C. E. LUCKE AND J. GOOD.

LIQUID FUEL CARBURATION.

APPLICATION FILED APR. 9, 1914. RENEWED JUNE 24, 1919.

1,345,378.

Patented July 6, 1920.

4 SHEETS—SHEET 1.

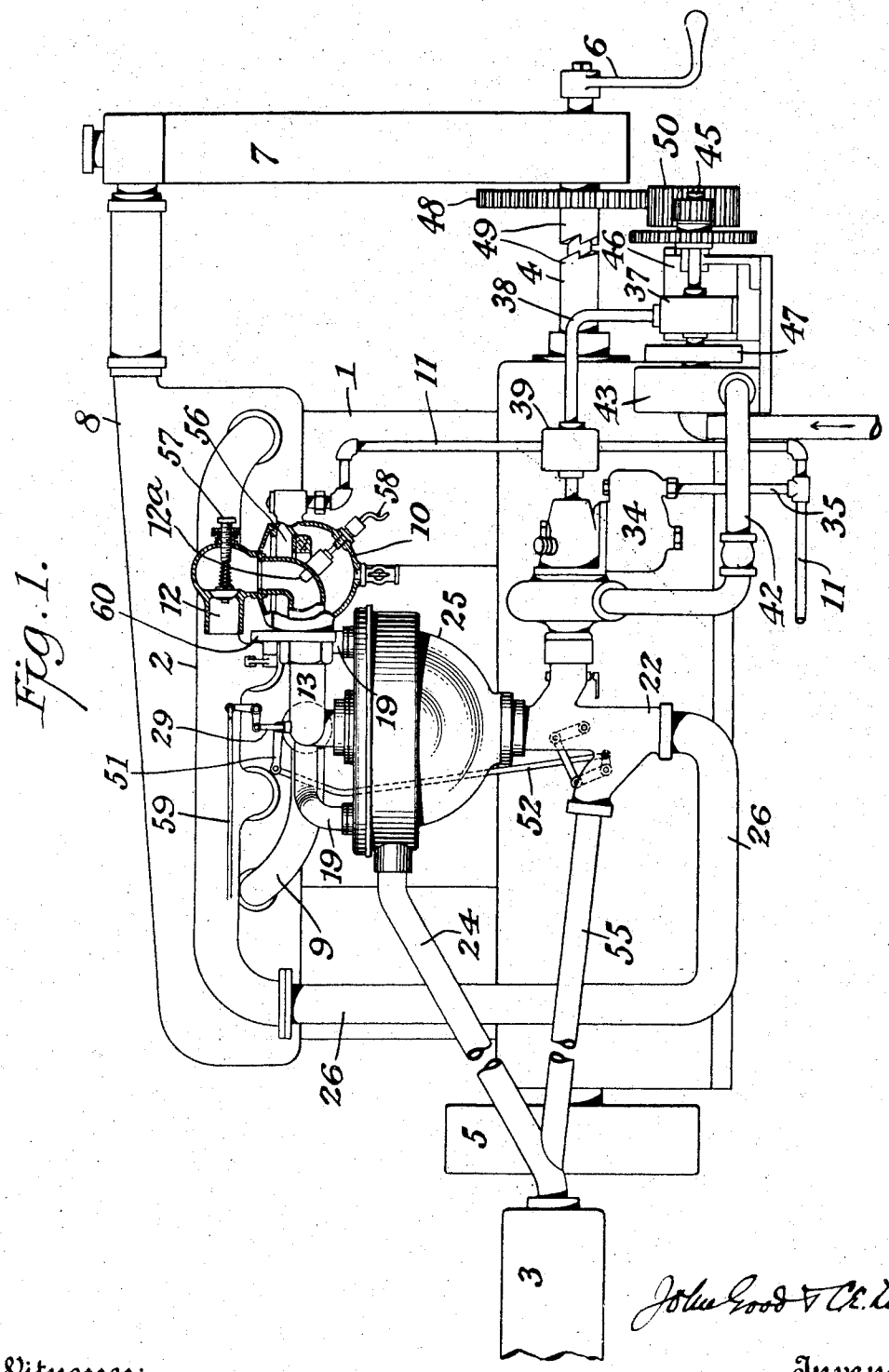


Fig. 1.

Witnesses:
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W. H. Hawkins

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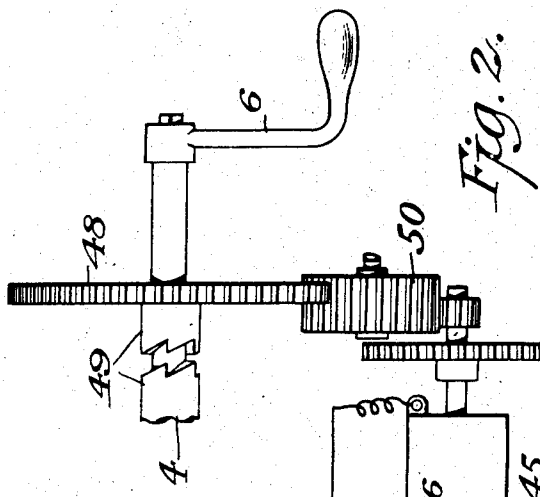


Fig. 2.

