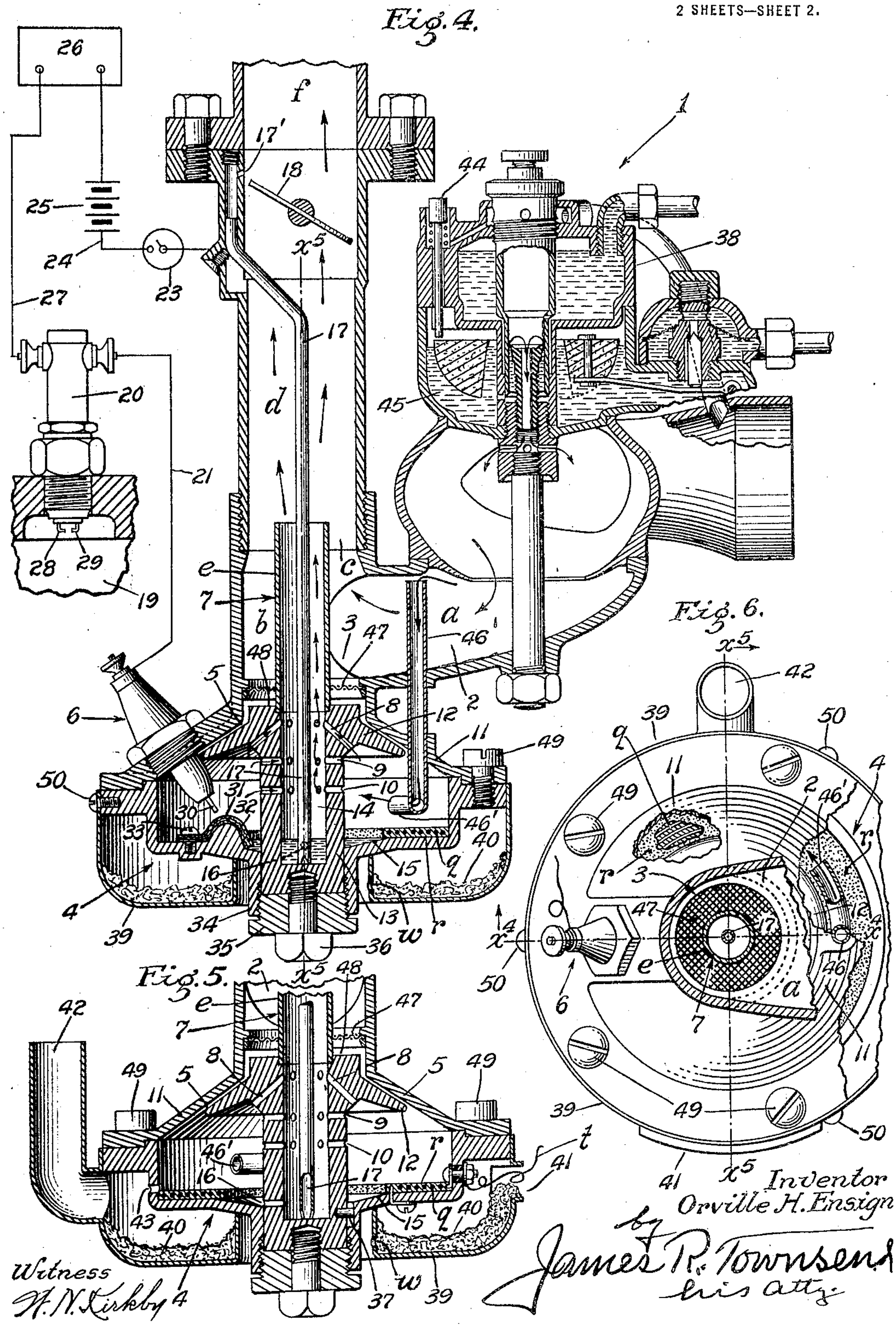

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UNITED STATES PATENT OFFICE.

ORVILLE H. ENSIGN, OF PASADENA, CALIFORNIA.

METHOD OF AND MEANS FOR PRODUCING EXPLOSIVE MIXTURES OF AIR AND FUEL.

1,408,277. Specification of Letters Patent. **Patented Feb. 28, 1922.**

Application filed July 5, 1917. Serial No. 178,869.

To all whom it may concern:

Be it known that I, ORVILLE H. ENSIGN, a citizen of the United States, residing at Pasadena, in the county of Los Angeles and State of California, have discovered and invented a new and useful Method of and Means for Producing Explosive Mixtures of Air and Fuel, of which the following is a specification.

I have made an improvement in the art of developing power from mixtures of air and fuel. I have discovered and invented a new process and means to perform the same for making a new form of explosive fuel for operating internal combustion motors and for other uses; and in this behalf have provided means whereby kerosene or other heavy liquid fuel and air are introduced together into a passage where a mixture of said air with lighter portions of said liquid fuel will be formed and a portion thereof caused to flow on as carbureted air and a portion of such carbureted air will be diverted and, together with any portion of the heavier liquid fuel which may also be diverted, will be ignited and partly combusted, and the products of the partial combustion will be extinguished and the products after extinguishment will be returned, beyond the point of diversion, to said onflowing carbureted air as a fixed gas with portions of free carbon and will be mixed with said onflowing carbureted air and will thus produce a new form of explosive fuel, characterized as a highly mobile and stable fluid mixture of vaporized fuel and fixed gases remaining well mixed even at moderately low temperatures, thus avoiding the high temperatures heretofore necessary to handle these low grade fuels.

By this means I have made it possible to immediately put a cold internal combustion engine into full power on the heaviest grades of petroleum distillates with a very small priming charge of gasolene, and to maintain such engine in operation indefinitely with such heavy grades of fuel with high economy of maintenance and fuel.

