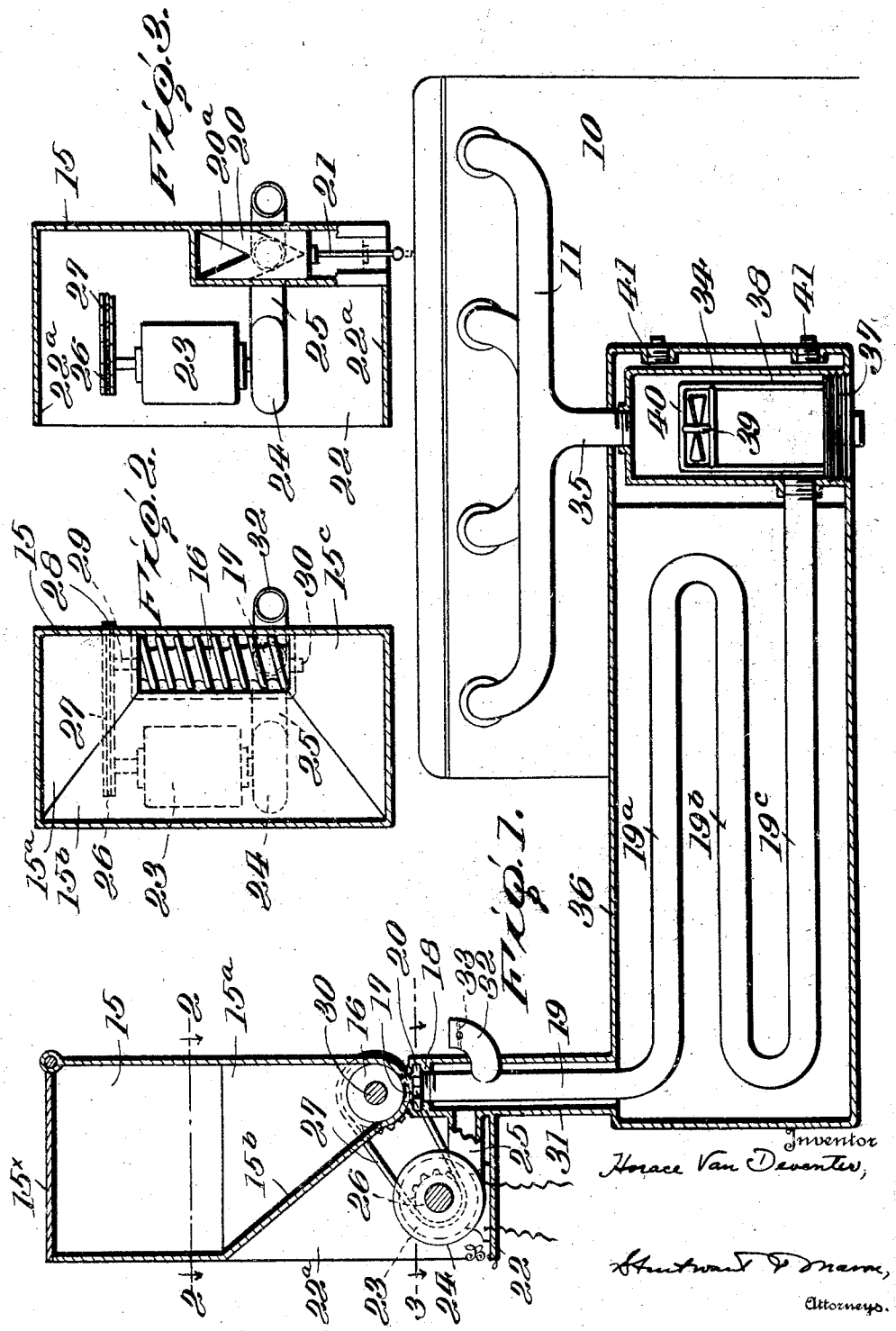
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FUEL FEEDING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed March 3, 1927 2 Sheets-Sheet 1