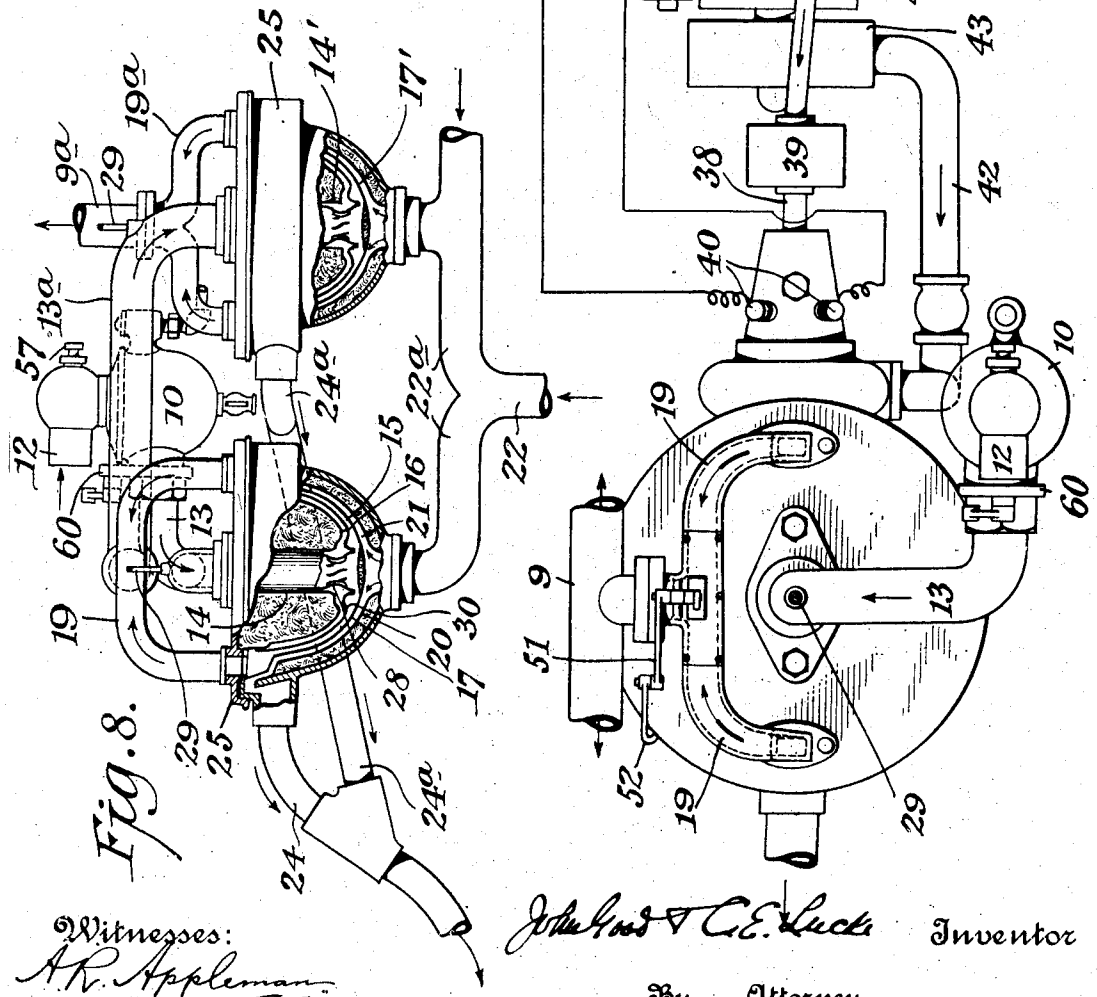


Fig. 8.

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4 SHEETS—SHEET 3.

Fig. 4.

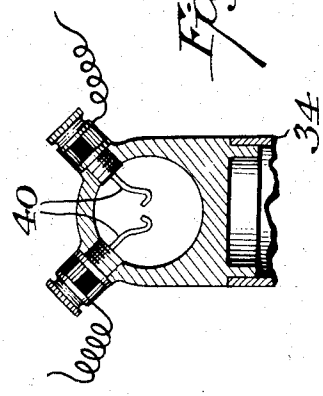


Fig. 3.

Witnesses:

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4 SHEETS—SHEET 4.

Fig. 5.

