United States Patent

[11] 3,556,065

[72] Inventor Wilmer C. Jordan
2414 N. 76th Court, Elmwood Park, Ill. 61529

[21] Appl. No. 792,227
[22] Filed Jan. 15, 1969
[45] Patented Jan. 19, 1971
Continuation-in-part of application Ser. No. 653,073, July 13, 1967, which is a continuation-in-part of application Ser. No. 457,427, May 20, 1965.

[54] **DEVICES AND METHODS FOR FORMING AIR-FUEL MIXTURES**
9 Claims, 11 Drawing Figs.

[52] U.S. Cl. 123/122, 123/179
[51] Int. Cl. F02m 31/12
[50] Field of Search 123/179H, 122F, 122A1, 122A2, 122D, 122E

[56] **References Cited**

UNITED STATES PATENTS

909,896	1/1909	Hertzberg et al.	123/122(F)
946,239	1/1910	Low et al.	123/122(F)
1,110,482	9/1914	Collier	123/122(F)
1,171,145	2/1916	Sachs	123/122(F)
1,236,267	8/1917	Clark et al.	123/122(F)
1,459,307	6/1923	Laise et al.	219/253(X)
1,474,359	11/1923	Grant	123/122(A1)
1,637,104	7/1927	Crone	123/122(F)
1,959,397	5/1934	Turner	123/122(F)
2,597,251	5/1952	Mansoff	123/122(F)
3,139,874	7/1964	Krein et al.	123/122(A)

FOREIGN PATENTS

195,939	2/1923	Great Britain	123/122(F)
356,537	9/1931	Great Britain	123/122(F)
523,175	7/1940	Great Britain	123/122(F)
839,740	5/1952	Germany	123/122(F)

Primary Examiner—Wendell E. Burns
Attorney—Alberts, Brezina & Lund

ABSTRACT: Devices and methods in which liquid fuel droplets are supplied into a mixing region of a flowing air stream and in which a heating element, preferably electrical, is used to propagate radiant heat into the fuel droplets with a controlled amount of heat being applied approximately equal to that required to substantially completely vaporize the liquid fuel droplets. Specific features relate to the mounting of the heating elements and to the use of an elongated tubular or flat element between a venturi section and a throttle valve, or an annular element below the throttle valve.

