May 11, 1937. E. RECTOR 2,079,632

METHOD OF GASIFYING LIQUID HYDROCARBON FUELS

Filed Dec. 14, 1935 2 Sheets-Sheet 1

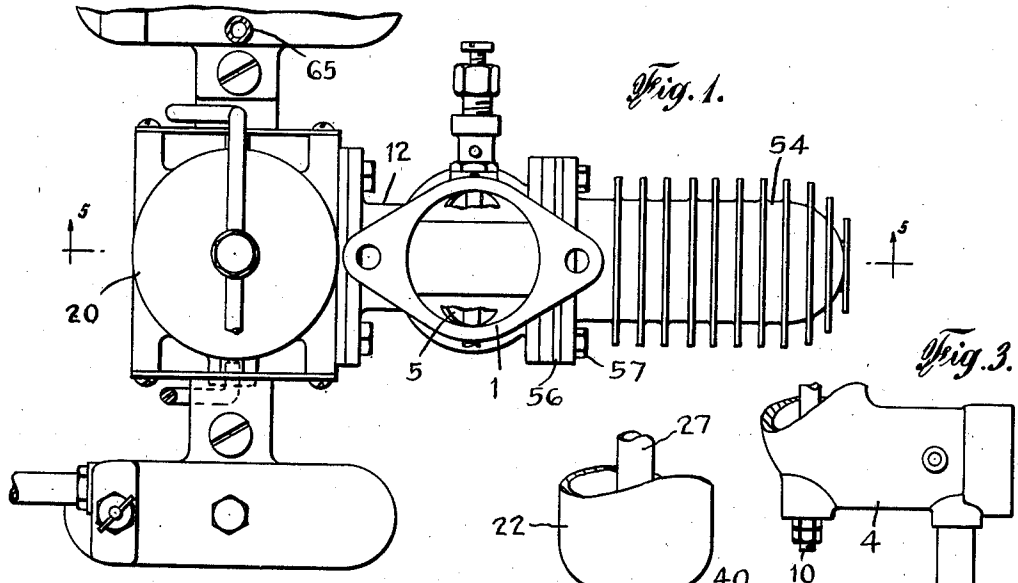

Fig. 1.

Fig. 3.