An object of this discovery and invention is to supply to internal combustion engines an explosive mixture made from air and liquid fuel which will cause the engine to operate more smoothly and with greater power than has heretofore been possible with the use of the same amount of corresponding fuel.

An object is to utilize kerosene and other low grade distillates in the operation of internal combustion engines, at the same time insuring greater flexibility of power production and application.

The invention may be carried out and the method conducted in various forms of apparatus adapted to add to a combustible mixture of air and fuel an increment of hot gas before introducing the mixture to the place of combustion.

A feature consists in supplying air and fuel in combustible proportions to a passage, producing a mixture from such air and fuel in said passage, diverting portions of said air and fuel to an enclosed space outside of said passage, and conducting the rest of the mixture onward igniting the diverted fuel and air and thereby producing hot gaseous fuel in said enclosed space extinguishing the combustion and then delivering said hot gaseous fuel to said mixture at a point from whence it can be conducted to the place of final combustion.

An object is to provide for adjusting the amount of fuel diverted to the gasifying chamber so as to supply the required amount of hot gaseous fuel to suit the different conditions imposed by various internal combustion engines.

An object is to utilize kerosene in gasoline engines without likelihood of pre-ignition. This is accomplished by adding to the mixture of liquid fuel and air, an increment of inert and slow burning gases.

This invention includes an appliance to be interposed between a carbureter or other proportion metering device and the inlet valve of an internal combustion engine for the purpose of acting upon the mixture of fuel and air produced by the carbureter or metering device and which is to be supplied to the cylinder of the internal combustion engine.

An object of this invention is to make practical use in an engine adapted to gasoline, of fuel of a more viscous or less volatile character, such as kerosene and other hydrocarbon distillates and alcohols and the like.

A great difficulty in handling mixtures of air and kerosene or other similar low grade fuels for internal combustion engines is in conveying them through manifolds or pipes from the carbureter and delivering them to the cylinder in an evenly distributed manner both with respect to the uniform density of mixture and with respect to an even distribution to all the cylinders. At any ordinary temperatures kerosene does not vaporize sufficiently for power production in a gasolene engine, and if the necessary vaporizing temperature is produced by such considerable heating of the pipes as is necessary to vaporize all the kerosene, the resulting temperature of the mixture of air and kerosene reaching the cylinders is so high that the weight of the air entering the cylinder is so small that a great reduction of engine capacity results. In this invention the temperatures are much lower as will hereinafter more particularly appear.

This difficulty is overcome by diverting from the initial mixing passage, a portion of the mixture of air and fuel together with some of the heavier bodies of the fuel, and by means of partial combustion, converting them into a fixed gas; utilizing the heat developed by said partial combustion to vaporize other heavy bodies from the initial mixture; mingling the hot gas from said partial combustion and the hot vaporized portion of the fuel with that portion of the fuel which is sufficiently atomized by the metering device to cause it to be supported by the flowing air. Upon this atomized mixture coming into contact with the mixture of hot fixed gas and hot vaporized fuel, there results a fog-like mixture of air, fixed gas and suspended liquid fuel at a regulatable moderate temperature sufficiently high to enable the mixture to flow evenly throughout the engine manifold and to enter each engine cylinder as a homogeneous explosive mass, thus supplying uniform charges to all the cylinders.

Such a mixture made with kerosene having a dry boiling point of 600° Fahrenheit will flow evenly to all the cylinders, and, at a temperature as low as 160° Fahrenheit, will be highly explosive, producing the required result.

In the operation of internal combustion engines with different grades of fuel, different temperatures of the mixture to suit the different grades of fuel are necessary for perfect results; and an object of this invention is to provide means whereby the requisite temperature will be automatically developed by the forces liberated during the operation, so that when the appliance has been adjusted to the correct temperature for utilizing kerosene or other extremely low grade fuel, and a fuel of a higher grade is introduced instead, such fuel will set up its own required temperature without any attention or manipulation on the part of the operator.

This invention is an appliance adapted to be used in connection with various carbureters of well known construction although in applying the device to a carbureter said carbureter may be built over or changed in form to receive the device without in any way interfering with the principles of the operation of such carbureter.

A feature of the invention is thermal regulation of the amount of hot gas produced by the operation of the physical elements involved and the temperature attained by the final mixture to meet the conditions imposed by different grades or gravities of liquid fuel used.

This result is automatically brought about by the arrangement of and shapes of the passages of the apparatus whereby the nature of the combustible is made to perform a selective operation suitable to the composition and constituent components.

Further objects, advantages and features of invention may appear from the accompanying drawings, the subjoined detail description and appended claims.

The nature of this discovery and invention may be understood by reference to the accompanying drawings.

Figure 1 is a diagrammatic representation of an internal combustion engine mounted in an automobile and embodying this invention and adapted for use in carrying on the method above stated. Parts of the engine and an automobile dash-board are shown in section.

Fig. 2 is a mid-sectional elevation of an embodiment of the invention applied with a typical metering and mixing device.

Fig. 3 is a fragmental sectional elevation on line x^3, Fig. 2.

Fig. 4 is a sectional elevation of the invention applied with a metering device of a more elaborate character than that shown in Figs. 1, 2 and 3. Fuel is shown as the same might appear when the apparatus is just starting into operation. The electrical ignition system is diagrammatically shown.

Fig. 5 is a fragmental sectional elevation of the apparatus of line x^5, Figs. 4 and 6.

Fig. 6 is a fragmental plan of the gasifying chamber. Parts are broken away to show interior construction.

In the drawings alternative fuel pre-heating means are shown for the purpose of dispensing with the need of gasolene for starting and it is understood that where an electric starter for the engine is used, or any other adequate electric current is available, an electric heater in the gasifying chamber is sufficient for starting the gasifier and engine into operation.

