AUSTRALIA
CONVENTION APPLICATION FOR A PATENT

EDWARD DAVIES,
of 29 Victoria Street,
Casseldale, Springs,
Transvaal Province,
Republic of South Africa,
hereby apply for the grant of a Patent for an invention entitled: "SUPPLYING FUEL TO INTERNAL COMBUSTION ENGINES"

which is described in the accompanying complete specification. This application is a Convention application and is based on the application numbered 76/0734.

for a patent or similar protection made in South Africa, on 9th February, 1976.

My address for service is Messrs. Edwd. Waters & Sons, Patent Attorneys, 50 Queen Street, Melbourne, Victoria, Australia.

DATED this 20th day of January 1977

EDWARD DAVIES,
by
D.B.MISCHLEWSKI,
Reg'd Patent Attorney

To:
THE COMMISSIONER OF PATENTS.
(CONVENTION. One or more persons.)

COMMONWEALTH OF AUSTRALIA


DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT OR PATENT OF ADDITION

In support of the Convention Application made by(1) EDWARD DAVIES

for a patent. for an invention entitled:(3) "SUPPLYING FUEL TO INTERNAL COMBUSTION ENGINES"

(1) EDWARD DAVIES,

of(4) 29 Victoria Road, Casseldale,

Springs, Transvaal Province,

Republic of South Africa,

do solemnly and sincerely declare as follows:

1. I am the applicant for the patent.

2. The basic application as defined by Section 141 of the Act was made in(4) South Africa,
on the 9th day of February 1976, by

3. I am the actual inventor of the invention referred to in the basic application.

4. The basic application referred to in paragraph 2 of this Declaration was the first application made in a Convention country in respect of the invention the subject of the application.

DECLARED at PRETORIA, South Africa,
this 21st day of December 1976

(1) EDWARD DAVIES

To: THE COMMISSIONER OF PATENTS.

(1) Signature of Applicant or Applicants.
Complete Specification

Application Number: 96025477
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Complete Specification for the invention entitled: "SUPPLYING FUEL TO INTERNAL COMBUSTION ENGINES"

The following statement is a full description of this invention, including the best method of performing it known to Us,

1.
THIS INVENTION relates to the supply of fuel to internal combustion engines, and more particularly to the supply of a combustible mixture of air and hydrocarbon fuel to such engines. It relates in particular to a method of and to apparatus for supplying such a mixture to an internal combustion engine, in which portion of the fuel is in liquid form and portion is in vapour form. The invention relates more particularly, to a method of reducing air pollution, by supplying a combustible mixture of air and a combination of fuels to an internal combustion engine.

Air pollution occurs increasingly in areas where motor vehicles using conventional liquid hydrocarbon fuels are in high concentration. Particularly where the vehicles
stop and start frequently, air pollution is likely to occur, and is even likely to exceed acceptable levels, because of incomplete combustion of the mixtures supplied to the engines of the vehicles. Frequent stopping and starting of the vehicles, and too wide opening of the throttle for a particular engine speed, results in mixtures being momentarily too rich, until engine fuel demand matches the supply.

In this specification, the term 'gasoline' includes the liquid hydrocarbon fuel also referred to as 'petrol' in some parts of the world.

It is an object of this invention to reduce air pollution by providing a combustible air/fuel mixture for internal combustion engines, resulting in more complete combustion in such engines than is obtainable with air/fuel mixtures known to the applicant heretofore.

In accordance with the invention a method of providing a combustible mixture to an internal combustion engine having a throttle and using liquid hydrocarbon fuel includes the steps of

reducing the supply of liquid hydrocarbon fuel to the engine;

permitting the engine to run on its reduced liquid fuel supply thereby causing air to flow in an air flow stream to the engine;
permitting a supplementary fuel supply of liquid petroleum gas in vapour form to enter an air flow stream in response to a predetermined minimum rate of flow of air in the air flow stream; and

permitting increasing rates of flow of the said supplementary fuel into the air flow stream in response to increasing rates of flow of air in the air flow stream.