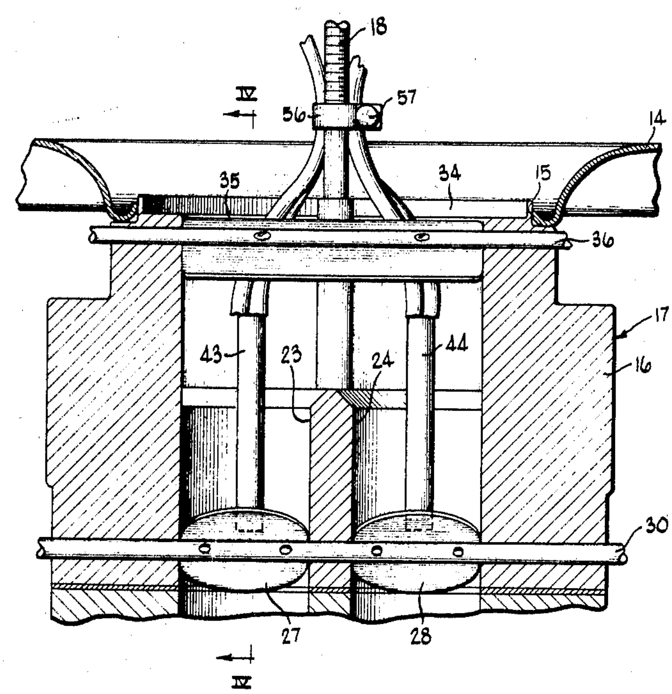


FIG. 1

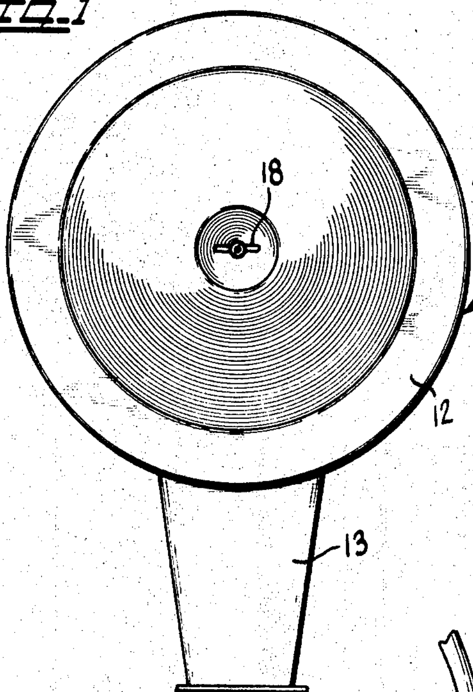


FIG. 2

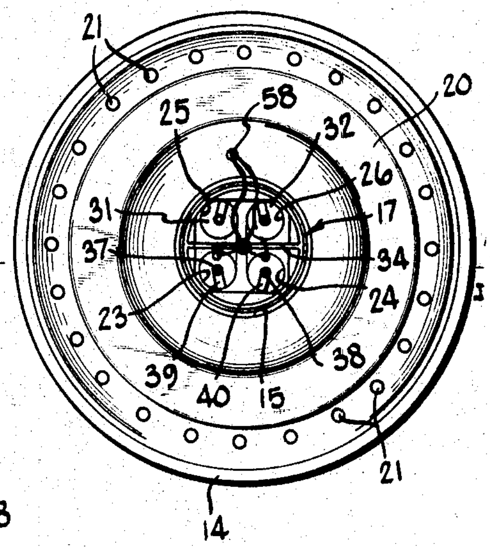
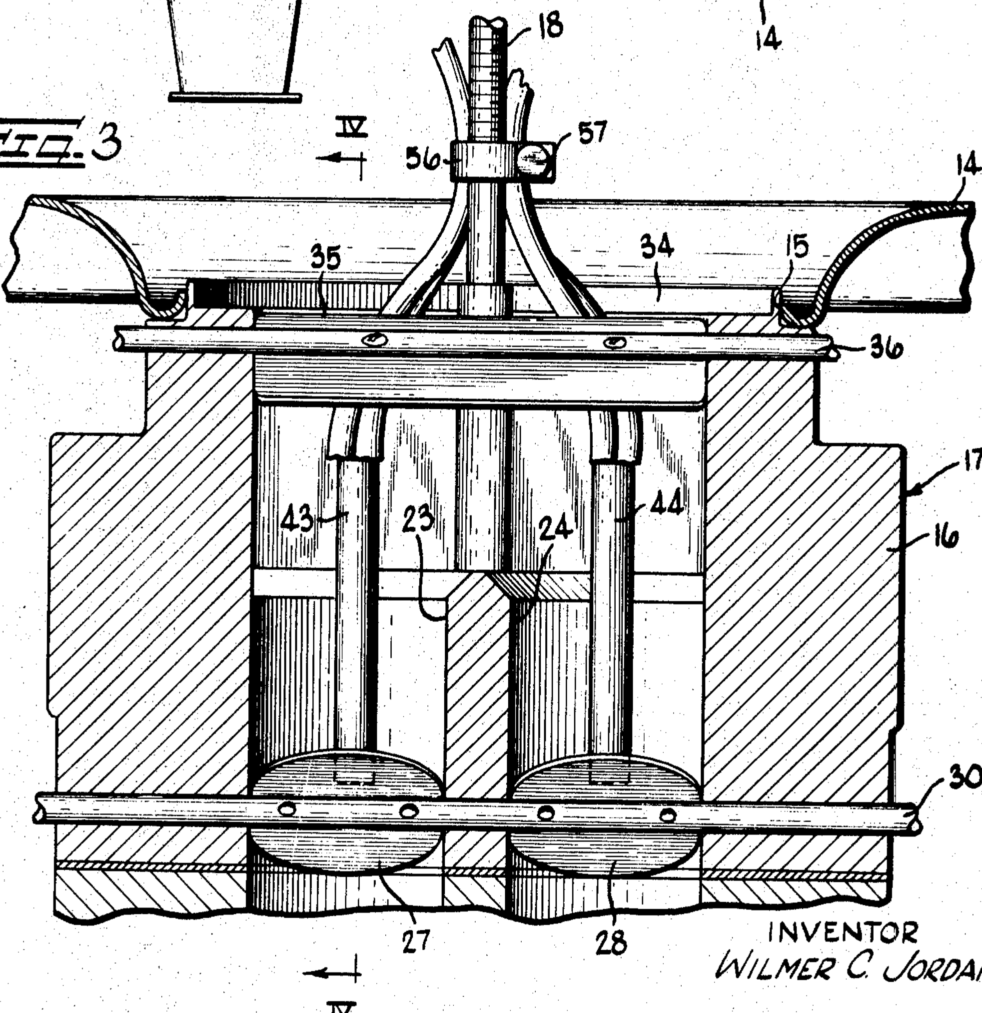


FIG. 3



INVENTOR
WILMER C. JORDAN

Alberts, Brezina & Lund
ATTYS.

FIG. 4

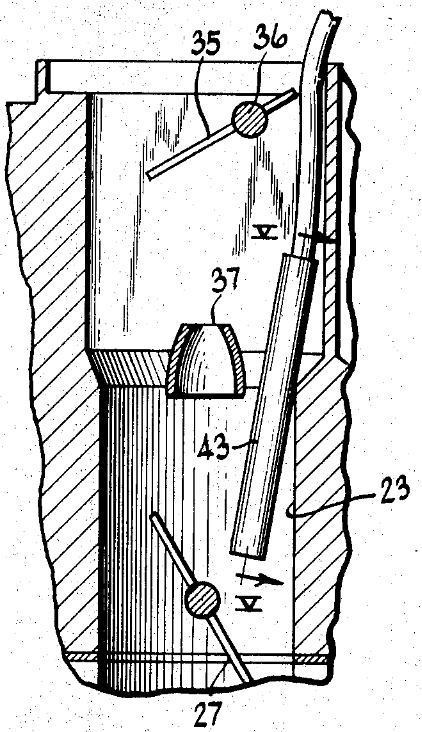


FIG. 5

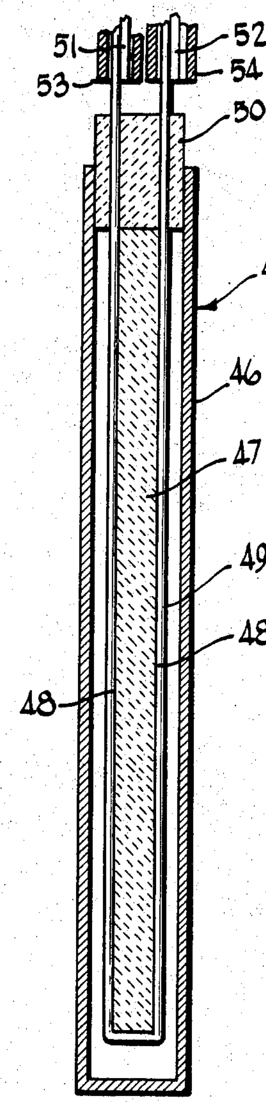


FIG. 6

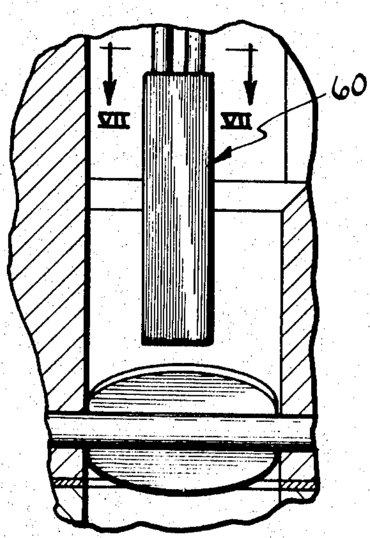
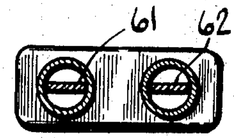


FIG. 7



INVENTOR
WILMER C. JORDAN

Alberts, Brezina + Lund
ATTYS.