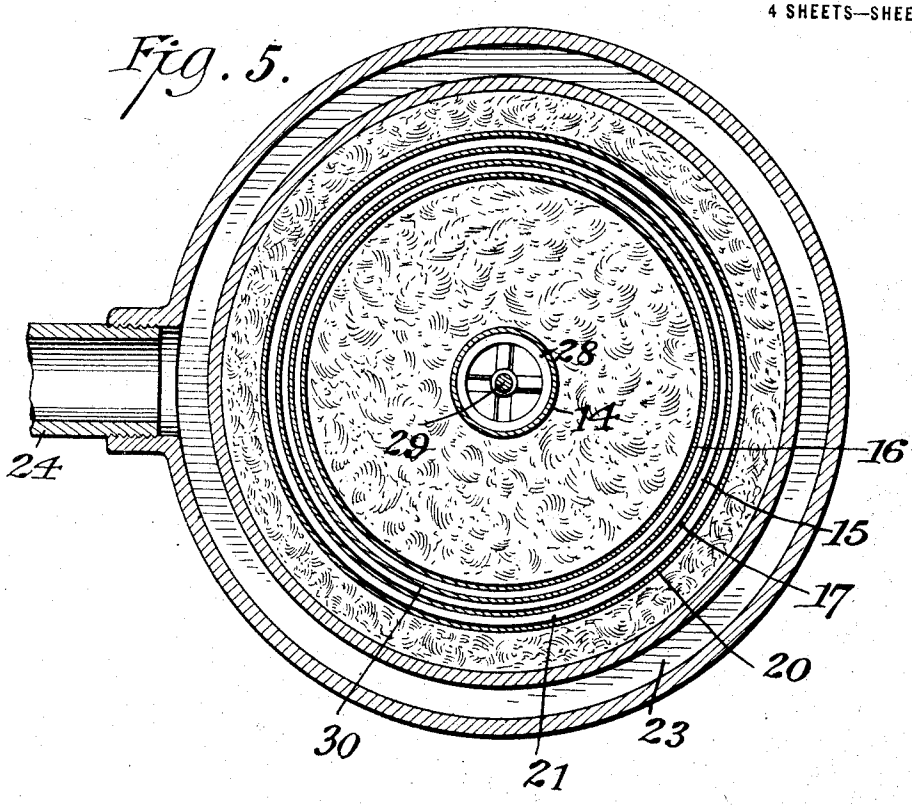


Fig. 6

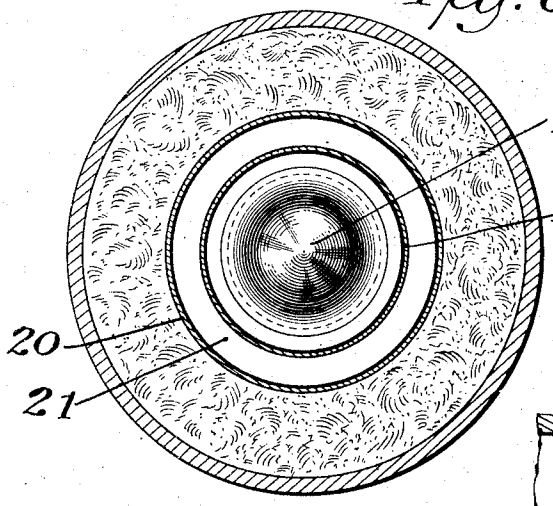
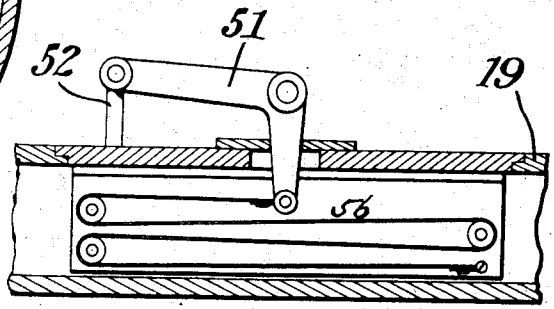


Fig. 7.



Witnesses:
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John Good & C. E. Lucke Inventor

By Attorney

UNITED STATES PATENT OFFICE.

CHARLES E. LUCKE, OF NEW YORK, AND JOHN GOOD, OF BROOKLYN, NEW YORK, ASSIGNORS TO GOOD INVENTIONS CO., OF BROOKLYN, NEW YORK, A CORPORATION OF NEW YORK.

LIQUID-FUEL CARBURATION.

1,345,378. Specification of Letters Patent. Patented July 6, 1920.

Application filed April 9, 1914, Serial No. 830,705. Renewed June 24, 1919. Serial No. 306,429.

To all whom it may concern:

Be it known that we, CHARLES E. LUCKE and JOHN GOOD, both citizens of the United States, residing, respectively, in New York city, county and State of New York, and in Brooklyn, county of Kings, and State of New York, have invented the following-described Improvements in Liquid-Fuel Carburation.