Wherever the term metering device is used in this specification, it is understood to mean any device for measuring out the correct amount of fuel at any instant of time, to make a proper mixture with the air flowing at that instant.

In the form shown in Fig. 2 the metering device is of the Venturi tube type so arranged that the quantity of fuel drawn into the apparatus is proportional to the quantity of air drawn in. In the form shown in Fig. 4 the metering device is of the vertical type in which the quantity of fuel drawn by the vortex is proportional to the quantity of inflowing air which produces the vortex.

In the several views, 1 indicates in a general way metering means whereby the air and liquid fuel, such as kerosene and other heavy distillates, and also gasoline, benzine, alcohol and other light fuels may be metered and measurably mixed. 2 indicates a passage to which the fuel and air is delivered from the metering means. 3 indicates means for diverting from the passage an increment of fuel. 4 indicates a gasifying chamber; 5 a way for conducting the fuel increment from the passage to the gasifying chamber. 6 indicates means, as a spark plug, for igniting the diverted fuel in said chamber. 7 indicates a flue connected by orifices 8, 9 and 10, with the gasifying chamber. Said flue discharges into the passage 2 beyond the point of diversion indicated at 3. Said passage 2 is bent at the point of diversion and comprises a horizontal limb *a*, a bend *b*, a throat *c* and an onward extension *d*. The flue 7 opens into said extension *d* beyond the throat *c* and serves to choke said throat to produce back pressure in the throat *c*, so that the diversion of the fuel at 3 is accompanied by a flow of air or mixture of fuel and air downward through the way 5, which is made narrow and is extended downward a considerable distance so as to avoid back firing in the way 5, that would otherwise be likely to occur when the fuel in the gasifying chamber is ignited.

Said way 5 is a frusto-conical annular slit extending between the top wall 11 of the gasifying chamber and a hollow frusto-conical or umbrella-shaped spreader or distributer 12 that is supported by a central tube 13 in which the orifices 8, 9, 10 are provided to lead gas from the interior gasifying chamber below the distributer 12 to the central bore 14 of said center tube 13; said tube being supplemented by a nipple *e* which together with the bore 14 forms the flue 7.

The bottom of the gasifying chamber is provided with a central depression 15 which discharges through a drain 16 into the lower end of the bore 14, that extends somewhat below the level of the drain 16 to form a well to supply liquid fuel to the bottom of the starting and idling tube 17, which extends upward therefrom and discharges into the engine manifold *f* that is a continuation above the throttle 18 of the passage 2 which at this point merges into the engine manifold *f* that leads to the place of combustion under pressure; namely, the engine cylinder 19, where ignition is effected in a desired way by the series spark plug 20, in circuit through the leads 21, with the spark plug 6 of the gasifying chamber, and thence through the metal walls of the device, the timing mechanism 23, lead 24, battery 25, induction coil 26, lead 27 and the spark points 28, 29, thus completing the circuit. The lead 27 is connected to spark point 28 and the spark point 29 to the lead 21.

Ignition in the gasifying chamber is effected by a spark point 30 and a conductor wick, constructed of asbestos 31 enclosed in a fold of wire gauze 32 and clamped by a binding screw 33, to the floor of the chamber 4 so that a high tension circuit having two spark gaps is completed as above stated.

The timing mechanism is operated in the usual way by the engine mechanism, so that at intervals during the operation of the engine, sparks are produced inside the gasifying chamber, thereby insuring an early and continuous ignition. It is understood that this operation after combustion has started in the gasifying chamber, will continue until the engine is stopped, and that continued combustion is not dependent on the operation of the spark plug.

The dimensions of the way 5 may be changed by adjusting the height of the spreader 12; and in the form shown, this is effected by the construction now to be described. The depression 15 of the gasifying chamber terminates in a tubular downward extension 34, and said tubular down extension is threaded at its lower end to receive a threaded plug 35 and is clamped thereto by a cap screw 36 inserted through the plug 35 and screwed into the lower end of the support 13. Support 13 is notched to receive a key 37 to prevent relative rotation between the support 13 and the gasifying chamber.

To adjust the way 5, the cap screw 36 will first be loosened and then the plug 35 may be screwed up or down to decrease or increase the width of the way, and by tightening the set screw 36, the distributor is held firmly in place.

Ignition, in an engine cylinder, of slow vaporizing or heavy liquid fuels, such as kerosene and other hydrocarbon distillates, alcohol and the like, is not practicable at ordinary atmospheric temperatures by means of a sparking device. For this reason the appliance is provided with means by which the engine may be supplied with a priming liquid such as gasoline at the outset in order to start the engine to turning so that from its own power it will cause the sparking system to work. To this end a priming device 38 is connected to supply gasoline to the engine at the outset.

Said gasoline supply means is adapted to supply a priming charge of gasoline for the purpose of starting the engine before vaporization of the more viscous fuel is effected.

Referring now to Fig. 1, *g* is a priming rod extending through the dash *h* and connected to the tilting toggle *i* which is connected by connection *j* with a valve *k* to discharge gasoline from the tank *m* through the pipe *n* and the priming chamber 38, which is of sufficient size to contain the charge of gasoline requisite for starting the engine into operation while the more viscous fuel becomes heated.