FIG. 8

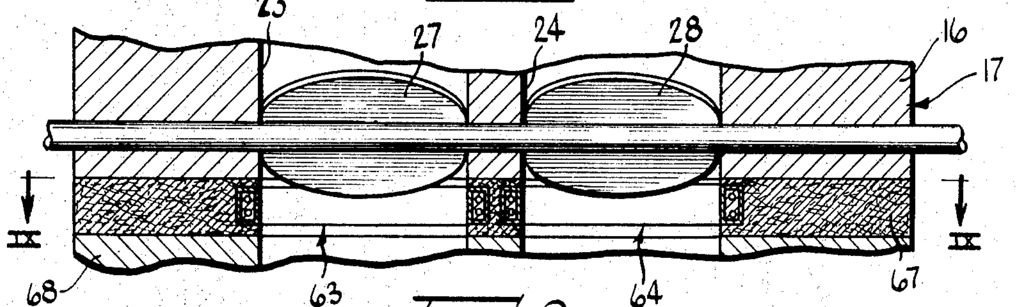


FIG. 9

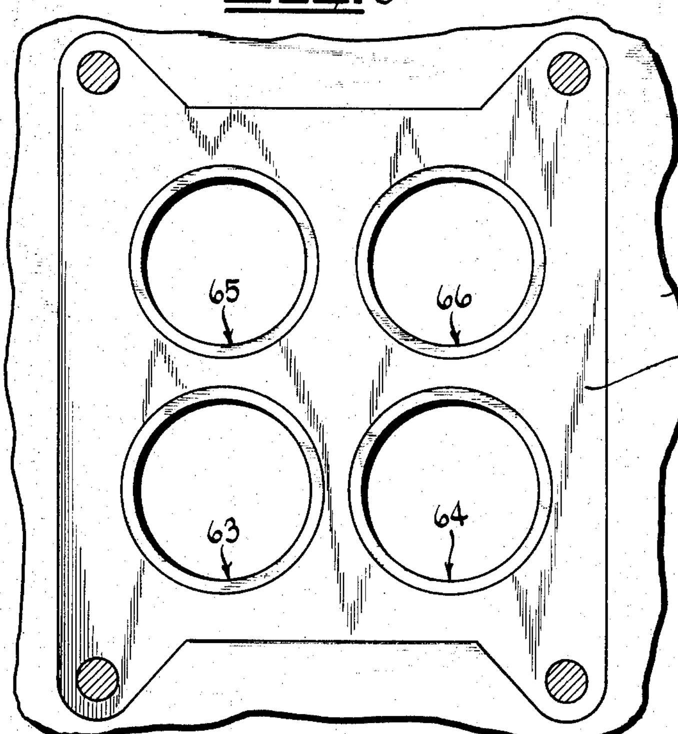


FIG. 10

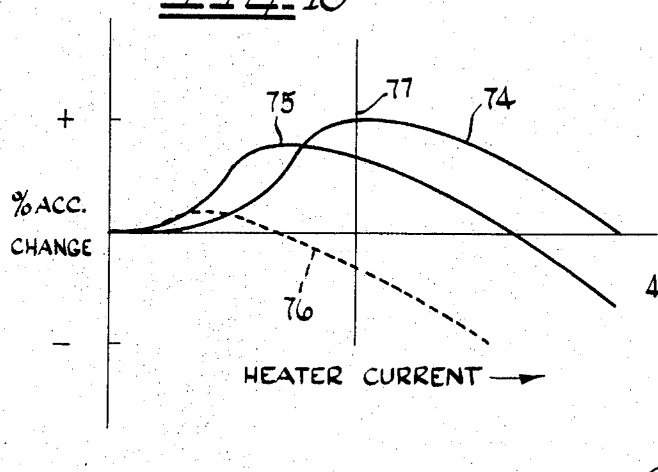
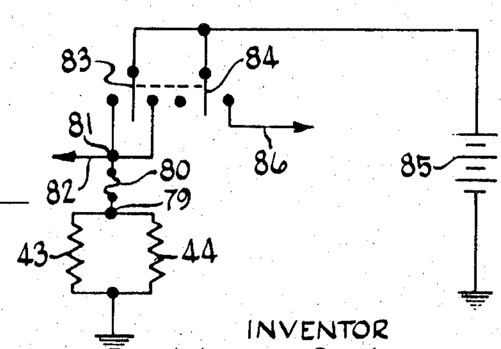


FIG. 11



INVENTOR
WILMER C. JORDAN

Alberts, Brezina + Lund
ATTYS.

DEVICES AND METHODS FOR FORMING AIR-FUEL MIXTURES

This application is a continuation of a copending application entitled "Devices and methods for Forming Air-Fuel Mixture," filed July 13, 1967, Ser. No. 653,073, which was continuation-in-part of a copending application entitled "Devices for Vaporizing and Expanding of Gasoline and Fuel Mixtures Thereof," filed May 20, 1965, Ser. No. 457,427.