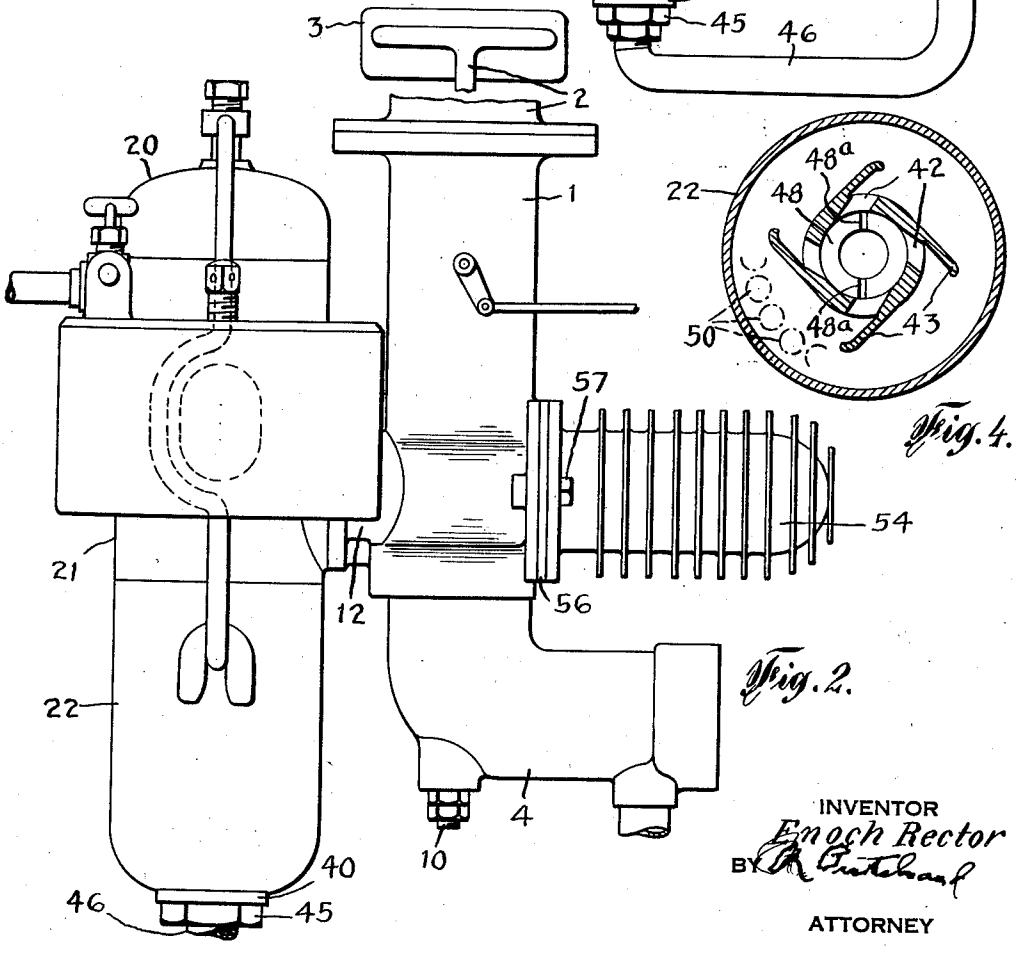

Fig. 4.

Fig. 2.

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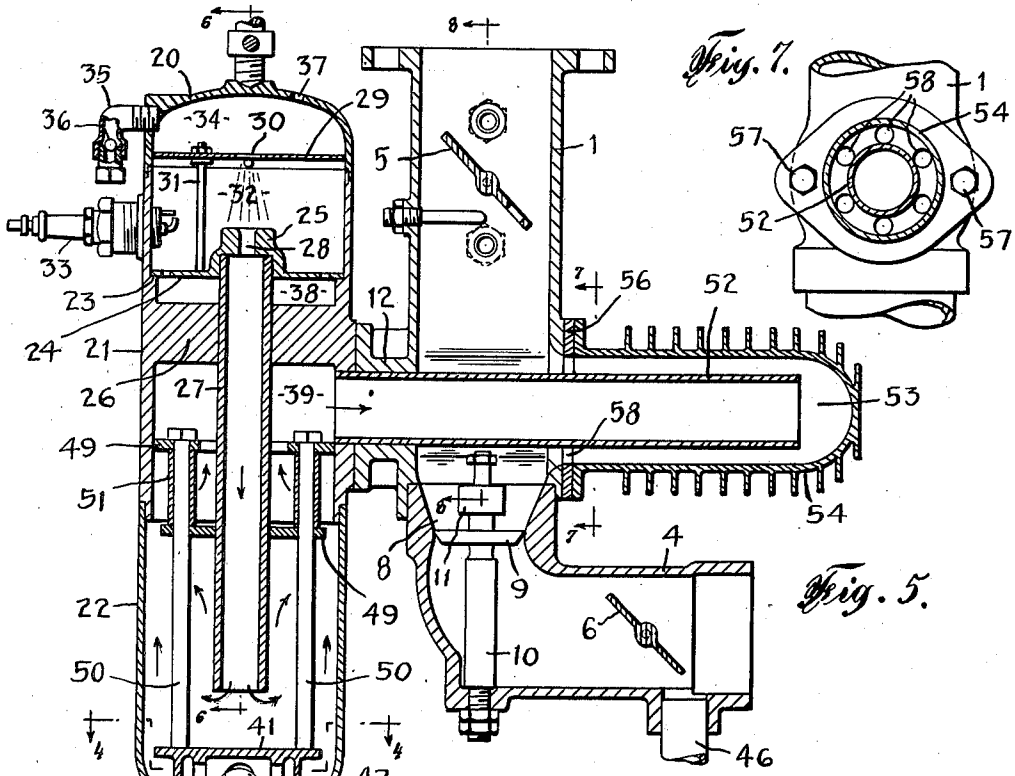

Fig. 5.

Fig. 7.