Referring to Fig. 2, the gasoline flows from priming chamber 38 through the small port *o* into the passage 2 which in that view is a Venturi tube. A portion of said charge sufficient to fill the depression 15 and the lower end of the well 14 will run down the Venturi tube and through the way 5 into the gasifying chamber 4, and will fill said depression and the lower part of the well. Then the engine may be turned over and the suction thereof will suck up the gasoline from the well through the starting and idling tube 17 and the small port 17′ above the throttle 18, and thence to the engine cylinder; thus enabling the engine to start at once. A spark at 30 will immediately be produced as the engine operates, thus igniting the gasoline which may have been absorbed by the wick 32, and thereupon the gasifier will be started into operation. The suction of the engine causes the metering device to supply the more viscous fuel through the spray nozzle *p*, and the more volatile portion of such fuel taken up by the air while heavier particles fall to the floor of the passage tube and flow onto the screen 47 and are thereby distributed upon the table 48 upon which they fall and from thence flow down over the spreader 12 and into the gasifying chamber, where they are acted upon by the heat of the combustion occurring therein. Such combustion raises the temperature of all the parts thus making possible the objects aimed at as will hereinafter more fully appear.

As a simple means for producing from the heavy fuel a highly inflammable mixture to start the engine without the necessity of using gasoline, I provide a heating pan 39, having at its bottom an asbestos wick 40, and having inlet 41 and stack 42 on opposite sides of the pan; and I provide a small drain 43 (see Fig. 5) opening through the floor of the gasifying chamber at a level above the rim of the depression 15; so that on priming the gasifying chamber with heavy fuel from the metering means by depressing the priming pin 44, the heavy liquid fuel will flow from the fuel reservoir 45 into the passage 2 and find its way to the gasifying chamber 4 filling the depression 15 and then flowing through the drain 43 into the pan 39, where said fuel may be ignited by inserting a lighted match or the like through the draft opening 41. A drain hole *w* prevents overloading the pan 39. A draft of air will flow through the pan to the stack 42, thus allowing combustion to occur freely and the heat thus generated will in a short time cause the liquid fuel in the depression 15 and in the bottom of the bore of the tubular support 13 to boil; so that when the engine turns over, the boiling liquid in the well and depression will be sucked up the starting tube 17, and vapor from the gasifying chamber will be sucked up the flue 7 into the portion *d* of the passage 2; and the fuel thus supplied for the engine cylinder will be drawn thereinto as the engine is turned over. Immediately the engine turns over, sparks occur at the spark points 28, 29 and 30, thus igniting the fuel which is in the gasifying chamber and that which is in the engine cylinder. For automobile engines and the like it is important that ready means for instant starting at full load be provided, and the gasoline priming device or an electric heater is therefore deemed very necessary in all such engines though not so necessary for stationary or marine engines.

By the means just described, in case the gasoline supply be exhausted, heat from the combustion in the heating pan and in the gasifying chamber is sufficient to make it possible to start a cold engine into immediate action without the use of gasoline or any other highly volatile liquid fuel.

When the engine is running, air as well as liquid fuel flows down the way 5 into the gasifying chamber; but it has been noted, that an excess of fuel flows down the side nearest the metering means and an excess of air flows down the other side and that in consequence thereof, combustion on the side nearest the metering means is not so complete as on the other side, so that unless remedied, sooty deposits may form on one side while on the other side the gasifying chamber may become too hot.

As a means to correct these conditions, I have provided an air by-pass 46 leading from the upper portion of the passage 2 and opening into the chamber 4 on the side nearest the metering means, so that the supply of air is at that point increased. In order to perfectly distribute the air and fuel in the gasifying chamber, and to cause even combustion throughout the chamber, the air by-pass 46 discharges into the chamber 4 through a tangential outlet 46′ thus setting up a whirling action of air, fuel and flame in the gasifying chamber, thereby producing an even mixture of highly inflammable products of partial combustion that are drawn out through the orifices 8, 9, 10 into the flue 7.

The inlet end of the by-pass tube is arranged near the top of the passage 2 where the air will be comparatively free from the heavier fuel so that comparatively pure air is delivered to the gasifying chamber to regulate the combustion and to facilitate control of the temperature.

The diverter 3 is provided with a screen 47 and a distributing table 48 from which liquid may flow more or less evenly to all parts of the frusto-conical annular way 5 and consequently to the gasifying chamber.

The gasifying chamber as shown is constructed of upper and lower members fastened together by several cap screws 49, and the heating pan is held in position under the gasifying chamber by machine screws 50.

The gasoline auxiliary supply for starting the engine and gasifier into operation is regarded as necessary only to fit the device for convenient use with engines which are not provided with storage batteries, or when no electrical supply sufficient for heating an electrical unit in the gasifier is available.

The electrical heating unit in the gasifier may be of any suitable construction and in the drawings is shown as a coil *q* enclosed in a heat conducting electrical insulator *r*. Said unit is so located that the fuel from the spreader will drip onto the unit when the gasifier is primed by operating pin 44. The heating unit is indicated as being connected with storage batteries through the lead *t*, switch *u*, and lead *v* that is grounded to the gasifying chamber with which the electrical heating element is likewise grounded.

In starting the engine with the electrical heater, the operator will first depress the priming pin 44 to cause a flow of heavy fuel into the gasifying chamber, then he will close the switch *t*, thus causing the heating unit to immediately heat up so as to produce a hot vapor from the kerosene. Thereupon, by turning over the engine, these hot vapors will be sucked into the engine and the engine will start in the usual way. Simultaneously therewith the spark at the spark point 30 will ignite the vapors, thus causing the gasifier to operate from the heat generated by combustion therein.

Assuming that the apparatus is attached to an automobile engine and is standing cold, the practical operation of the device is as follows when gasolene is used for starting.