This invention relates to devices and methods for use in forming volatile air-fuel mixtures for combustion and more particularly to devices for supplying a controlled amount of heat to substantially completely vaporize liquid fuel droplets and to thereby obtain maximum combustion efficiency upon combustion of the air-fuel mixture. The principles of the invention are generally applicable in any apparatus or system in which a volatile air-fuel mixture is formed, but are illustrated herein as applied to a carburetor for an internal combustion engine. The use of the devices and methods of this invention greatly increase gas mileage and at the same time results in greater acceleration and power. In addition, engines can be started in subzero conditions in which they would not otherwise start, engine flooding is substantially eliminated, and stalling is minimized. By increasing the efficiency of combustion, carbon deposits are destroyed and much smoother and more responsive engine performance is obtained.

The prior art is replete with disclosures of various forms of heating devices for use with carburetors, designed for heating the housing of a carburetor to prevent icing, for heating the fuel supplied to a carburetor, and for heating the fuel-air mixture leaving a carburetor. Although some improvement may be obtained from the use of such devices in engine starting, the designs have been such that it would not be possible to obtain improved efficiency and performance under operating conditions. Specially constructed carburetors have been required and the design of some of the devices is such that excessive restriction and turbulence in the flow of the air and the air-fuel mixture would be produced. The designs of the prior art devices are such that they would not be capable of continuous operation to improve efficiency and performance and none of the prior art devices are such that they would not be capable of continuous operation to improve efficiency and performance and none of the prior art devices have been commercially acceptable to any significant extent.

Said continuation-in-part application discloses improvements upon the prior art arrangements wherein an electric heating element is designed for continuous energization to obtain improved gas mileage and acceleration as well as to improve cold weather starting and to minimize flooding and vapor lock problems. In particular, the heating element is extended into a region downstream from the region of a venturi section of a carburetor, at which liquid fuel droplets are supplied into a flowing air stream, the element being operative to propagate radiant heat into the liquid fuel droplets to vaporize the same. That application further discloses the use of an elongated heating element disposed generally parallel to and alongside to the flow path of the air-fuel mixture which has an important advantage in that maximum radiant heat can be propagated into the fuel droplets with minimum interference in the flow of the mixture. In addition, that application discloses the disposition of the heating element immediately downstream from the mixing region, the element being disposed between the venturi section and the throttle valve. This feature is important because at this point, the fuel droplets can be efficiently vaporized without unduly increasing expansion of the fuel vapor or the temperature of the air-fuel mixture, which would tend to decrease the efficiency of the engine.

In addition, the copending application discloses a heating element in which a resistance wire is supported by insulating means within an outer metal casing, effective to minimize "hot spots" and to prolong the life of the resistance wire.

The features disclosed in the prior application are very important and have been used to obtain significant improve-

ments with respect to gas mileage, acceleration, cold weather starts and minimization of flooding and stalling problems. However, it was believed that additional improvements might be made and this invention was evolved with the general object of improving upon the devices and methods of the prior application.

In continuing experimental work, it has been found that a further improvement in results can be obtained through the application of a controlled amount of heat in vaporizing the fuel, especially when combined with the feature as disclosed in the copending prior-filed application.

In particular, it has been discovered that greatly improved results can be uniformly obtained, under all operating conditions, by using a controlled amount of heat approximately equal to that required to substantially completely vaporize the liquid fuel droplets. If the amount of heat is less than this value, liquid fuel droplets are contained in the air-fuel mixture which cannot be effectively burned up in combustion, and a reduced efficiency of combustion results. If the amount of heat is increased substantially beyond this value, it is found that little if any increase in efficiency and power is obtained, apparently due to an unduly large expansion of the fuel and an elevation of the temperature of the fuel-air mixture.

The devices and methods of this invention have other applications but are particularly advantageous when applied to an internal combustion engine carburetor in which gasoline or other liquid fuel is supplied into a venturi section located upstream from a throttle valve. It has been found that optimum overall results are obtained when the controlled amount of heat is equal to that required to substantially completely vaporize the fuel when the throttle valve is fully opened. With this value of a controlled amount of heat, the engine develops maximum acceleration and torque, and the engine can be operated at maximum efficiency under high speed and load conditions. With this value, the increase in torque and efficiency obtained at low throttle valve openings is reduced below that which might be obtained with a lower value of the controlled amount of heat. However, the reduction is small and is insignificant under normal operating conditions.

The optimum value of the controlled amount of heat is relatively high and it is found that in addition to an improvement in torque and efficiency, it results in a significant improvement with respect to cold weather starting and with respect to elimination of flooding and elimination of stalling under high moisture conditions. Cold weather starting is improved because the amount of heat is sufficient not only to completely vaporize the liquid fuel droplets but also to expand the vaporized fuel to cause a mixture to reach the cylinders having a high proportion of vaporized fuel therein. Flooding is minimized because of the increased vaporization of the fuel.

High ambient moisture conditions normally interfere with proper vaporization of the fuel and produce difficulties with respect to starting of the engine and also with respect to stalling of an engine after it is started. By this invention the fuel is substantially completely vaporized as it leaves the mixing region to minimize such problems. This feature is particularly important with respect to marine engines or other engines subjected to high moisture conditions.

In accordance with very important features of the invention, the amount of heat required with a particular engine and with a heating element of a certain size, configuration and placement is determined through use of a certain testing method or by use of an empirical formula.

In one preferred embodiment of the invention, the heating element is an elongated tubular electric element similar to that disclosed in the aforementioned prior filed application which produces excellent results when a controlled amount of electric power is applied to produce a controlled amount of heat in accordance with this invention.