The invention relates to the method of making explosive gaseous mixtures of air and the vapor of certain liquid fuels. These fuels include the distillates of petroleum and the liquid parts of the products of coal or wood roasting, and also certain simple chemical substances that distil without residue, such as benzol, the alcohols, etc., but particularly those commonly called "heavy," such as kerosene and the heavy petroleum distillate solar oil, and the like. The invention is more especially concerned with the proper application of the heat necessary to accomplish the vaporization of these distillates, and to the establishment of suitable physical relations between the source of such heat, the liquid to be vaporized and the air with which the vapor is to be mixed. The object of the improvement is to produce explosive gaseous mixtures of air and such liquid fuels which shall be substantially free of fuel in liquid form and may therefore be said to be dry, such mixtures being no warmer than necessary to maintain the vapor condition of the fuel they carry and therefore as dense as consistent with this physical state. Gaseous mixtures when produced in accordance with this invention may be introduced into the cylinders of internal combustion engines or supplied to surface-combustion or other burners or furnaces insuring operation at maximum efficiency, and also, in multicylinder engines, reducing inequality of power in the several cylinders, as well as smoke or internal carbonization, and other difficulties referred to below.

Unless the fuel part of the carbureted mixture introduced into an ordinary explosive combustion engine be in the vapor, rather than the liquid, form, efficient combustion and operation is not possible. Any fuel in the liquid form, as in drops, films, streams, or pools, may easily fail to burn because of the inability of the liquid particles, in the center of a drop, for instance, to reach the necessary air for their combustion, and not only will such particles fail to burn and perform their useful and desired function, but in addition, by reason of the heat of combustion of neighboring particles, they will decompose creating harmful cylinder residues in the form of tar or coke and making a foul smell and smoke in the exhaust. In case such liquid particles happen to be in a cool spot in the cylinder at the time of general combustion of the rest of the mixture they may not be decomposed as just described, but may still exert a harmful influence by dissolving the lubricating oil, which, escaping past the piston, interferes with lubrication. Unvaporized liquid in the cylinder in any case represents a direct loss of fuel.

The mixture introduced into internal combustion engines, moreover, should be as cool as possible, because, other things being equal, the amount of heat developed by each explosion, and the amount of work that can be done as a consequence, are both greater in proportion as the weight of the cylinder charge is greater, so that the cooler the mixture or the greater its density, the more power will be developed. But such mixtures if too cool will be wet,—that is, some of the fuel will be in liquid state instead of vapor, either by reason of condensation of vapor previously formed at a higher temperature, or of an original failure to vaporize. If the mixture is too warm other conditions develop equally objectionable. Most of the liquid fuels have a tendency to decompose or polymerize when heated beyond a certain temperature and residues are formed due to chemical changes therein which residues may be solid or liquid, but either of which will cause serious obstruction to efficient operation. All liquid fuels of the distillate class have been produced by vaporization at some temperature or within some temperature range below a definite maximum temperature. Any of them may be again subjected to the same temperatures without harm, but because of the complex nature of some of these liquid fuels, especially such hydro-carbons as gasolene, kerosene, solar oil, distillate or tops, these being really solutions of various hydro-carbons of different densities and vapor pressures or boiling points, they cannot ordinarily be completely revaporized below or at the

highest temperature at which they were produced as vapors but must be heated to some higher temperature, and, before they completely vaporize at this higher temperature, they will ordinarily polymerize or decompose leaving objectionable residues, as stated. Those liquid fuels which are simple chemical compounds, such as benzol or alcohol, for example, have definite boiling points the same for all parts of a given volume and will completely vaporize at said points under atmospheric pressure except when influenced by the presence of matter in solution, like water in alcohol, for instance. These compounds will not decompose when so evaporating or distilling, but, evaporation in any case requires continued heat addition at the boiling point to supply the energy needed for the change of state from liquid to vapor.

The objections to wet mixtures on the one hand and to overheated or decomposed mixtures on the other, are both avoided by the vaporization method of this invention, by means of which all these heavy distillate and other liquid fuels may be completely vaporized without residue and at temperatures not only lower than the highest temperature at which they were originally produced but at practically the lowest temperatures at which the amount of vapor needed for combustion can exist as vapor in the mixture; that is to say, as cool as physically possible for the conditions in hand. For accomplishing this result, we make use of known physical laws, applying them in apparatus that is simple, reliable and effective. This apparatus may take many forms within the scope of the invention as will later appear.

In the drawings forming part hereof, one form of apparatus is illustrated as applied to an ordinary internal combustion engine.

Figure 1 is a side elevation of a liquid fuel carbureter device of this invention, including the heating means therefor and indicating an engine in outline, to which such device is shown applied.

Fig. 2 is a top plan of the same parts without the engine on a larger scale;

Fig. 3 an enlarged axial section through the vaporizer proper;

Fig. 4 a detail section of the preheating device on line IV—IV of Fig. 3;

Figs. 5 and 6 are cross-sections on the lines indicated in Fig. 3;

Fig. 7 is a detail of a thermostat control; and

Fig. 8 is a modification illustrating two vaporizers arranged in series relation.

The parts of the engine shown in the several figures include the cylinder 1, the exhaust manifold 2, connected as later explained with an exhaust outlet 3, a crankshaft 4, fly-wheel 5, and starting crank 6. The numerals 7 and 8 represent the radiator and cooling-medium connections of the engine, as will be recognized.