The operator by pulling the priming rod *g* fills the priming chamber 38 with a small charge of gasoline which begins immediately to flow by gravity through the diverting means 3, thence to the table 48 over the surface of the spreader 12 whence it falls into the gasifying chamber 4, filling the depression 15 and the bottom of the well 14. The engine may then be started on straight gasoline by cranking, the gasoline being drawn through the starting tube 17, and issuing from port 17′ into the manifold *f* as a highly atomized spray, thus making the engine start easy. After the engine has started and continues to run in the idling position, this tube 17 will prevent the accumulation of excess fuel in the combustion chamber and therefore the production of a corresponding rich mixture, so that when the engine is cold it will build up quickly to a high temperature and when idling continuously after it is hot, will maintain the higher temperature desired for idling, and flexibility as compared with the lower temperature produced under load. Immediately the engine begins to turn, a spark is produced at spark point 30, igniting the fuel in the asbestos and wire wick 31, 32. Simultaneously with these operations the heavy fuel, such as kerosene, begins to issue from the jet *p* and flows with the air through the passage 2 in a more or less atomized form. Heavy particles of the fuel as it is blown along will fall to the floor of the passage 2 and will be blown onto the screen 47, dropping thence to the table 48 and flowing more or less evenly over the distributer 12 and falling into the gasifying chamber there to continue the partial combustion already started with the gasoline charge.

The air from the top of the by-pass tube 46 being more or less free from fuel, aids combustion and the direction given to it by entering the gasifying chamber through the tangential opening 46, causes the flaming elements in the chamber to take on a whirling motion which promotes an even distribution of combustion throughout the chamber. After a few moments, the table 48, the spreader 12 and the flue 7, get extremely hot and some of the heavy bodies of fuel strike these hot surfaces and, expanding as vapors, move along through the passage *c*, as such, with that portion of the lighter bodies of fuel which remains atomized after issuing from jet *p*. The suction at the top of the flue 7 is intensified by the obstruction of the passage *c* at that point by said flue, and at each suction stroke of the engine a draft is thereby produced through the diverter 3, the gasifying chamber 4, the orifice 8, 9 and 10 and up through the flue 7. Such suction also causes the air to flow through the by-pass 46. This draft draws the hot products of combustion through the flue and causes these hot gases to mingle with the hot vapors produced by contact with table 48 and the outside of the flue 7 and with the atomized fuel flowing on the air stream; the result being that when the cooler air containing the atomized fuel, mingles with vaporized fuel and hot gas, all of the fuel, vaporized or atomized, turns into a fog as distinguished from a rainlike mixture, and forming a true invisible vapor; and, mixing with the hot gas produces a homogeneous well mixed mass of uniform density at a sufficient temperature to heat the manifold or intake pipes so that after a very few minutes none of the mixture will condense, and it all flows into the engine cylinders, in the form of a highly explosive combustible medium. The temperature of this final high explosive mixture is regulated by controlling the amount of fuel drawn into the gasifying chamber 4, and this is done by controlling the draft into the chamber. This is accomplished by adjusting the spreader 12 up or down as may be desired. Raising the spreader diminishes the way 5 and reduces the flow of fuel and air to the gasifying chamber 4 thus reducing the fire and lowering the temperature, and the mixture of fuel and air is also thereby adjusted, because an excess of air flows down the by-pass 46. Lowering the spreader 8 accomplishes the opposite result, creates a greater draft through 5, and draws more fuel and air into the chamber 4.

The distinction herein made between a fog and a true invisible vapor formed from the liquid fuel is that such a vapor is the liquid evaporated into a state of invisibility due to certain conditions of temperature and pressure, and the fog herein referred to is the result of a sudden change in a mixture of air and liquid fuel vapor in relation to the temperature, whereby a measurable condensation of such vapor occurs and liquid fuel takes on the form of microscopic bubbles or particles involving air, which bubbles or particles and the air involved, become en masse visible to the eye. In such product the liquid fuel will remain suspended in the air for an appreciable period of time at comparatively low temperatures, such as from 40° to 150° Fahrenheit, so as not to fully condense or become rain-like before reaching the engine cylinder, and may be readily ignited and caused to explode under pressure or in the open air, by means of an electric spark plug or other suitable igniter.

In starting the engine, whether on gasoline, kerosene or distillates of a character midway between the two, the whole of chamber 4, spreader 12 and flue 7, become hot very quickly, because at first a very large portion of all the fuel flows through and burns in the chamber 4, setting up great heat. Very quickly, however, when this table 48 and the flue 7 become heated, less fuel is diverted, because portions of these heavier bodies, which boil at less than the higher boiling points of the fuel, are vaporized and pass on without going down into the chamber 4. At no time therefore, after starting operation, does any but the heaviest fuel and that which is hardest to combust in the cylinders pass into the chamber 4. Therefore, the most undersirable portion of the fuel for direct use in the engine cylinders is utilized as hot gas to make the remainder of the fuel more effective.

After having adjusted the spreader to get the correct temperature on kerosene, the fuel may be changed to gasoline while the engine is running and the mixture and all the apparatus will immediately cool down. This results from the fact that the gasolene, being more easily vaporized, will, upon striking the top of the distilling table 48, burst into violent distillation, and expanding, will exclude some of the air with which the gasolene is mixed. Also when the apparatus is running, gasoline will be vaporized from the floor of the passage 2 and will cause gasolene mixture to flow down the by-pass tube 46. Both of these phenomena result in a rich mixture in the combustion chamber, which mixture, on account of being short of oxygen and rich in fuel, releases much less heat than is released in case heavier fuel, as kerosene is used; because less explosive distillation will take place with kerosene and more air will then pass into the combustion chamber over the distilling table 48 with kerosene and more air will pass down the by-pass tube 46, so that the combustion is much more violent with kerosene than with gasoline; thus causing mixtures of heavy fuels and air to run hotter in the manifold than the lighter fuels which are necessary for good operation.