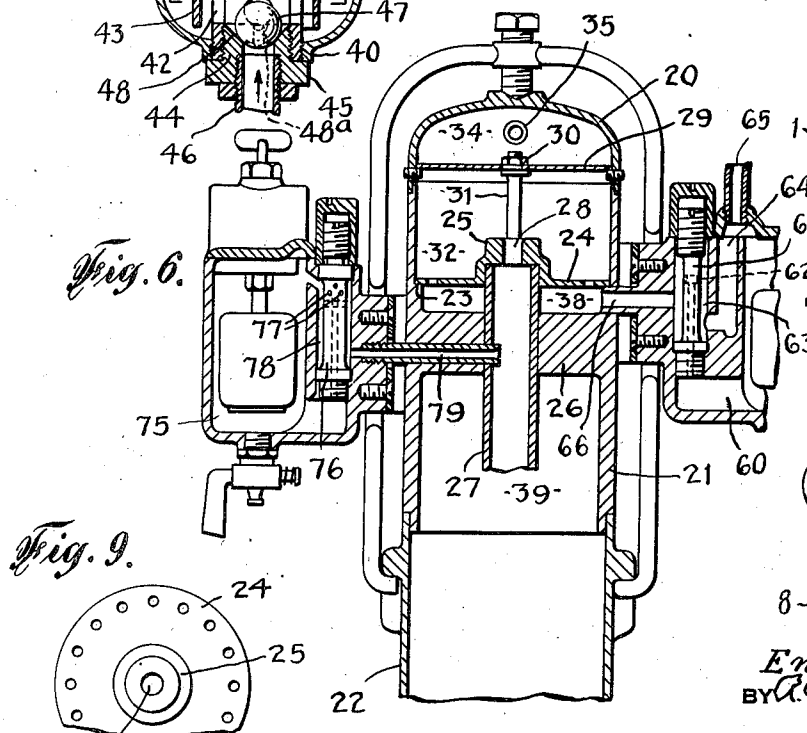

Fig. 6.

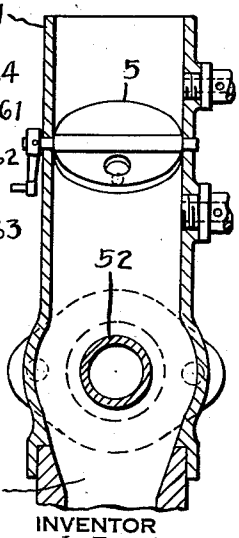

Fig. 8.

Fig. 9.

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UNITED STATES PATENT OFFICE

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METHOD OF GASIFYING LIQUID HYDROCARBON FUELS

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Application December 14, 1935, Serial No. 54,377

3 Claims. (Cl. 48—212)

This invention relates to improvements in methods and means for converting liquid fuel to form highly combustible fixed gases, and especially to a method and means for converting liquid hydrocarbons, such as distillates, fuel oil, or the like into lighter, combustible fixed gases, particularly adapted to the operation of internal combustion engines, and domestic and industrial furnaces.

This application for Letters Patent is a continuation-in-part of my copending application Serial No. 690,427, filed September 21, 1933.

One of the objects of the invention is to convert non-readily volatilized hydrocarbons into lighter, volatile, and highly combustible fixed gases, substantially free of uncombined carbon.

Another object of the invention is a method and means whereby a mixture comprising heavy hydrocarbons is mixed in a gasifying chamber to accomplish burning of a portion of the mixture and the conversion of the remainder into highly combustible fixed gases.

A further object is to provide a process and means in which the conversion of liquid hydrocarbons is assisted by catalytic activity.

It is also the purpose to provide a process and means, as described, in which the respective supplies of fuel and air are proportioned in accordance with conditions of operation, the proportions of the fuel and air supplies being controlled from a single source of pressure.

Another aim of the invention is to provide a process and means whereby the conversion of liquid fuel into highly combustible fixed gases is accomplished quickly, efficiently and economically.

Other objects and advantages will more fully appear as the description proceeds.

In the drawings which illustrate a preferred and novel means whereby the process may be carried out:

Figure 1 is a top plan view of the apparatus.