For brevity liquid petroleum gas is hereinafter referred to as L.P. gas. Like gasoline (petrol) L.P. gas is a hydrocarbon fuel. Its principal constituents are Butane or Propane or a mixture of these gases. Under ordinary ambient atmospheric conditions it is in vapour phase, unlike gasoline (petrol) which under similar conditions occurs in liquid phase.

The supply of supplementary fuel to the engine may be permitted to take place only upon negative pressure of a predetermined magnitude occurring in the air flow stream.

The reduction of the liquid fuel supply is of the order of about one third to one half by volume. For an engine having a carburettor, the reduction may be obtained by reducing the diameter of the main jet(s) of the carburet or of the engine by about one fifth.
The relative proportions of supplementary and liquid fuels may be adjusted by opening the throttle to a predetermined extent, while the engine is running on its reduced liquid fuel supply, and by then adjusting the rate of supply of supplementary fuel to the engine until it runs at maximum speed for that degree of throttle opening.

The invention extends also to a supplementary fuel supply system for an internal combustion engine having an air inlet and a throttle for controlling the flow of air along the air inlet, to the engine, the system comprising:

- a supplementary fuel reservoir for storing supplementary fuel in the form of L.P. gas in liquid and vapour form under a pressure substantially above atmospheric pressure;
- a supplementary fuel feed line leading from the reservoir to the air inlet of the engine;
- a pressure reducing valve in the feed line and adapted to reduce the pressure of the supplementary fuel in the reservoir to a value slightly above atmospheric pressure in the feed line;
- a metering device adapted to meter a predetermined rate of flow of supplementary fuel along the feed line under a predetermined pressure; and
- a supplementary fuel feed valve in the feed line and adapted to open only upon negative pressure of a predetermined magnitude occurring in an air flow stream to the engine.
corresponding to a predetermined minimum rate of flow of air in the air flow stream, and adapted to permit increasing rates of flow of supplementary fuel into the air flow stream in response to increasing rates of flow of air in the air flow stream.

The supplementary fuel feed line may be arranged to receive supplementary fuel in liquid form from the reservoir; and there may be provided expansion means, pressure reducing means, and heating means for absorbing the coolth of expansion.

The system may include interlocking means which prevent opening of the supplementary fuel feed valve unless the predetermined minimum rate of flow of air to the engine is taking place. The interlocking means may comprise a stop biased to an operative position in which opening of the supplementary fuel feed valve is prevented; and a suction connection to the air inlet of the engine, for displacing the stop to an inoperative portion to permit opening of the supplementary fuel feed valve.

The invention will now be described by way of example with reference to the accompanying diagrammatic drawings.

In the drawings:
Figure 1 shows a schematic arrangement of one example of a supplementary fuel supply system according to the invention, and in which supplementary fuel is drawn off in liquid form from a reservoir;

Figure 2 shows diagrammatically a sectional side elevation of the introduction of supplementary fuel into an air flow stream of an engine;

Figure 3 shows diagrammatically a detail of a feed regulator forming part of the system of Figure 1;

Figure 4 shows diagrammatically a sectional side elevation of a filter lock forming part of the system of Figure 1;

Figure 5 shows diagrammatically another example according to the invention in which supplementary fuel is drawn off in vapour form from the reservoir; and

Figure 6 shows diagrammatically a sectional side elevation of a feed regulator forming part of the system of Figure 5.

Referring to the drawings, reference numeral 10 refers generally to a supplementary fuel supply system, comprising a supplementary fuel reservoir 12, having a
supplementary fuel feed line 14, feeding fuel in liquid form via a filter lock 16 to a feed regulator 18, in which the supplementary fuel becomes vapourised and is then fed via the downstream portion 14.1 of the supplementary fuel feed line 14, to the carburettor generally indicated by reference numeral 20 of an internal combustion engine not shown. The carburettor is mounted on the inlet manifold 22 of the engine.

The reservoir 12, is mounted at a convenient place in the motor vehicle and is held down by clamping straps 24. Supplementary fuel in the form of liquid petroleum gas in liquid and in vapour phase may be under a gauge pressure in excess of 1500 kPa (approximately 200 psi) inside the reservoir 12. However the gauge pressure of the supplementary fuel inside the reservoir may be much less, e.g. only 200 - 350 kPa (approximately 30 - 50 psi).