In another embodiment of the invention, a flat elongated heating element is used in place of the tubular element, to provide a planar area facing the path of flow of the fuel-air mixture and to increase the propagation of heat into the fuel droplets.

In a further embodiment of the invention, an annular heating element surrounds the path of flow of the fuel-air mixture. The annular element may be conveniently located in a gasket between the carburetor and the intake manifold of the engine and a number of such elements may be employed equal to the number of carburetor barrels.

A specific feature of the invention relates to the provision of holes in a carburetor air cleaner to increase the supply of air to the carbûretor. Without the provision of heating elements in accordance with this invention, the increase in the supply of air has no substantial effect. However, when combined with the devices of this invention, increased acceleration torque and power and increased efficiency are obtained under high acceleration and high speed conditions of operation.

Another specific feature of the invention relates to improved and simplified means for mounting of the tubular or flat heating element in a carburetor of conventional construction.

This invention contemplates other objects, features and advantages which will become more fully apparent from the following detailed description taken in conjunction with the accompanying drawings which illustrate preferred embodiments, and in which:

FIG. **1** is a top plan view of an air cleaner and carburetor assembly in which a fuel vaporizing device is installed in accordance with the principles of this invention;

FIG. **2** is a top plan view similar to FIG. **1**, but with the cover of the air cleaner removed;

FIG. **3** is a elevational sectional view taken substantially along line III–III OF FIG. 2;

FIG. **4** is a sectional view taken substantially along line IV–IV of FIG. 3;

FIG. **5** is a sectional view, on an enlarged scale, taken substantially along line V–V OF FIG. 4, and illustrating the internal construction of a heating element;

FIG. **6** is a sectional view similar to a portion of FIG. 3, illustrating a modified flat form of heating element;

FIG. **7** is a sectional view taken substantially along line VII–VII of FIG. 6;

FIG. **8** is a sectional view similar to a lower portion of FIG. 3, illustrating a modified arrangement using annular heating elements below throttle valves and supported in a gasket;

FIG. **9** is a sectional view taken substantially along line IX–IX of FIG. 8 and constituting a top plan view of the gasket with the annular heating elements therein;

FIG. **10** is a graph illustrating how performance characteristics are changed with variations in amount of heat; and

FIG. **11** is an electrical circuit diagram.

Reference numeral **10** generally designates an air cleaner and carburetor assembly for an internal combustion engine in which a fuel vaporizing device is installed, in accordance with the principles of this invention.

The assembly **10** includes an air cleaner **11** having a cover **12** formed with with a radially extending air intake tube **13** and mounted on a circular base plate **14**, FIG. **2** being a view with the cover **12** removed. The base plate **14** has a central opening **15** which receives the upper end of a housing **16** of a carburetor **17**. A post **18** projecting upwardly from the carburetor **17** extends through a hole in the cover **12** to receive a wing nut **19** which is tightened to clamp the cover **12** to the base plate **14**. An annular air filter **20** is disposed between the cover **12** and the base plate **14** to filter the air passing into the space above the carburetor **17**.

In accordance with a specific feature of the invention, the restriction in the passage of air into the carburetor **17** is reduced by drilling holes **21** in the base plate **14** in angularly spaced relation outside the air filter **20**. As shown, twenty-four of the holes **21** are provided in equiangularly spaced relation each of which may have a diameter on the order of one-fourth or three-eights inches. With the holes **21**, additional air can be supplied to the carburetor under high acceleration and high speed conditions of operation and increased torque and power can be obtained when the heating devices of this invention are used. Without the heating devices of this invention, however, little if any advantage would be obtained by providing the holes **21**. It will be understood that the supply of air can be increased in other ways, but the provision of the holes **21** is advantageous in that they can be readily formed by drilling the base plate of a conventional air cleaner.

The illustrated carburetor **17** is a conventional four barrel carburetor in which the housing **16** is formed with two main flow passages **23** and **24** and two auxiliary flow passages **25** and **26**. A pair of butterfly throttle valves **27** and **28** are mounted on a operating shaft **30** which is operated from a foot-operated control through a conventional linkage, not shown. An additional pair of throttle valves **31** and **32** are provided at the lower ends of the auxiliary passages **25** and **26** and are mounted on a shaft which is connected to the shaft **30** through a conventional linkage, not shown, operative to start to open the auxiliary valves **31** and **32** when the main valves **27** and **28** are at an intermediate position and to fully open the auxiliary valves **31** and **32** when the main valves **27** and **28** are fully opened. The upper ends of the main passages **23** and **24** receive air from a common region which is separated by a wall **34** from a common region above the auxiliary passages **25** and **26**.

A conventional choke valve plate **35** is provided across the upper ends of the main passages **23** and **24** and is mounted on a shaft **36** which is operated by a conventional mechanism, either automatic or manual. A pair of venturi sections **37** and **38** are supported in the main passages **23** and **24** between the choke valve plate **35**, by means of a pair of arms **39** and **40** which extend from the sidewalls of the carburetor housing **16** and which are internally passaged for supply of gasoline or other fuel from a float chamber (not shown) into the venturi sections **37** and **38**. A similar pair of venturi sections are supported in the auxiliary passages **25** and **26**.

In accordance with this invention, heating devices in the form of a pair of elongated tubular electric heating elements **43** and **44** are supported in the main passages **23** and **24** and extend downwardly below the venturi sections **37** and **38**, the lower ends of the elements **43** and **44** being preferably disposed slightly above the throttle valves **27** and **28**. A spacing on the order of one-fourth inch is satisfactory. The elements **43** and **44** thus propagate radiant heat into the region immediately downstream from the mixing region defined by the venturi sections **37** and **38**. The radiant heat so propagated does not have any substantial effect on the air, which has comparatively low absorption characteristics, but the liquid fuel droplets are relatively highly absorptive and as a result, the liquid droplets are rapidly vaporized by absorption of the radiant heat. It is important that the elements **43** and **44** are elongated and that they extend in parallel relation alongside and closely adjacent the flow of the air-fuel mixture from the venturi section. The intensity of the radiant heat decreases approximately as the square of the distance from a source and therefore is it is important that the elements be as close as possible to the flow path. It is also desirable that any obstruction of the flow path be minimized and that excessive direct contact of fuel droplets with the heating element be minimized to obviate undue expansion of the vapors and excessive turbulence.