Figure 2 is a side elevation and illustrates the apparatus as applied to the intake manifold of an internal combustion engine.

Figure 3 is a detail view of the air feed for the gasifying chamber of the apparatus.

Figure 4 is a view on line 4—4 of Figure 4 showing the means for admitting and deflecting the air admitted to the gasifying chamber.

Figure 5 is a vertical section on the line 5—5 of Figure 1.

Figure 6 is a cross-sectional view on the line 6—6 of Figure 5.

Figure 7 is a detail section on the line 7—7 of Figure 5.

Figure 8 is a cross-sectional view on the line 8—8 of Figure 5.

Figure 9 is a detail view of the burner element of the apparatus.

The practices heretofore employed in the conversion of liquid hydrocarbons into gaseous fuels, particularly for use in the operation of internal combustion engines, have generally comprised vaporizing processes, and have usually been attended by a number of recognized objections. The principal objections associated with prior methods have been the formation of carbon, condensation of vaporized fuel, or incomplete vaporization, resulting in a wet mixture forming carbon in the motor, causing dilution of the crank case oil, and detonation.

It has been found that the conversion of liquid fuels in accordance with the invention about to be described results in the substantial elimination of the disadvantages enumerated above.

Briefly, the invention contemplates the effective conversion of heavy hydrocarbons into fixed gases of high heat value by mixing regulated quantities of air and liquid fuel, drawing this mixture into a vaporizing chamber, wherein the hydrocarbons are vaporized, burning the vaporized mixture to maintain a pilot flame, mixing the products of combustion with regulated quantities of additional air in a heating zone, mingling the mixture, at igniting temperature, with liquid fuel from a main fuel supply, discharging the last-named mixture at relatively high velocity into a gasifying chamber, admitting air to and mixing the mixture in the gasifying chamber to effect further combustion of the mixture comprising the outer zone and liberate heat sufficient to crack the mixture comprising the inner zone, whereby highly combustible fixed gases of high B. t. u. content are produced. The attainment of this result is preferably assisted by catalytic activity and thereafter the fixed gases so formed are drawn through a cooler wherein flame extension is prevented and the temperature of the gases is considerably reduced. The cooled gases are then drawn into an outlet pipe wherein they are mixed with regulated quantities of air from a main air supply. In this manner heavy hydrocarbons are converted into gases of the paraffin and olefine series, the product comprising fixed gases such as methane, ethane, butane, propane, ethylene, etc. The respective quantities of fuel and air supplied are proportionately con-

trolled from the same pressure-developing source. Preferably sub-atmospheric pressures are employed such as are developed in a known manner in an internal combustion motor, or by connection to the suction end of a blower.

Referring now to the drawings, there is illustrated a gasifying apparatus adapted to be used with an internal combustion engine. As shown an outlet pipe 1 is provided which is adapted to be communicably connected with an intake manifold 2 communicating with the engine cylinders, the latter being shown diagrammatically at 3 in Figure 2. At its opposite end the outlet pipe 1 is communicably connected with an air inlet conduit 4. A throttle valve 5 of known design is arranged in the pipe 1, and a similar valve 6, which can be used as a choke, is provided in air conduit 4.

Adjacent pipe 1 (see Figure 5) the conduit 4 is formed at 8 with a venturi-like constriction which serves as a seat for a vertically movable valve 9, carried on a post 10. A counterweight 11 mounted on the post above the valve normally holds the valve in idling position and permits it to rise in accordance with increase in the suction developed in the engine. The post 10 at its lower end terminates in a stem threaded through the wall of conduit 4 and held in place by locknuts. The post can by these means be adjusted to regulate the idling position of the valve.

Pipe 1, as shown, is provided with a branch conduit 12, which, see Figure 1, is flanged and bolted to an intermediate section of a three-part housing of the gasifying apparatus. The three-part housing comprises a dome or head 20, removably secured to the upper end of the intermediate section 21, and a cup section 22, removably connected with the lower end of the intermediate section 21.