The fuel in liquid form, is withdrawn from a level below the level of liquid in the reservoir 12. This may conveniently be done by having the upstream end of the fuel feed line 14, projecting down into the reservoir 12, to an extent well below the level of the liquid fuel in the reservoir 12.
The reservoir can be filled with supplementary fuel via a vapour equalizing valve 26. It has a relief valve 28 to permit liquid petroleum gas in vapour form to blow off under excess pressure in the vessel. This is a safety feature. Further filling of the reservoir 12 is prevented by a float level device 30, and the level of the liquid petroleum gas in the reservoir is indicated by a gauge 32. A shut-off valve 34 controls the delivery of the gas from the reservoir 12. The various items 26 to 34, are protected by a surround 36 having handles 38.

The filter lock 16, is interconnected with the ignition switch 40 of the vehicle via conductor 40.1, so that fuel is prevented from passing beyond the filter lock 16, unless the ignition switch 40 has been switched on. After the filter lock 16, the fuel passes along that portion of the fuel feed line 14.11 into the regulator 18 which will be described more fully hereafter. The regulator 18 embodies an expansion valve in which the liquid fuel turns into gas. The expansion results in cooling. In order to dry the vapour it is desirable to have the coolth absorbed by hot water passing along conduits 42 and 44 from the cooling system 46 of the engine, and through a water jacket in the regulator 18.
The regulator 18 has a supplementary fuel feed valve, delivering supplementary fuel into the flow stream 21 via the downstream portion 14.1 of the fuel feed line, and via a metering device 48 to the carburettor 20, at a region upstream of the throttle 50 of the carburettor. Liquid fuel is fed along line 52 into the float chamber 20.1 of the carburettor 20.

The regulator 18, further comprises interlocking means which prevent operation of the supplementary fuel feed valve, unless a predetermined minimum flow of air to the engine is taking place. In other words, there must be a predetermined minimum suction or negative pressure in the inlet manifold 22 before the interlocking means will operate, and before it will permit the opening of the supplementary fuel feed valve in the regulator 18. The suction to operate the interlocking means, is communicated to the regulator by means of conduit 52 connected to the inlet manifold 22, at a position downstream of the throttle 50. The predetermined minimum suction will correspond to a predetermined minimum rate of flow of air in the air flow stream to the engine.
Referring now to Figure 2 of the drawings, the supplementary fuel, is fed into the air passage 19 of the carburettor 20, at a region downstream of the choke 54 but upstream of the venturi 56, which is itself upstream of the throttle 50. The feed line 14.1, terminates in the open end 14.2 in the central zone of the air passage of the carburettor 20. The opening is directed transversely to the direction of flow of the air flow stream 21 in the passage 19. In being directed transversely to the direction of flow along the passage, the opening 14.2 is directed partially upstream.

Reference 20.2 indicates the level of liquid fuel in the float chamber 20.1 of the carburettor 20. Liquid fuel enters the passage 20.3 via the main jet 20.4 and liquid fuel is then admitted into the air stream, in the venturi throat, via opening 20.31. It is the main jet 20.4 which is replaced by a smaller main jet so as to reduce the supply of liquid fuel to the engine, in accordance with the invention.

The regulator 18 will now be described in detail. It comprises a connection 60, adapted for connection to the fuel feed line 14.11. The fuel enters under a pressure of about 250 kPa, passes through the expansion valve 62 into the chamber 64, where the pressure is about 30 kPa. Supplementary fuel in vapour form, passes from the chamber 64, via a supplementary fuel feed valve 66 into a supplementary fuel feed chamber 68 having a connection 70 connectable to the
downstream, portion 14.1 of the fuel feed line. The expansion of the supplementary fuel from liquid to vapour phase, results in cooling. This cooling is neutralized and the vapour is dried by heat obtained by passing hot water from the engine cooling system through a jacket 72, via connections 74 and 76 adapted respectively for connection to conduits 42 and 44.