The vaporizing apparatus by which the gaseous combustible mixture is produced, is connected with the several engine cylinders by the intake manifold 9, and receives its fuel and air requirements through a supply device 10, the function of which is to admit the air and liquid fuel to the vaporizing chamber in predetermined and regulable proportions. In the case illustrated, and which is satisfactory in operation, the said proportioning supply device is an ordinary so-called spray carbureter such as is in use for gasolene engines. This device comprises an air passage 12, a spray-nozzle 12^a, and a float-controlled liquid chamber 56 which is supplied with liquid from a fuel pipe 11. The liquid is discharged as a jet or spray from the nozzle by the inspirative action of the air current in conjunction with the pressures thereof, and both the air and the liquid flows are under control, by means of the valves 57 and 58, respectively, and hence capable of adjustment to preserve any predetermined proportion of air and liquid, as will be understood. The liquid is desirably introduced to the vaporizer chamber as an air-atomized spray, as just described, but no special degree of subdivision of the liquid is essential, and it may enter in the form of a stream, or in coarse drops like rain, or in any other condition, as will later appear. The air at this time may have any temperature, that of the atmosphere or higher, as later explained. The mixture of air and liquid passes through the pipe-connection 13 into a tube 14 (Fig. 3) which is desirably placed in an upright or vertical position. At its lower end this tube turns outwardly and then upwardly, forming a bowl-shaped wall 16. A second tube 28, fitted to slide on the interior of the tube 14, carries at its lower end a generally similar upturned and bowl-shaped wall 30, which extends upwardly approximately parallel with the wall 16, fitting upon the latter at its upper margin. The tube 28 and its wall 30, are adapted to be raised and lowered by means of a rod 29, which extends upwardly through the top of the device and is connected to the top of the tube by a spider 29^a, the latter being provided with packing rings, as indicated, to form a tight sliding connection between the tubes 14 and 28. At one or more points the tube 28 is contracted after the manner of a venturi and in one or both of the contractions is equipped with an annular series of inclined or spiral vanes 28^a intended to impart a rotary or whirling motion to the air and fuel passing therethrough. The arms of the spider 29^a are similarly inclined, as vanes, for the same

purpose. The bowl-shaped walls 16 and 30 are disposed in nested relation to a second bowl-shaped wall 17 and the annular space between this wall and the movable wall 30, forms a shallow bowl-shaped chamber extending radially outward and upward from the end of the tube to an annular collecting chamber 18, which latter is connected by two or more pipes 19, with the intake manifold 9 of the engine. The wall 17, which is a fixed wall, is similarly nested in a wall or casing 20, also of the same general shape and forming a bowl-shaped chamber 21, surrounding the other chamber but separated from it. This chamber 21 forms a communication of annular section between the heat pipe 22 and an annular chamber 23 at the top, connecting with the exhaust outtake 3, through the pipe 24. Products of combustion from the exhaust pipe 2 reach the heat pipe 22, by a pipe 26, and thence pass upwardly through this chamber 21 on their way to the outtake 3. Thereby such chamber serves as a means of applying heat to the shallow space or chamber between the walls 30 and 17.

The several fixed walls 16, 17 and 20, are readily made of metal, flanged at their margins so that when nested together they will be compactly inclosed within a main casing 25 and protected against loss of heat by a packing or filling of heat-insulating material, as indicated, the purpose being to maintain all of the interior parts, and particularly the chamber 17 thereof, at a desired temperature. While the relative arrangement and manner of assemblage of the said walls is not of particular importance to the generic invention, as will later appear, the arrangement shown in the drawings is, nevertheless, of great advantage by reason of its compactness and efficiency and the ease with which the parts can be opened for inspection, and such arrangement constitutes part of the present invention.

The air and liquid fuel from the supply device 10 move downwardly through the tubes 14 and 28 under the suction effect of the engine and are immediately subject to an increase of velocity by passing through the venturi contractions in the latter tube. At the same time they receive a whirling motion, as above explained, and issue forcibly from the lower end of the tube into the central part of the vaporizing chamber 15. By reason of the shape of the curved wall 30, the chamber is enlarged at its center forming a sort of expansion space 15^a immediately at and around the depending lip or skirt 28^b of the Venturi tube section, the purpose of such expansion space being to cause the liquid in the air to be thrown down upon the floor of the chamber in such uniform state of distribution as to be capable of forming a uniform film of the liquid extending outwardly from the expansion chamber in all directions. Most, if not all, of the liquid will thus be deposited initially upon the floor of the bowl-shaped chamber 15, while the air passes upwardly through the chamber toward the collecting chamber 18. The liquid is thus brought into film form on the wall or walls of the shallow vaporizing chamber and the air current sweeping thereover with high velocity and high frictional effect, tends to advance the liquid outwardly and upwardly, thereby spreading it out thinner and thinner as it approaches the larger diameters of the chamber. The film on the wall 17 is thus spread, as it were, and brought to the thinnest possible condition, in which it presents the maximum surface exposure to the air and being simultaneously heated is in a favorable condition for complete vaporization.