Section 21 is provided at 23 with shoulders on which is seated a burner element 24, having a central cap portion 25, and below the shoulders a partition 26 extends across the intermediate section 21. This partition has a central opening and a tube 27 passes vertically through and is supported by the partition. The upper end of tube 27 is received in the cap 25 of the burner and communicates with a restricted opening provided at 28 in the upper portion of the cap. Above the burner 24 and arranged in the dome or head 20 is a plate 29 having a central opening at 30 through which air is drawn. The plate 29 is held in place at a predetermined distance above the burner by means of a post 31 which passes through the plate and rests on the burner.

The plate 29, burner element 24 and the housing serve to provide a chamber 32, termed a flame chamber. Preferably a spark plug 33 is mounted in the wall of chamber 32, by which means initial ignition can be effected in the chamber. Above the flame chamber is an air-receiving chamber 34 to which air is admitted through piping 35 connected with the chamber 34 and with a suitable source of air supply (not shown). The supply of air to the chamber 34 is controlled by a valve such as the ball valve 36 in the piping 35. Means are also provided whereby air is continuously supplied to the chamber 34, and, in the present instance, this is accomplished by providing a small opening at 37 in the wall of the dome 20. Below the flame chamber is a vaporizing well or chamber 38, which, as will be described, receives a mixture of air and liquid fuel for maintaining a flame in the chamber 32.

The lower portion of intermediate section 21, and the lower section 22 of the three-part housing cooperate to provide a gasifying chamber 39 into which the tube 27 discharges.

It is the purpose of the invention to scatter the mixture discharged through tube 27 into the gasifying chamber 39 and to supply air to and deflect it toward the walls of the chamber whereby an outer zone of combustion is established in the gasifying chamber and the heat thus liberated is utilized to crack the mixture of the inner zone.

As illustrated, see Figure 5, lower section 22 of the housing is formed, at the bottom, with an opening and an interiorly threaded boss 40, into which is threaded a deflector 41. Within the gasifying chamber, the deflector is provided with a plurality of circumferentially spaced air ports 42, cooperating with each of which is an angularly extending deflector arm 43. Deflector 41 is interiorly threaded to receive a cup 44 having a flange at 45 which rests against the boss 40 of the lower section 22 of the housing, and threaded into the lower portion of the cup is one end of an air supply pipe 46, which communicates, in turn, with the conduit 4, see Figure 3. It will be observed that the pipe 46 communicates with the conduit 4 beyond the choke 6, whereby the latter can be shifted to closed position without affecting the air supply to the gasifying chamber of the apparatus. The supply of air to the gasifying chamber is controlled by means of a ball 47 having a seat at 48 in the cup 44. By means of ports provided at 48a in the valve seat, the air supply to the chamber is maintained when the engine is idling.

In the preferred embodiment of the invention, the conversion of hydrocarbons into fixed, combustible gases is assisted by catalytic activity by causing the gases, while being drawn through the gasifying chamber, to contact material such as nickel or the like having catalytic properties. In the arrangement shown, the catalytic material has the form of a plurality of spaced plates 49 through which the tube 27 is adapted to pass. Posts 50 extending vertically in the chamber and carry spacer sleeves 51 for spacing the plates one above the other in the chamber. A series of posts is preferably provided and the posts and the sleeves carried thereby are likewise formed of catalytic material. Preferably, a multiplicity of plates 49 are employed, alternate ones of which closely fit the tube 27 and the housing 21, respectively. By this arrangement the mixture is drawn through the gasifying chamber in a serpentine, tortuous path and come in contact with a large area of surface of the catalytic means.

It is also the purpose of the invention to prevent the extension of flame to the outlet pipe 1 and to avoid undue expansion of the gases and consequent lowering of the volumetric efficiency of the engine. For this purpose, a cooler is provided which comprises a tube 52 communicating at one end with the gasifying chamber 39 and discharging at its opposite end into a chamber 53 formed by a casting 54. The casting 54 is flanged at its open end and engages a ring or gasket 56 interposed between the casting and the outlet pipe 1. The casting and gasket are attached to the outlet pipe by means of bolts 57. The ring or gasket 56, as shown, is provided with a series of circularly spaced openings at 58, having a total cross-sectional area equal to the cross-sectional area of the tube 27. The gases passing through the tube and chamber of the cooler pass out through the openings 58 and enter the pipe 1, at considerably reduced tem-

perature, whereby undue expansion of the gases is avoided.