It is also noted that the heating elements **43** and **44** are disposed alongside portions of the flow paths which are relatively restricted such that the air is passing therethrough at a relatively high velocity, so that minimum heat is imparted to the air while at the same time, the liquid droplets are vaporized from absorption of the radiant heat.

The heating elements **43** and **44** are of identical construction. As shown in FIG. **5**, the heating element **43** comprises a metal tube **46** in which a core **47** of ceramic material is disposed having longitudinally extending slots **48** in which a wire **49** of nichrome or other high resistance metal is wound. The opposite ends of the wire **49** extend through a cap **50** of ceramic material and are connected to the ends of insulated wires **51** and **52** which extend through spaghetti tubing members **53** and **54** of insulating material. With the elements **43** and 44 properly positioned, the tubing members 53 and 54 and the corresponding tubing members for the element 44 are held tightly against the support rod or post 18 and a C-shaped clamp band 56 is then disposed around the tubing members, with the ends of the band 56 being pulled together by use of a screw 57. Although not shown, a spacer sheet of insulating material may be disposed between the clamp band 56 and the tubing members, and a safety wire may be provided, connecting the head of the screw 57 to the support rod 18, so as to ground the clamp band 56.

The spaghetti tubing members and the wires mounted therein are quite stiff to hold the heating elements 43 and 44 in fixed positions after mounting thereof. The wires from the heating elements may be extended through an opening 58 in the base 14 of the air cleaner, for connection to an energizing circuit, described hereinafter in connection with FIG. 11.

The illustrated support arrangement for the elements 43 and 44 is advantageous in that the heating elements can be readily and quickly installed in a carburetor. In addition, the elements 43 and 44 are suspended in a manner such as to minimize heating the housing 16. In this connection, it is noted that heat is propagated from the heating elements toward the inner surfaces of the housing passages, but due to reflection at such internal surfaces, a portion of the heat is returned toward the path of the air-fuel mixture, and with the cylindrical internal surface of the passage 23, the radiant heat energy can be concentrated to some extent at the central portion of the passage, where the fuel droplets are concentrated.

It is also noted that it is desirable that the venturi sections 37 and 38 be heated to a limited extent but excessive heating of the housing and of the fuel passages extending to the venturi section should be avoided because vaporization of the fuel before it reaches the venturi section can prevent proper and uniform flow of the fuel.

Referring to FIG. FIGS. 6 and 7, reference numeral 60 designates a modified form of heating element which is like the heating elements 43 and 44 except that it is not cylindrical but it is flat to provide an enlarged planar area for propagation of radiant heat into the fuel droplets while offering minimum interference with flow. The internal construction of the heating element is not shown but it is similar to that of the elements 43 and 48, a wire being wound on a ceramic core, disposed within a metal casing. The ends of the wire are connected to insulated wires 61 and 62 and the element 66 may be supported in the same manner as the elements 43 and 44.

Referring to FIGS. 8 and 9, another modified construction is illustrated in which four electric heating elements 63—66 of annular form are supported in a gasket 67 between the lower end of the carburetor housing 16 and wall 68 of the intake manifold of the engine. The electric heating elements 63 and 64 surround the lower ends of the main flow passages 23 and 24, below the main throttle valves 27 and 28, while the elements 65 and 66 surround the lower ends of the auxiliary flow passages, below the auxiliary throttle valves and 32. The elements 63—66 are of identical construction, the element 63, for example, comprising an outer metal case or housing 70 with resistance wires 71 being supported within the housing 70 by means of a core 72, preferably of a ceramic material.

Preferably, the gasket 70 extends above and below the elements 63—66 to provide heat insulating material between the elements and the housing 16 and the wall 68 of the intake manifold. The elements 63—66 serve to propagate radiant heat into the restricted path through which the fuel-air mixture flows and to vaporize the liquid droplets. The arrangement lacks one important advantage of the other arrangements in that the dimension of the elements in a direction parallel to the direction of flow is relatively small and the elements are spaced a substantial distance from the venturi sections. Like the other arrangements, however, the arrangement can be installed without modification of an existing carburetor.

It is noted that the use of additional heating elements 65 and 66 for the auxiliary passages is an advantage under high acceleration and high speed operating conditions, although the electrical power consumption is increased. In this connection, additional electric heating elements of the type shown in FIGS. 3—7 can be installed in the auxiliary flow passages to obtain improved results. Further, elements of the type shown in FIGS. 3—7 can be used in combination with the arrangement shown in FIGS. 8 and 9 and it is also noted that annular elements of the type shown in FIGS. 8 and 9 could be disposed above the throttle valves, with the carburetor being specially constructed for that purpose.

It requires appreciable time for the elements to reach operating temperature and all elements continuously are energized, the elements being preferably being connected in parallel although they could be connected in series.

It is noted that in each of the illustrated constructions of the heating elements, an outer metal case or housing is provided within which a resistance wire is supported on a core of insulating material. This type of construction is advantageous in that the surface temperature of the metal housing is maintained at a uniform temperature because of the high coefficient of heat conductivity of the metal and the production of "hot spots" is obviated. With the resistance wire being thus protected from sudden changes in temperature, its life is prolonged. In addition, the construction provides greater surface area for contact with liquid fuel droplets and for propagation of radiant heat into the liquid fuel droplets.