The operation of the expansion valve 62 is controlled by spring 78 and diaphragm and spring combination 80 and 82 respectively. The diaphragm 80 defines one wall of a chamber 84, which is open to atmosphere via opening 86. Adjustability in the stiffness of the spring 82, is provided by adjusting screw 88.

The interlocking means generally indicated by reference numeral 90, comprises a spring 92, and a stop 94 fast with a diaphragm 96 which defines one wall of a chamber 98 having a connection 100, connectable via the suction conduit 52 to the inlet manifold 22 of the engine.

In the position shown in Figure 3 of the drawings, the stop 94 abuts the tail end 66.1 of the lever 66.2 and prevents the opening of the valve 66. The valve 66 is also biassed to
the closed position, by the spring 102. Only when there is a predetermined minimum value of suction i.e. a predetermined negative pressure in the chamber 98, corresponding to a predetermined rate of flow of air in the air flow stream to the engine, will the spring 92 collapse under the action of the diaphragm 96, and the stop 94 withdrawn from the tail end 66.1 of the lever 66.2. If now the pressure inside the chamber 68 reduces sufficiently as the result of suction at the opening 14.2, then the diaphragm 104, which is open to atmosphere on one side via opening 106, will collapse and will cause the spring 102 to compress, and thereby will result in the opening of the supplementary fuel feed valve 66. Thereby supplementary fuel is admitted under about 30 kPa pressure from the chamber 64 into the chamber 68 whence the fuel can pass via the connection 70, and via the downstream portion 14.1 of the fuel feed line, into the air passage 19, and into the air flow stream via the opening 14.2.

Referring now to Figure 4 of the drawings, the construction of the filter lock 16 will be described. The filter lock comprises a body 120, having a connection 122 adapted for connection to the upstream portion of the fuel feed line 14. The supplementary fuel in liquid form, passes from the connection 122, via passages 124 into a chamber 126 and thence via a filter element 128, into a central passage 130 into a chamber 132. The chamber 132 has an outlet 134
adapted for connection to that portion 14.11 of the supplementary fuel feed line, located between the filter lock 16 and the regulator 18. The chamber 132 is closed off from the outlet 134, by the valve member 136 at the end of the armature 138 biassed to the closed position by spring 140. Around the one end of the casing, there is provided a coil 142 having the connection 40.1 for connection to the ignition switch 40. The valve is shown in the closed position. When a current flows in the coil 142, the armature 138 is drawn into a central position within the coil 142, thereby compressing the spring 140, and unseating the valve closure member 136, and thereby placing the chamber 132 in communication with the connection 134 and permitting the supplementary fuel in liquid form, to flow along that portion of the fuel feed line 14.11 to the expansion valve 62 in the regulator 18.

Referring now to Figure 5 of the drawings, there is shown an alternative arrangement in which supplementary fuel is drawn off in vapour form by supplementary fuel feed line 15 from the reservoir 12, under a pressure of about 250 kPa. The fuel passes into a pressure reducing valve 140, then through a metering device 142, and then via a portion 15.1 of the supplementary fuel feed line, to a supplementary fuel feed regulator 144. This supplementary fuel feed regulator 144 operates in similar fashion to the feed regulator 18, except that it does not incorporate an expansion valve and a reducing valve, and a water jacket. The feed
regulator 144, is also provided with interlocking means generally indicated by reference numeral 90. The parts of feed regulator 144, which are similar to and which correspond to similar parts in the feed regulator 18 have been similarly numbered. The supplementary fuel feed chamber 68 has a connection 146, adapted for connection to that portion 15.1 of the supplementary fuel feed line downstream from the reducing valve and metering device, the fuel being fed into the supplementary chamber 68, at a gauge pressure of about 30 kPa. The chamber 98 of the interlocking means 90, has a connection 100, adapted for connection via the suction conduit 52, to the air passage leading to the engine, at a region downstream of the throttle 50.