By this automatic action the apparatus adjusts itself to the use of any grade of fuel furnished, after having been once adjusted to any particular grade.

In handling low grade fuels it is also desirable that the mixture should be at a very much higher temperature when idling, and at low speeds, than under load, in order, first, that flexibility may be had when maneuvering, and, second that the maximum power may be obtained under load. This apparatus fulfills these conditions. When idling, the great depression above the throttle, operating through the tube and passage 17, keeps the excess fuel drawn out of the combustion chamber, so that a comparatively high temperature of combustion takes place due to a good mixture in the combustion chamber; and there results a high temperature of the mixture in the main mixture passages *a*, *c*, *d* and *f* on account of such good combustion with a small mass of mixture thus passing through the apparatus.

A further characteristic of the apparatus is that it gets hotter as compared with temperature of the atmospheric air in colder weather than it does in warmer weather. When the warmer air is entering the mixing apparatus, a larger percentage of the heavier bodies will be atomized or vaporized and carried on to the manifold *f*. But when cold air enters the mixing device, much of this heavier material will be condensed and will flow into the chamber 4 and will then be gasified, so, in actual practice on cold days the mixture and manifold are supplied with more heat than on warm days. For the same reasons the mixture becomes heated relatively quicker in cold weather than it does in warm weather. Therefore this appliance is a universal device with respect to preparation of all grades of fuels for use in all internal combustion engines, both with respect to the grade of fuel and with respect to the atmospheric conditions.

This is effected by means shown in the drawings; that is to say, on account of stratification of mixture formed from fuel and air in passage *a*, changes of temperature of atmospheric air will not cause corresponding changes in the final mixture; for, in cooler weather the top of the by-pass tube 46 will be in air that is largely free from fuel, because the cold fuel would not be so well broken up in the mixing chamber of the carbureter and would flow along the bottom of the passage *a*, thereby putting more fuel into the combustion chamber and at the same time admitting cleaner air through the by-pass tube 46. This tends to increase the heat of combustion in the chamber to meet the variable atmospheric and load conditions. That is to say, in cold weather, with lowered temperature or increased load, or both, the construction and arrangement shown causes a resultant higher temperature of combustion in the combustion chamber to take place; which tends to sustain the mixture temperature in spite of the change in the temperature of the supplied atmospheric air, or the change of temperature brought about by an increase in the volume of the mixture with its load of fuel. The greater flow of air causes direct cooling effect and vaporization of the fuel in the mixture causes additional cooling due to latent heat of vaporization.

Furthermore the greater the flow of mixture through the throat *c* brought about by opening the throttle with the consequent increase of engine speed, the greater will be the draft through the combustion chamber, with a corresponding greater release of heat, which prevents the lowering of the temperature of the mixture in the manifold with increasing load on the engine, which otherwise would occur to an undesirable degree in spite of the great cooling effect of the increased flow of mixture. At the same time the increased atomization brought about by the greater mixture effect at the higher velocity of the air operates to prevent the load temperature from becoming too high; because under such conditions, the air flowing through by-pass 46 will carry more fuel to the combustion chamber thus producing incomplete combustion due to excess of fuel.

In hot weather, the heat from the combustion chamber will be conducted by the walls of the passage *a* toward the mixing chamber of the carbureter, and these heated walls cause vaporization in such passage, of a larger percentage of the total fuel; furthermore, due to the warmer atmospheric air, the fuel in the mixture will be more readily vaporized under the agitation in the mixing chamber, so that while very little liquid fuel will tend to flow down into the combustion chamber, any such fuel will be already heated and will vaporize quickly as it enters the hot combustion chamber and will also be accompanied by mixture rich in fuel, and at the same time there will be more fuel in the mixture at the top of the by-pass 46, than in colder weather and this will also supply to the combustion chamber a pronounced mixture instead of nearly clean air; and therefore tends to cause a rich mixture in the combustion chamber with a consequent low flame temperature. A small change in the temperature of the mixture results from a comparatively large change in the temperature of the outside atmospheric air.

The construction and arrangement shown in which advantage is taken of the stratification of the mixture flowing in the passage *a*, causes the temperature of such mixture to increase and decrease the heat of combustion in said chamber as compared to the temperature of the admitted atmospheric air. That is to say, in cold weather there is greater stratification and less fuel is contained in that portion of the mixture which reaches the combustion chamber through the by-pass 46.

By the arrangement shown conversion of the fuel to a form better adapted to explosive combustion is effected.

This is brought about by the arrangement of the passage *a* combined with the diversion 3, and way 5 for carrying condensed fuel and mixture into the combustion chamber while at the same time the by-pass 46 delivers cleaner air, to such chamber, and by the arrangement of the flue 7 beyond the bend *b* in the passage *a*, *c*, *d*, which applies the draft to the combustion chamber. It is therefore shown that means operable by the temperature of such mixture, that is the inflowing mixture, will increase and decrease the heat of combustion in said chamber to meet variable atmospheric and load conditions, meeting both tendencies by reacting to lowered temperature to build up combustion.

In freezing weather if the mixing device is supplied with kerosene, one charge of gasoline in the priming chamber 38 is sufficient to place an automobile motor in action under full power, and by the time the one charge of priming fluid in 38 is exhausted, the engine will be working smoothly on kerosene. Tests of the apparatus so far conducted indicate that more power can be obtained by the use of this apparatus from a pound of kerosene than can be obtained from a pound of gasoline as ordinarily used, and with a greater flexibility than is ordinarily obtained with gasoline, and with the further advantage of an absolutely clean motor and spark plugs.

I claim:

1. The method set forth of producing explosive from air and low-grade liquid fuel which consists in first producing a mixture of air and such low grade fuel in proportions adapted to complete combustion, continuously combusting a portion of such combustible mixture and thus producing an increment of hot fixed gas and returning such portion in such gaseous form to the remainder of said combustible mixture, thus producing a final explosive mixture before introducing the same to the place of final combustion.