As previously indicated, an important feature of the invention is in the use of a controlled amount of heat and FIG. 10 graphically illustrates this feature. In this graph, the percentage acceleration change obtained with the use of the heating devices is plotted against current through the devices. The percentage acceleration change may be measured by operating an automobile at a certain uniform speed on a level highway, then moving the throttle valve to a certain more fully opened position, and then measuring with a stopwatch the time required to reach a certain higher speed, preferably with a plurality of measurements being made at each value of heater current. In changing from one heater current value to another, time is allowed to insure that the devices reach a uniform temperature.

In FIG. 10, the curve 74 indicates the percentage acceleration change obtained with a fully open throttle valve setting. The percentage acceleration change increases more and more rapidly as the heater current is increased until a maximum value is approached. After reaching the maximum value, the acceleration change reduces quite gradually until a relatively high current is applied. Curve 75 illustrates the type of curve obtained with with the throttle valve moved to an intermediate setting. This curve has the same general shape as the curve 74, but the peak is reached at a lower current value.

It is very difficult to obtain an accurate measurement of acceleration at low throttle valve settings, but tests indicate that a curve similar to dotted line curve 76 will be obtained.

In explanation of the depicted results, it is noted that under equilibrium or steady state conditions of operation, the electrical power applied to the heating elements is equal to the heat energy per unit time conducted and radiated from the elements. For thermal radiation, the total emissive power of a body varies with the fourth power of absolute temperature, while the electrical power is proportional to the square of the current. Thus the heat applied to the liquid fuel droplets by direct contact and in the form of radiant energy increases approximately as the square of the current. The vaporization of the fuel droplets increases and the performance improves in approximately the same fashion until a point is reached at which the liquid droplets are substantially completely vaporized. Thereafter, the current can be increased without any substantial effect upon vaporization but the increased heat serves to elevate the temperature and to expand the fuel-air mixture. This produces a condition in which, in effect, less fuel and air are supplied into the intake manifold and into the engine cylinders. As a result, the performance is gradually decreased with the increased current. In this connection, it is noted that because of the fact that increased vaporization of the fuel is obtained, it is possible to supply a greater amount of air to the carburetor, accomplished in the illustrated arrangement through the provision of the holes **21** in the air cleaner base **14**. However, without the increased vaporization, no substantial improvement in performance is obtained through the supply of additional air.

When the throttle opening is reduced, the velocity of flow is reduced and the supply of the fuel droplets is reduced so that complete vaporization can be obtained at a lower value of current.

It is noted that at a current value indicated by line **77**, peak performance is obtained at the fully opened throttle valve setting. With this current value, the performance is reduced at the intermediate throttle valve setting but only slightly and optimum overall performance is obtained at the current value **77**.

To determine the optimum value of electrical power to be applied with a particular engine and with a heating element or elements of certain sizes, configuration and placement, the test method set forth above may be used. In the alternative, the following empirical formula may be used:

$$P=\frac{D}{CHK}$$

where P is the electrical power input to the heating element or elements, in watts;

D is the displacement of the engine in cubic inches;

C is a fuel constant equated to the compression ratio of the engine;

H is a heat factor corresponding to the ratio of the portion of the area of the heating element which is effective to propagate radiant heat into the air-fuel mixture to the total area of the element; and

K is a constant having a value of less than 1.5, preferably in the range from 0.8 to 1.1 and most preferably approximately 0.95.

With respect to the constant C, less power need be supplied when a higher grade of fuel is used as is recommended for higher compression engines. If a lower grade fuel is to be used with a high compression ratio engine, the power can be increased somewhat.

Likewise, if a higher grade fuel is used with a low compression engine, the power can be reduced somewhat.

With respect to the heat factor H, this may be estimated from the physical configuration and placement of the heating element or may be determined by test. By way of example, with a heating element positioned as shown in FIGS. **3** and **4**, a factor of 0.5 is estimated. In particular, more than the lower one-half of the length of the element is directly opposite the fuel-air mixture path, and the heat propagated from the upper half of the element has some effect, but since one side of the element is facing the housing wall, a portion of the radiant heat would be absorbed by the wall without being reflected back toward the fuel-air mixture path. Thus it is estimated that about one-half of the heat is transmitted to the fuel-air mixture. In the alternative, the factor may be determined by determining the power P required to produce optimum results and then calculating H from the above formula with K being set equal to 0.95.

As an example of the operation of the formula, it may be assumed that heating elements are constructed and positioned as shown in FIGS. **3—5**, in two main barrels of a four barrel carburetor for a 1966 Cadillac engine having a cubic inch displacement of 429 and a compression ratio of 10.5. Assuming a heat factor H of 0.5, the power P is calculated to be approximately 86 watts. In actual operation, excellent results have been obtained with the use of two 42 watt units.

As another example, assume a single heating element in a single barrel carburetor of a 1966 Ford 6 engine having a cubic inch displacement of 240 and a compression ratio of 9.2; with the heating element having a size and placement relative to the carburetor approximately as shown in FIG. **4**, a heat factor H of 0.5 is again assumed. The power P is calculated to be 55 watts. In actual practice, excellent results have been obtained with the use of a 56 watt heating element.

It is noted that the curves depicted in FIG. **10** show the change in acceleration with changes in heater current, but similar improvements are obtained with respect to efficiency and gas mileage. Also, as above noted, cold weather starting is improved because the amount of heat is sufficient not only to completely vaporize the liquid fuel droplets but also to expand the vaporized fuel and to cause a mixture to reach the cylinders having a high proportion of vaporized fuel therein. Flooding is minimized because of the increased vaporization of the fuel. The increased vaporization of the fuel is also very important in facilitating starting under high ambient moisture conditions and also in minimizing stalling of the engine.