The connection 70, leading out of the supplementary fuel feed chamber 68, is connected via the downstream portion 15.2 of the supplementary fuel feed line, to the carburettor 20. The supplementary fuel feed line terminates in an opening 15.2, similar to the opening 14.2 described with reference to Figure 2 of the drawings. The ends of the tubes 20.3 and 15.2 are situated inside a nozzle bar 146 whose lower end, is in line with the narrowest portion of the venturi 56. The supplementary fuel feed valve 66 is positioned in close proximity to the outlet end of the fuel feed line 14.1 or 15.2.
In installing the system, smaller main jets 20.4 are substituted for the jets normally used. The new jets 20.4 are about one fifth smaller in diameter than the jets normally used. For normal starting and idling purposes, the engine will use liquid fuel from the flow chamber 20.1. In other words, liquid fuel will be used for average engines, up to speeds of about 900 rpm. The regulators 18 and 144 are so adjusted, that the supplementary fuel feed valve 66, will open only at speeds above this engine speed.

The relative proportions of supplementary fuel to liquid fuel are adjusted by letting the engine run on its reduced fuel supply, at a predetermined throttle setting e.g. one quarter full throttle, and by then adjusting the metering devices 48 and 142 to obtain maximum engine speed under no load at that throttle setting. The applicant has found that in this way, adequate proportions of vapour to liquid fuel, are obtained for the full range of throttle openings.

With the dual fuel supply system according to the invention, no problems are encountered with the idling of the engine, because the engine still idles on its liquid fuel supply. If the engine should run out of L.P. gas, then it is still possible to travel on the reduced liquid fuel supply until the supply of supplementary fuel can be replenished. It is an advantage of this invention, that the distance
which a vehicle can travel on a full supply of liquid and L.P. gas fuel is greater than on liquid fuel alone. For some vehicles, the increase in range is of the order of 30 per cent, for others it is in excess of 50 per cent.

The applicant has found that more complete combustion is obtained with an air/fuel mixture in which L.P. gas and gasoline are used together than when gasoline alone is used. This has been found by analysing the exhaust gases.

Liquid petroleum gas has a higher octane rating (that is anti-knock characteristics) than many gasolines which are on sale. Some engines require gasoline having a high octane rating. When a gasoline L.P. gas fuel combination is used, then it is possible to use in such fuel combination, a gasoline having a lower octane rating than a gasoline which would normally be used alone in such engines. This is made possible by the high octane rating of the L.P. gas which renders a low octane gasoline and L.P. gas combination into a suitable fuel for such engines.

Depending upon the relative costs of the gasoline and the L.P. gas fuel, a saving in cost can also be obtained, particularly if the gasoline used (having a lower octane rating) is less expensive than a gasoline having a high octane rating.
In South Africa, (and it is believed in other countries as well) liquid petroleum gas is in plentiful supply and is less expensive than gasoline (petrol). This invention therefore provides a ready use for L.P. gas as a supplementary fuel in internal combustion engines.

This invention has the advantage over an earlier system known to the applicant, that supplementary fuel is fed in only upon demand, that is, when the engine runs at a predetermined minimum speed to produce sufficient suction to induce opening of the supplementary fuel feed valve. Increased opening of this valve, is obtainable only upon increased suction, which in turn depends upon increased engine speed. In other words, supplementary fuel is not supplied before engine demand is there, but only after such demand is there. Fuel supplied by the accelerator pump or power jet of a carburettor is an example of fuel supplied before engine demand is there.
CLAIMS
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of providing a combustible mixture to an internal combustion engine having a throttle and using liquid hydrocarbon fuel, which includes the steps of reducing the supply of liquid hydrocarbon fuel to the engine;

   permitting the engine to run on its reduced liquid fuel supply thereby causing air to flow in an air flow stream to the engine;

   permitting a supplementary fuel supply of liquid petroleum gas in vapour form to enter the air flow stream in response to a predetermined minimum rate of flow of air in the air flow stream; and

   permitting increasing rates of flow of the said supplementary fuel into the air flow stream in response to increasing rates of flow of air in the air flow stream.

2. A method as claimed in claim 1 in which the supply of supplementary fuel to the engine is permitted to take place only upon negative pressure of a predetermined magnitude occurring in the air flow stream.

3. A method as claimed in claim 1 or claim 2, in which the reduction of the liquid fuel supply is of the order of about one third to one half by volume.