The floor of the expansion space 15^a is desirably protected by insulation against the heat from the chamber 21. This insulation in the present case is formed by a false bottom 17^a of the bowl 17, and a filling of asbestos or other heat insulator. It is desirable and important that such liquid as may rest or collect in the vaporizing chamber shall not be directly subject to the heat except when also subject to the frictional action of the high velocity air current and in the form of a thin expanded film. For this reason the heat insulated wall 17^a should extend to the beginning of the shallow part of the vaporizing chamber and care should be taken that the liquid shall spread evenly in all directions on the insulated floor 17^a, so as to form a film of substantially uniform thinness all the way around the chamber. When such film is formed of kerosene, solar oil or similar heavy and complex hydrocarbon distillates, the prompt and forcible removal of the vapor forming on the surface thereof by the scouring action of the high velocity air current brings about a complete vaporization of the liquid at a temperature lower than that at which those distillates or any of their component ingredients were originally produced, and very much lower than will effect decomposition or polymerization of the constituents, and notwithstanding that these constituents will not evaporate without residue or decomposition when boiled, for example, in an open vessel at atmospheric pressure. This action is due to the fact that the forcible removal of the vapor as fast as formed leaves the liquid surface of the film naked, as it were, and freed from its normal covering of its own vapor, so that the progress of vapor formation takes place, even from the heaviest oils, with great rapidity and with somewhat the same effect as though the very thin film of liquid were exposed to a vacuum in a cham-

ber very much larger than the vapor of such liquid could fill by its complete evaporation at a pressure corresponding to a given temperature, that is to say, the localized, forcible and continuous removal of the vapor tends to disturb or upset the normal equilibrium between the liquid and its vapor, so that the vapor pressure at the liquid surface is no higher than in the rest of the space occupied by the air and, by the evaporation, is always kept properly low to keep the temperature down to the desired point or permit complete vaporization within a given limit of temperature. It may be further noted, that in a mixture of air and vapor, such as present in the shallow vaporizing chamber, the pressure of the vapor is not that of the mixture, but only a fraction of it, corresponding thereto as the volume of the vapor to the volume of the mixture, and it is therefore possible for a limited amount of liquid, such as represented by the thin film, to become completely vaporized at a low vapor pressure, less than atmospheric, and at a correspondingly low temperature, and we have found that whether the liquid be simple, or complex like kerosene, a limited or isolated amount may be completely vaporized at a temperature low enough to avoid decomposition, and in a large vapor space where it will exert a correspondingly low vapor pressure.

To produce this effect it is necessary that heat be supplied, but by reason of the extent and thinness of the film and the energetic scouring action of the shallow air current thereon, the degree of heat may be so low as to prevent any decomposition of the liquid, while nevertheless sufficient to vaporize all of the liquid in the limited proportion of air which enters into the mixture. If the heat is supplied in excess of what is actually needed to complete the vaporization, that is in nowise harmful, and will not cause deposits of residue unless the excess be great, but of course overheating results in unnecessary expansion of the resulting mixture and means are taken to guard against it as later explained. The source of heat is of course immaterial; in internal combustion engines it is convenient to utilize the exhaust gases and they may be used in the direct manner as illustrated or in any other way whereby their heat is transferred to the advancing films of liquid and air in the vaporizing chamber, and while the air is spreading and scouring the liquid as above explained.

The character of the air current is important. It should be of high velocity and also shallow, so that the vapor leaving the liquid surface may have but a short distance to go to penetrate to the most distant air, this being necessary to secure homogeneous mixture, and also to gain the necessary strong surface friction on the liquid. The high velocity is attained by the reduced cross-section of the vaporizing chamber, but this velocity is limited by the tendency to pick liquid particles bodily from the surface in the same way that high winds blow spray from the surface of the sea. Such liquid drops would be harmful in the ultimate mixture and must be eliminated, as, for example, by providing sufficient area of flow to keep the velocity below the film-rupturing point. But we find that higher velocities than are otherwise possible may be used by suitable provisions in the structure for the removal of such spray-drops, should they thus be formed, and several such means are known to us and illustrated herein. Any one may be used alone or in combination, as may be structurally most convenient. One means consists in a continuous reduction of velocity from a very high value, by enlarging the cross-sectional area of flow, and this is illustrated in Fig. 3. The chamber 15, by reason of its flaring form, is of larger cross-sectional area near its annular outlet chamber 18, than at a point nearer to the junction with the expansion chamber 15^a (notwithstanding that the chamber may be shallower at the upper part). The corresponding and progressive reduction of velocity toward the upper part of the chamber assists in depositing liquid particles. Also by reason of the curvature of the vaporizing chamber the thin air current traveling radially therethrough is subject to constant change of direction and the liquid particles are thrown down by their inertia and thus replaced in the liquid film. The curvature of the chamber 15 is thus of importance inasmuch as it provides not only for the establishment of the film, in the first instance, but also for the maintenance of the same by deposit or re-deposit of liquid particles from the air current. The curvature is desirably such as to maintain a constant velocity ratio for all adjustments of the wall 30. Other means of producing the elimination or throwing down of liquid particles suspended in the air current may be employed, such as those in use in the art of steam separators in addition to, or in place of, those already described; for instance, as shown in Fig. 8, where two vaporizing devices substantially like that of Fig. 3, are joined in series relation so that the mixture, if it contains suspended liquid particles, will pass from pipes 19, through a pipe 13^a and into an introducing tube 14′ of a second vaporizing device where such liquid particles will be thrown down as a film (of smaller area) forming on the wall 17^1 of said second device, becoming forcibly vaporized in a similar manner. The re-