A small quantity of liquid fuel is admitted to the metering jet 61 through a duct 60 in communication with a conventional float chamber. A proportionate amount of air is drawn, by suction established in the apparatus when in use, through the ducts 65 and 64, into the space 63 about the jet 61 and a mixture of air and fuel is thus obtained and passed to the vaporizing chamber 38 of the burner. From the chamber 38 the mixture is drawn through orifices of the burner plate 24 into the burning chamber proper 32.

The main supply of liquid fuel is drawn from the float chamber 75 through the metering jet 76, whereafter it is mixed with a small quantity of air admitted to the space 78 and passed, through the duct 79, into the tube 27.

By the selection and arrangement of the respective inlets, the admission of air and fuel to the apparatus is properly controlled and, in accordance with variations in the degree of pressure reduction established throughout the apparatus by operating demands at a single source, the rates of fuel and air supplied are proportionately changed to produce gasified fuel of substantially uniform quality at rates corresponding to variations in operating conditions.

In operation, when starting, a priming fuel, such as gasoline, can be injected into the flame chamber 32 and ignited by the spark plug 33 to establish a pilot flame in the flame chamber. Thereafter, a mixture of air and liquid fuel in quantities regulated by the degree of pressure reduction developed by the engine, is drawn into the vaporizing chamber, wherein the liquid fuel is vaporized. Initially, this fuel is vaporized by the heat transmitted from the burner element, and later the vaporization is assisted by heat transmitted from the partition 26, as the apparatus becomes heated. The vaporization occurs closely adjacent the flame chamber, and the vaporized mixture passing from the vaporizing chamber through the burner element serves to maintain a pilot flame in the flame chamber. The products of combustion in the flame chamber are caused to mix with regulated quantities of air admitted to the chamber 34 and are drawn into the flame chamber through a central opening in the plate 29, which latter is arranged at a predetermined distance above the outlet from the flame chamber. The air so supplied, and the products of combustion in the flame chamber combine to form an intensely hot aerated mixture which is drawn through the outlet at 28 into the tube 27, wherein, at igniting temperature, it mixes with the main supply of liquid fuel to be converted, which is drawn in quantities controlled by the suction developed by the engine, through duct 79 into tube 27. In its passage through the tube the hot aerated mixture mingles with, vaporizes and, by reason of its highly heated condition and oxygen content, causes ignition of a portion of the liquid fuel injected into the tube 27 through the duct 79. This thus ignited mixture discharges at a relatively high velocity from the tube into the gasifying chamber 39, wherein it impinges on the deflector plate 41. Within the gasifying chamber, the suction developed by the engine causes reversal of flow of the now intimately mixed, homogeneous mixture, and quantities of air, regulated by the degree of reduction of pressure within the chamber, are admitted through valve 48. The air thus applied passes into the chamber through air openings 42 and is deflected by the angularly extending arms 43 in such manner that it develops a swirling motion and is directed outwardly toward the wall of the gasifying chamber. This action of the air streams establishes an outer fringe or zone comprised of a highly aerated mixture and an inner zone relatively low in air content, resulting in an outer zone of combustion wherein sufficient heat is developed, by continued combustion, to crack the hydrocarbons comprising the inner zone. In the preferred arrangement the cracking of the hydrocarbons is assisted by catalytic activity, and the mixture in its passage upwardly through the gasifying chamber is forced to travel a serpentine course and contact a large area of metallic material having catalytic properties. The employment of catalytic activity in assisting in the conversion of the liquid fuel into light, fixed gases is of particular advantage in connection with the uses to which the present invention is especially directed, where the period of time available is short and varying conditions of temperature are encountered. The mixture drawn from the gasifying chamber comprises gases of the paraffin and olefine series, such as methane, ethane, propane, butane, ethylene, etc.