4. A method as claimed in claim 1 or claim 2 or claim 3, in which the reduction of the liquid fuel supply for an engine having a carburettor, is by reducing the diameter of the main jet(s) of the carburettor of the engine by about one fifth.
5. A method as claimed in any one of the claims 1 to 4 inclusive, in which the supplementary fuel is stored under a pressure substantially above atmospheric pressure, its pressure being then reduced to only slightly above atmospheric pressure before the fuel vapour is fed into the air flow stream.

6. A method as claimed in claim 5, in which the supplementary fuel supply is in liquid form, and in order to get it into vapour form before permitting it to enter the air flow stream it is subjected to expansion and pressure reduction and heating.

7. A method as claimed in any one of the preceding claims in which the supplementary fuel is supplied to the air stream in a zone upstream of the throttle.

8. A method as claimed in any one of the preceding claims in which the relative proportions of supplementary and liquid fuels are adjusted by opening the throttle to a predetermined extent, while the engine is running on its reduced liquid fuel supply, and by then adjusting the rate of supply of supplementary fuel to the engine until it runs at maximum speed for that degree of throttle opening.

9. A supplementary fuel supply system for an internal combustion engine having an air inlet and a throttle for controlling the flow of air along the air inlet, to the engine, the system comprising:
a supplementary fuel reservoir for storing supplementary fuel in the form of L.P. gas in liquid and vapour form under a pressure substantially above atmospheric pressure;
a supplementary fuel feed line leading from the reservoir to the air inlet of the engine;
a pressure reducing valve in the feed line and adapted to reduce the pressure of the supplementary fuel in the reservoir to a value slightly above atmospheric pressure in the feed line;
a metering device adapted to meter a predetermined rate of flow of supplementary fuel along the feed line under a predetermined pressure; and
a supplementary fuel feed valve in the feed line and adapted to open only upon negative pressure of a predetermined magnitude occurring in an air flow stream to the engine corresponding to a predetermined minimum rate of flow of air in the air flow stream, and adapted to permit increasing rates of flow of supplementary fuel into the air flow stream in response to increasing rates of flow of air in the air flow stream.

10. A system as claimed in claim 9 in which the supplementary fuel feed line is arranged to receive supplementary fuel in liquid form from the reservoir; and in which there are provided expansion means, pressure reducing means, and heating means for absorbing the coolth of expansion.
11. A system as claimed in claim 9 or claim 10, in which interlocking means are provided which prevent opening of the supplementary fuel feed valve unless the predetermined minimum rate of flow of air to the engine is taking place.

12. A system as claimed in claim 11, in which the interlocking means comprises a stop biassed to an operative position in which opening of the supplementary fuel feed valve is prevented; and a suction connection to the air inlet of the engine, for displacing the stop to an inoperative portion to permit opening of the supplementary fuel feed valve.

13. A system as claimed in any one of the claims 9 to 12 inclusive, in which the supplementary fuel is supplied to the air flow stream upstream of the throttle.

14. A system as claimed in claim 13 in which the supplementary fuel feed inlet into the air stream is via a tube having an opening in the central zone of the air stream the opening being directed transversely to the direction of flow of the air flow stream.

15. A system as claimed in claim 14 in which the opening in the tube is provided by an oblique cut across the tube.
16. A system as claimed in any one of claims 9 to 15 inclusive, in which the metering device is adjustable.

17. A system as claimed in any one of claims 9 to 16 inclusive, in which the supplementary fuel feed valve is positioned in close proximity to the outlet end of the feed line.

18. A kit for a supplementary fuel supply system for an internal combustion engine and which comprises
   a supplementary fuel reservoir;
   a pressure reducing valve;
   a metering device;
   a supplementary fuel feed valve; and
   piping and fittings to make up the system as claimed in any one of the claims 9 to 17 inclusive.

19. A method of providing a combustible mixture to an internal combustion engine, substantially as described and illustrated herein.

20. A supplementary fuel supply system for an internal combustion engine substantially as supplied and illustrated herein.

21. A kit for an internal combustion engine supplementary fuel supply system substantially as described and illustrated herein.
DRAWINGS