sulting mixture passes thence through the passages 19ª to the intake manifold 9ª. One vaporizing chamber may be smaller than the other, although not so shown, and any number of them may be used. The heat pipe 22ª is branched in this form and the exhaust gases pass in multiple through both heat chambers, leaving thence by pipes 24 and 24ª to the exhaust outlet.

The bowl-form vaporizing chamber is desirably set so that the film has to travel upwardly therein under the influence of the air current, since it is thereby more effectually preserved, continuous and uniform, because the point of highest velocity of the air current thereby coincides with the point where the film tends to be the thickest. It will be understood that the film spreads out radially from the center of the chamber becoming thinner toward the periphery and being eventually dissipated, under normal conditions, before it reaches the annular outlet. The diameter or radial length of the vaporizing chamber should be adequate for this purpose, as will be evident, and the effective length may be increased, by connecting one or more chambers in series in the manner above explained.

In the initial operation of the vaporizer, before the engine has begun to produce exhaust gases of a temperature sufficient to heat the vaporizing chamber, a temporary heating device is used and is also illustrated herein, but this same device, or an equivalent, may be continuously used when it is inconvenient to convey exhaust gases or other sources of heat to the vaporizer. This device (which forms the subject matter of a co-pending application) is arranged to be put in operation to establish a desired temperature of the vaporizing chamber, or chambers, by the simple motion of one of the machine parts, for instance, the starting-crank or any other starting device,—a starting motor, for instance. It consists of a burner chamber or casing 31 connected with the heat pipe 22 above referred to, through a shut-off valve 32, and equipped with liquid fuel atomizing means at the opposite end. This spray-producing means comprises a jet-nozzle 33 taking liquid from a float-controlled reservoir 34 supplied by a pipe 35 which is connected with the supply pipe 11 above referred to. The nozzle 33 is in inspirative or atomizing relation to an air nozzle 36 which is supplied with air from an air compressor 37, through a pipe 38, having an air dome 39 interposed therein. The finely atomized spray blast produced by these nozzles is intercepted by the opposite electrodes 40 of an igniting circuit, which ignites the blast at that point and the flame therefrom passes through the shut-off valve 32 into the heat pipe 22 and thence through the heat chamber 21 heating the vaporizing chamber thereby. Additional air for the combustion of the spray blast may be introduced at the enlargement 41, here shown as introduced in tangential relation to such enlargement, through the pipe 42 leading from a fan blower 43, and at a point beyond the igniter. The positive air compressor 37 is driven by a gear 44 forming part of a train of gears receiving motion from the starting device 6, which, as above stated may be a crank-handle as shown, or the starting motor-generator of an automobile. The rotary blower 43 is driven by a shaft 45 from the same train of gearing and the magneto 46 for the igniter electrodes 40 is also driven by the same train. A fly-wheel 47 is also desirably applied to the train. The gear 48, which is the driving gear of the train, is directly connected to the shaft of the crank 6, and is intended to be used, first, for operating the preheating agency without affecting the engine, and then to be shifted axially along the long gear 50, as by pressing inwardly on the crank, or otherwise, so as to connect with the clutch teeth 49 and thereby rotate the engine crank-shaft 4. Such operation results in the immediate establishment of a flame in the casing 31 which heats the vaporizer as above described, so that when the gear 48 is shifted, the first charge taken in by the engine will be suitably vaporized and the engine may start at once upon its combustion process. The nature of the means described is such that no flame is exposed to the atmosphere and no possible back-fire in the chamber of the casing 31 can issue therefrom, except through the exhaust discharge or muffler 3. The preheating means just described may be used in connection with the exhaust gases, if desired, when for any reason, the temperature of the latter is not of itself sufficient, but we have found that the exhaust gases are ordinarily sufficient. In case it is not convenient to use the exhaust gases, the preheating device may be used in its stead as a constant source of heat or any other means, electrical or combustion, may be used for such purpose.