FIG. **11** shows an electrical circuit for energizing the heating elements. The elements **43** and **44** are connected in parallel between ground and a point **79** which is connected through a fuse **80** to a point **81** connected through a line **82** to accessories of the automobile and also connected to switch terminals engageable by a key-operated switch contact **83** both in the normal running or ignition position thereof and in the "accessory" position thereof. The contact **83** and a second contact **84** are connected to one terminal of a battery **85** the other terminal of which is connected to ground. In the ignition position, contact **84** engages a terminal connected through a line **86** to the ignition system of the engine. With this arrangement, the heater elements **43** and **44** are energized in either position of the switch and are always continuously energized when the engine is operating.

In starting, particularly in cold weather, the switch is moved to the accessory position and the elements are energized for approximately 30 seconds to allow the elements to reach an operating temperature. The accelerator foot pedal is then depressed approximately four times to pump fuel into the carburetor which is vaporized by the heat and then when the switch is moved to the starting position, a very rich mixture is initially supplied to the engine to cause starting thereof immediately. It will be understood that the circuit of FIG. **11** may be used with the other types of heating elements.

It is further noted that the invention is not limited to use in connection with automotive type engines but may be used for marine and aircraft engines or stationary engines as well. In connection with marine engines, the invention provides an important safety feature in that the vaporization of the fuel permits starting on a minimum of fuel, to lessen the possibility of fire, and an increased amount of fuel being needed to overcome the moisture factor when the device of this invention is not provided in the carburetor.

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of this invention.

I claim:

1. In a method of improving the performance of an internal combustion engine operable under certain normal ranges of load, speed and ambient temperature conditions, said engine including air-fuel mixing means, flow path means for flow of mixed air and fuel from said mixing means for combustion in said engine, and throttle valve means in said flow path means for controlling said flow of mixed air and fuel, said engine having characteristics such that an optimum amount of radiant heat applied to enhance vaporization of fuel within said flow path means is effective to cause said engine to develop maximum average torque and acceleration while operating within said normal ranges of load, speed and ambient temperature conditions and with said throttle valve means fully open, average torque and acceleration being reduced in proportion to a reduction of the amount of radiant heat below said optimum amount and being also reduced in proportion to an increase of the amount of radiant heat above said optimum amount, the steps of providing electrical heating means, arranging said heating means for installation in said flow path means to radiate heat into the mixed air and fuel and to enhance vaporization of the fuel, and providing connections for continuously supplying an optimum amount of electrical power to said heating means at all times during operation of said engine, said optimum amount of electrical power being predetermined in accordance with said characteristics of said engine and being effective to cause radiation of said optimum amount of radiant heat from said heating means into the fuel-air mixture in said flow path means.

2. In a method as defined in claim **1**, the step of arranging said heating means for installation on the downstream side of said throttle valve means.

3. In a method as defined in claim **1**, wherein said air fuel mixing means comprises a carburetor having a main venturi section and a fuel supply communicating with said main venturi section, said throttle valve means being located downstream from said venturi section, the step of arranging said heating means for installation in said carburetor between said venturi section and said throttle valve means.

4. In a method as defined in claim **1**, wherein said engine is of a type usable to propel a vehicle, said optimum amount of electrical power being determinable by a test comprising the steps of first installing said electrical heating means in said fuel air flow path of said engine, changing the electrical current through said heating means in steps from one current value to another and measuring at each electrical current value the torque and acceleration capabilities of said engine by first operating said engine to propel a vehicle at a certain uniform speed on a level highway, then moving said throttle valve means to a fully open condition and measuring the time required to accelerate to a certain higher speed on a level highway, said certain uniform speed and said certain higher speed corresponding to the limits of the normal range of speed of operation of said engine and said measurements of acceleration capabilities being performed at average ambient temperature conditions, said acceleration capabilities being measured at a number of electrical current values sufficient to establish a current value at which maximum acceleration is obtained, and said optimum amount of of electrical power being determined from the resistance of said heating means and the said current value at which maximum acceleration is obtained.

5. In apparatus for improving the performance of an internal combustion engine operable under certain normal ranges of load, speed and ambient temperature conditions, said engine including air-fuel mixing means, flow path means for flow of mixed air and fuel from said mixing means for combustion in said engine, and throttle valve means for controlling said flow of mixed air and fuel, said engine having characteristics such that an optimum amount of radiant heat applied to enhance vaporization of fuel within said flow path means is effective to cause said engine to develop maximum average torque and acceleration while operating within said normal ranges of load, speed and ambient temperature conditions and with said throttle valve means fully open, average torque and acceleration being reduced in proportion to a reduction of the amount of radiant heat below said optimum amount and being also reduced in proportion to an increase in the amount of radiant heat above said optimum amount, electrical heating means, means arranging said electrical heating means for installation in said flow path means, and electrical connection means arranged for continuously supplying an optimum amount of electrical power to said heating means at all times during operation of said engine, said optimum amount of electrical power being predetermined in accordance with said characteristics of said engine and being effective to cause radiation of said optimum amount of radiant heat from said heating means into the air fuel mixture in said flow path means.

6. In apparatus as defined in claim **5**, said electric heating means including an electric heating element comprising an outer metallic casing, insulation means within said casing, and a resistance wire supported by said insulation means within said casing.

7. In apparatus as defined in claim **6**, said casing being generally cylindrical.

8. In apparatus as defined in claim **6**, said casing having a relatively flat configuration.

9. In apparatus as defined in claim **6**, wherein said flow path means of said engine are formed by metal wall means, said means arranging said electrical heating means for installation in said flow path means comprising means for suspending said electric heating element in said flow path means in a manner such as to minimize direct conduction of heat from said outer metallic casing to said metal wall means.