2. The method set forth of regulating the temperature of mixtures of fuel and air to suit the boiling points of the fuel; which consists in diverting a portion of heavy elements of such fuel downwardly below the level at which the mixture is produced and spreading, heating and combusting said diverted portion of fuel and air at such lower level; the heat released by such combustion serving to vaporize the fuel passing over the place of combustion; so that the degree of such vaporization will control the richness of the mixture in the combustion chamber and thereby cause release of less heat for the lighter fuel than for the heavier.

3. The method set forth of producing an explosive from air and low grade liquid fuel which consists in first producing a combustible mixture of air and such low grade fuel, adding to such combustible mixture an increment of hot gas and thereby producing the explosive before introducing the combustible to the place of final combustion, said hot gas being the resultant of partial combustion of a heavy portion of the liquid fuel so that the heating power of such combustion will vary as the character of the fuel varies.

4. The method set forth of producing an explosive from air and heavy liquid fuel which consists in continuously supplying to a passage, air and fuel in proportions adapted to complete combustion; producing a mixture from such air and fuel in said passage; diverting a portion of said fuel and a portion of said mixture of air and fuel to an enclosed space outside of said passage; igniting the diverted fuel and thereby producing hot fixed gas in said enclosed space; and delivering said hot fixed gas to the remainder of original combustible mixture at a point from whence it can be conducted to the place of final combustion.

5. The method set forth of producing an explosive from air and heavy liquid fuel which consists in continuously supplying to a passage, air and fuel in proportions adapted to complete combustion; producing a mixture from such air and fuel in said passage; diverting some of the heavier portions of said fuel and some of said mixture of air and fuel to an enclosed space outside of said passage; igniting the diverted fuel and mixture and thereby producing hot fixed gas in said enclosed space; and delivering said hot gas to the undiverted portion of said mixture at a point from whence it can be conducted to the place of final combustion.

6. The method set forth of producing an explosive from air and heavy liquid fuel which consists in continuously supplying to a passage, air and fuel in proportions adapted to complete combustion; producing a mixture from such air and fuel in said passage; diverting a portion of said fuel and a portion of said mixture to an enclosed space outside of said passage; igniting the diverted fuel and thereby producing hot fixed gas in said enclosed space in automatically proportioned quantities to suit different grades of fuel; and delivering said fixed hot gas to the remainder of said original combustible mixture at a point from whence it can be conducted to the place of final combustion.

7. The method set forth of producing an explosive from air and heavy liquid fuel which consists in continuously supplying to a passage, air and fuel in proportions adapted to complete combustion; producing a mixture from such air and fuel in said passage; diverting some of the heavier portions of said fuel and a portion of said mixture to an enclosed space outside of said passage; igniting the diverted fuel and thereby producing hot fixed gas in said enclosed space in automatically proportioned quantities to suit different grades of fuel; and delivering said fixed hot gas to the remainder of said original combustible mixture at a point from whence it can be conducted to the place of final combustion.

8. The combination with a manifold of a carbureter adapted to furnish a mixture of air and fuel adapted to complete combustion, and a passage to receive a mixture of air and fuel from said carbureter and deliver it to the manifold, of a chamber arranged to receive air and fuel from the passage, a flue leading from said chamber and opening into said passage, and means to ignite fuel in said chamber to supply hot gas to said flue and passage.

9. Means for preparing explosive mixtures of air and liquid fuel for combustion, comprising a combustion chamber; a passage for receiving and conducting air and liquid fuel measurably mixed in proportions adapted to complete combustion;

means to divert some of the heavy constituents of the liquid fuel, with some air, from said passage to the combustion chamber; means to ignite the contents of said chamber; flue means to conduct products of combustion from the chamber to said passage beyond the place of diversion; a throttle to control the flow of final mixture to an engine manifold; and by-pass means to divert from the passage to the combustion chamber, some air supplied with some of the lighter portions of said fuel in quantities varying with the degree of vaporization of the fuel by heat or atomization, to increase and decrease the heat of combustion in said chamber under the influence of varied atmospheric and load conditions.

10. Means for preparing explosive mixtures of air and liquid fuel for combustion, comprising a combustion chamber; a passage having a horizontal portion, for receiving and conducting air and liquid fuel measurably mixed in proportions adapted to complete combustion; means to divert some of the heavy constituents of the liquid fuel, with some air, from said passage to the combustion chamber; means to ignite the contents of said chamber; flue means to conduct products of combustion from the chamber to said passage beyond the place of diversion; a throttle to control the flow of final mixture to an engine manifold; and by-pass means connecting the upper portion of said passage with the combustion chamber, to divert to the combustion chamber, some air supplied with some of the lighter portions of said fuel in quantities varying with the degree of vaporization of the fuel by heat or atomization, to increase and decrease the heat of combustion in said chamber under the influence of varied atmospheric and load conditions.

11. The combination with a carbureter adapted to furnish a mixture of air and fuel adapted to complete combustion, and a passage to receive a mixture of air and fuel from said carbureter, of a chamber arranged to receive fuel and a mixture of fuel and air from said passage, a flue communicating with said chamber and opening into said passage, an igniter in said chamber and a wick in the chamber to conduct liquid fuel to the igniter.

12. The combination with a carbureter adapted to furnish a mixture of air and fuel adapted to complete combustion, and a passage to receive a mixture of air and fuel from said carbureter, of a chamber arranged to receive fuel and a mixture of fuel and air from said passage, a flue communicating with said chamber and opening into said passage, an igniter in said chamber, and a combined asbestos and wire mesh wick in the chamber to conduct liquid fuel to the igniter.