In order to preserve the temperature of the combustible charge, at the lowest temperature, *i. e.*, in the most dense state, we may employ a thermostat 56 (Fig. 7) incorporated in the charge pipe 19 and operating to move a bell crank 51, which is connected by a link 52 with a pair of valves 53 and 54. The thermostat may consist of a wire 56 (Fig. 7) trained over a series of small pulleys and arranged in the pipe 19 so as to constitute but slight obstruction to flow therein. The operation of the valves 53 and 54, as will be evident from the drawings, serves to by-pass more or less of the

exhaust gases direct to the discharge space 3, through a pipe 55, so that the remainder only will pass into the heat chamber 21. In this manner the heat applied to the liquid film in the vaporizing chamber may be automatically controlled as desired, or as may be necessary for the particular liquid fuel employed, and the resulting vapor and air mixture may thus be delivered to the engine in the coolest and densest form. Of course, any other form of thermostatic mechanism can be employed with equal effect and no claim is made herein to the particular form illustrated and described and in some cases for operative reasons the thermostat may be eliminated entirely and hand control substituted.

From the description above given it will be evident that the result accomplished is the production of a dry combustible gaseous mixture of a desired low temperature and produced without tendency to decompose the heavy distillate or other liquid used for fuel, and without any unvaporized residue. It is the object, of course, to produce a mixture with the air and fuel vapor in the proper proportions to effect a complete combustion, that is to say, a complete chemical union of the fuel and the air with no appreciable residue of either left over after combustion, but it may do no harm, as is well known, if the air is slightly in excess.

It is found desirable under all conditions to pass all of the air through the vaporizing chamber, in contact with the film, and especially when using the heavier fuels, as this promotes and facilitates the vaporization which must be rapid, complete, and at the lowest possible temperature. The diminishment of velocity of the shallow air current when the engine runs at less than its normal speed tends to diminish the rate of vaporization and at slower speeds also tends toward the collection of a pool of liquid in the chamber instead of an extended liquid film, and may result in imperfect vaporization. This tendency may be corrected by controlling the air velocity so as to keep it above a predetermined value under all conditions. Thus, in the case illustrated, the adjustable wall 30 can be moved downwardly or toward the floor 17, thereby restricting the cross-sectional area of the annular vaporizing chamber reducing the thickness of the air stream and increasing or maintaining the velocity accordingly. This is done by manipulating the rod 29 by means of its bell crank and link connections 59, shown in Fig. 1. When the supply device 10, has been properly adjusted, the operation of the engine may be controlled in this way and the velocity of the air current maintained at the desired high rate As an alternative method, substantially the same effect may be produced by providing two or more vaporizing chambers, such as 15, arranged in multiple instead of series relation and by a proper valve cutting out one or more of them as the engine decelerates. In this case the vaporizers are arranged as indicated in Fig. 8, except that the outlet pipes from each vaporizing chamber would lead direct to the manifold and each would have its own supply device 10. The throttle 60, by proper adjustment, may facilitate the vaporization by causing a lower pressure in the vaporizing chamber, although the movable wall 30 will serve as a throttle in its stead.

While we have illustrated in the accompanying drawings and described above a certain apparatus in which the method which is the present invention may be carried out, we make no claims to this apparatus herein. This apparatus is both disclosed and claimed in our co-pending application Serial No. 306430 which is a division of the present application.

We claim:

1. The method of making combustible gaseous mixtures consisting in combining air and liquid fuel in predetermined proportions suited for complete combustion of the fuel, depositing the liquid as a thin, extended film upon a heated surface, and coincidently forcibly removing the vapor from such heated liquid film by advancing the air in the form of a stream of high velocity over and in frictional contact with the surface thereof while maintaining the temperature of said film lower than that which decomposes the liquid.

2. The method of making combustible gaseous mixtures consisting in combining air and liquid fuel in predetermined proportions, depositing the liquid upon an extended heated surface of progressively increasing area, passing the said air as a shallow expanding stream over said surface with sufficiently high velocity to advance the liquid as a thin, spreading film on said surface, and coincidently changing the direction of the said high velocity shallow stream.

3. The method of making combustible gaseous mixtures consisting in directing a current of liquid fuel particles and air in predetermined proportions against an extended heated surface forming a liquid film thereon of extended surface area, advancing the air as a shallow current over said heated liquid film, thereby forcibly removing the vapor forming thereon, and automatically maintaining a predetermined temperature relation between the heat applied to said film and the resulting gaseous mixture.

4. The method of making combustible gaseous mixtures for internal combustion engines which consists in combining air and liquid fuel in predetermined proportions,

advancing such mixture, with a changing direction, into and through an extended shallow chamber subjected to heat and controlling the velocity of the air and fuel in said chamber by controlling the dimensions of the said shallow chamber.

In testimony whereof, we have signed this specification in the presence of two witnesses.

CHARLES E. LUCKE.
JOHN GOOD.

Witnesses:
K. L. GRANT,
G. A. TAYLOR.