From the gasifying chamber, the fixed gases are drawn through a cooler, whereby combustion is controlled, extension of flame prevented, and reduction of the temperature of the gases is accomplished. The gases are thereafter drawn into the outlet pipe 1, wherein they will not expand unduly, owing to the cooling step of the process, so that a better volumetric efficiency for the engine will be obtained. In the outlet pipe 1, the gases mix with regulated quantities of air governed by the valve 9, which, in turn, is controlled by the suction developed by the engine. From the pipe 1, the properly proportioned combustible mixture now formed is delivered to the engine in the usual manner.

Having thus described the invention, it will be understood that various changes and modifications may be made in carrying the invention into effect, without departing from the principle thereof.

What I claim is:

1. The method of converting liquid hydrocarbon fuel characterized by a range of volatility, into substantially completely fixed gases suitable for use as fuel for consumption in internal combustion engines and the like, comprising: admixing a small quantity of fuel with a regulated amount of atmospheric air, subjecting said quantity of air and fuel to substantially complete combustion, introducing a second quantity of atmospheric air to the products of combustion evolved by said original mixture of air and fuel after its combustion but prior to appreciable cooling thereof to obtain an intensely hot mixture of combusted gases and air having an oxygen content sufficient only to spontaneously cause partial combustion of a relatively large body of such hydrocarbon fuel when injected thereinto, and injecting and intimately admixing, with said heated mixture of combusted gases and air, prior to appreciable cooling thereof, a regulated quantity of said liquid hydrocarbon fuel, whereby partial combustion of said relatively large body of said liquid hydrocarbon fuel is effected, with said secondly-admitted quantity of atmospheric air, sufficient to heat and gasify the remaining uncom-

busted portion of said injected fuel without completing the combustion thereof.

2. The method of converting liquid hydrocarbon fuel characterized by a range of volatility, into substantially completely fixed gases suitable for use as fuel for consumption in internal combustion engines and the like, comprising: admixing a small quantity of fuel with a regulated amount of atmospheric air, subjecting said quantity of air and fuel to substantially complete combustion, introducing a second quantity of atmospheric air to the products of combustion evolved by said original mixture of air and fuel after its combustion but prior to appreciable cooling thereof to obtain an intensely hot mixture of combusted gases and air having an oxygen content sufficient only to spontaneously cause partial combustion of a relatively large body of such hydrocarbon fuel when injected thereinto, injecting and intimately admixing, with said heated mixture of combusted gases and air, prior to appreciable cooling thereof, a regulated quantity of said liquid hydrocarbon fuel, whereby partial combustion of said relatively large body of said liquid hydrocarbon fuel is initiated with said secondly-admitted quantity of atmospheric air, and adding a regulated amount of additional atmospheric air to said last-mentioned mixture, after initiation of its combustion, to maintain combustion sufficient to heat and gasify the less volatile components of the injected fuel without completing the combustion thereof.

3. The method of converting liquid hydrocarbon fuel characterized by a range of volatility, into substantially completely fixed gases suitable for use as fuel for consumption in internal combustion engines and the like, comprising: admixing a small quantity of fuel with a regulated amount of atmospheric air, subjecting said quantity of air and fuel to substantially complete combustion, introducing a second quantity of atmospheric air to the products of combustion evolved by said original mixture of air and fuel after its combustion but prior to appreciable cooling thereof to obtain an intensely hot mixture of combusted gases and air having an oxygen content sufficient only to spontaneously cause partial combustion of a relatively large body of such hydrocarbon fuel when injected thereinto, injecting and intimately admixing, with said heated mixture of combusted gases and air, prior to appreciable cooling thereof, a regulated quantity of said liquid hydrocarbon fuel, whereby partial combustion of said relatively large body of said liquid hydrocarbon fuel is initiated, with said secondly-admitted quantity of atmospheric air, enveloping said last-mentioned mixture in a blanket of additional atmospheric air, and then intimately mixing said hot last-mentioned mixture with said blanketing air in the presence of a catalyst to complete gasification of the less volatile components of the injected fuel without completing combustion thereof or the formation of free carbon.

ENOCH RECTOR.