13. Means for preparing explosive mixtures of air and liquid fuel for combustion, comprising metering means whereby the air and liquid fuel may be proportioned for complete combustion and measurably mixed; a passage to receive the air and fuel from the metering means; means to divert heavy constituents of the liquid fuel from said passage; a chamber to receive the diverted fuel; means to ignite said fuel in said chamber; means to conduct products of combustion from the chamber to said passage beyond the place of diversion; and means below the chamber to heat said chamber.

14. Means for preparing explosive mixtures of air and liquid fuel for combustion comprising a carbureter; metering means whereby the air and liquid fuel may be proportioned for complete combustion and measurably mixed; a passage to receive the air and fuel from the carbureter, means to divert heavy constituents of the liquid fuel, a chamber to receive the diverted fuel, means to ignite said fuel in said chamber, means to conduct the products of combustion from the chamber to said passage beyond the place of diversion, means below the chamber to heat said chamber; and a heating pan enclosing the bottom of said chamber and provided with an air inlet and a stack.

15. Means for producing an explosive mixture from air and liquid fuel comprising a carbureter, metering means whereby the air and liquid fuel may be proportioned for complete combustion and measurably mixed, a passage to receive the air and fuel from the metering means, means to divert unvaporized heavy constituents of the liquid fuel and a portion of the air and fuel mixture, a chamber to receive the diverted fuel and mixture, means to ignite said mixture and unvaporized fuel in said chamber, means to conduct the products of combustion from the chamber to said passage beyond the place of diversion, means below the chamber to heat the chamber, and a heating pan under the bottom of said chamber and provided with an air inlet and a stack on opposite sides of said pan.

16. Means for preparing explosive mixtures of air and liquid fuel for combustion comprising metering means whereby the air and liquid fuel may be proportioned for complete combustion and measurably mixed; a passage to receive air and fuel from the metering means; means to divert heavy constituents of the liquid fuel and a portion of said mixture from said passage; a gasifying chamber below the place of such diversion; an open way to receive the diverted fuel and the diverted mixture, and to conduct the same downwardly to the gasifying chamber; means to ignite said fuel in said gasifying chamber; and means to conduct the products of combustion from the gasifying chamber

to said passage above the place of diversion.

17. Means for preparing explosive mixtures of air and liquid fuel for combustion, comprising metering means whereby the air and liquid fuel may be proportioned for complete combustion and measurably mixed; a passage to receive air and fuel from the metering means; means to divert a portion of the mixture and the heavy constituents of the liquid fuel from said passage; a gasifying chamber; means to deliver the diverted fuel and mixture to the gasifying chamber; means to ignite said mixture and fuel in said gasifying chamber; and means to conduct the products of combustion from the gasifying chamber to said passage between the place of diversion and the place of final combustion.

18. Means for preparing explosive mixtures of air and liquid fuel for combustion comprising metering means whereby the air and liquid fuel may be proportioned for complete combustion and measurably mixed; a passage to receive air and fuel from the metering means; a gasifying chamber; means including an open way to divert a portion of the mixture, and heavy constituents of the liquid fuel to the gasifying chamber; a distributer forming the lower side of the diverting means; means to ignite the diverted mixture and heavy fuel in said chamber; means to conduct the products of combustion from the chamber to the undiverted mixture beyond the place of diversion; and means to move the distributer to adjust the open way through which the diverted fuel is supplied to the chamber.

19. In combination with a carbureter, a chamber arranged to receive some of the heavier bodies of fuel from said carbureter, means to ignite fuel in the chamber, and means to supply air relatively free from fuel tangentially to said chamber for the purpose of causing an even distribution of combustion within the chamber.

20. In combination with a carbureter, a chamber arranged to receive some of the heavier bodies of fuel from said carbureter, means to ignite fuel in the chamber, and means adapted to receive air relatively free from fuel from the carbureter and to direct the same tangentially into the chamber.

21. The method of regulating the temperature of explosive mixtures of low-grade fuel and air which consists in producing a combustible mixture of such low-grade fuel and air, diverting the heavy portions of fuel with some air from the mixture downward into a combustion chamber; spreading and distilling such fuel at the upper end of such chamber through an annular space between heated surfaces, thereby causing vaporization to inversely affect the combustible power of the mixture delivered to the combustion chamber with respect to the volatility of the fuel.

22. The combination with a carbureter, of an engine manifold to receive fuel and air in proportions for complete combustion from said carbureter; a chamber between the carbureter and manifold and communicating with each; means to heat fuel in said chamber; means to supply air to fuel in said chamber, and electrical means to ignite said fuel.

23. The method of controlling the temperature of mixtures of heavy fuel and air delivered to an engine manifold which consists in utilizing the tendency of the degree of vaporization to inversely control the combustible power of a portion of the mixture delivered downwardly into a combustion chamber and there distilling and spreading the same over an extended surface; said combustion chamber being supplied with auxiliary air and mixture from the top of a supplying mixture flowing to the combustion chamber and to the place of use.

24. The method of producing an explosive mixture from low-grade liquid fuel and air which consists in supplying a proportioned mixture to a passage and in diverting downwardly from such passage into a combustion chamber the heavier portions of said mixture; such portions entering the combustion chamber over a distilling table with extended spreader surface exposed on the under side of the direct action of the flame of combustion in the combustion chamber; said distilling table operating by distillation of the products flowing over its surface to negatively affect and reduce the release of heat in the combustion chamber for fuels of light grade and to increase the release of heat in the combustion chamber for fuels of a heavy grade.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 29th day of June, 1917.

ORVILLE H. ENSIGN.

Witness:

JAMES R. TOWNSEND.