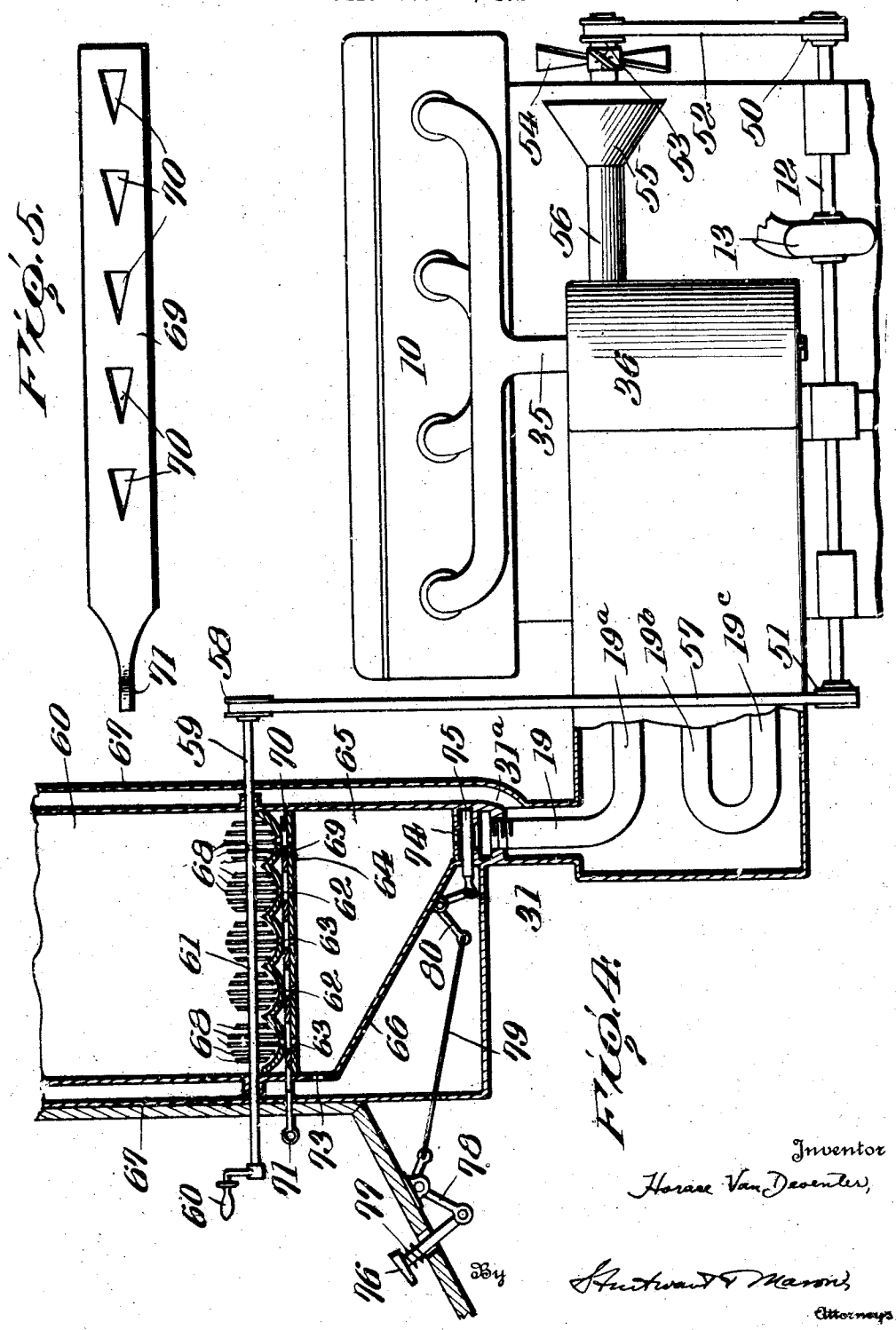


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FUEL FEEDING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed March 3, 1927 2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE.

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FUEL-FEEDING SYSTEM FOR INTERNAL-COMBUSTION ENGINES.

Application filed March 3, 1927. Serial No. 172,360.

This invention relates to improvements in fuel systems for internal combustion engines and more particularly concerns an apparatus for and method of employing a powdered fuel such as coal.

It has heretofore been proposed to employ powdered fuel such as coal in gas generators of various types for the manufacture of a producer gas which is then burnt in an internal combustion engine for the development of power. It has likewise been proposed to introduce powdered fuel of such type into the combustion chamber of a compression engine of, for example, the Diesel type, wherein it is then ignited by high compression of air.

In contradistinction from such devices, the present invention proposes to create a uniform and homogeneous suspension of finely pulverized coal dust in air for combustion, and to deliver this suspension to the operating cylinders of a gas engine under such conditions that the mixture may be caused to explode by ignition from the ordinary type of spark plug, and in particular proposes a system by which such powdered fuel may be employed as a substitute for the usual liquid fuel in its ordinary carbureted employment in such engines.

It has been found that finely powdered coal is well adapted for such employment, and that under certain specified conditions its action may be favorably influenced to obtain high efficiencies.

In addition to the general object of employing such suspended powder fuels, means are provided whereby the greater efficiency is obtained within the engine by the employment of a cooled mixture, which is in contradistinction to the usual heated mixture necessitated in the use of liquid fuels.

In the drawings:

Figure 1 is a side elevation of an internal combustion engine with a fuel feeding system of the present type applied thereto, parts of said system being in section for distinctness of disclosure.

Fig. 2 is a section substantially on line 2—2 of Fig. 1.

Fig. 3 is a section substantially on line 3—3 of Fig. 1.

Fig. 4 is a side elevation similar to Fig. 1 of a modified form of the invention.

Fig. 5 is a detail view of the control valve slide represented in Fig. 4.

This invention is particularly applicable to the use of coal as a fuel for internal combustion engines of automobiles, airplanes and the like, as a substitute for gasoline or other liquid fuel: and means are provided to effect a constant flow of coal powder to a stream of current of air, whereby a suspension of such coal powder in air in a quasi-gaseous state is delivered to the intake manifold and thence to the cylinders of the engine, either by suction or by a forced air current; this mixture or suspension then being ignited in the usual manner by means of spark plugs. Means are provided to keep the coal powder and the air current carrying it at a low temperature and, if necessary, to reduce the temperature during the progress of the mixture from the coal dust container to the engine: which in particular comprises the employment of another air current about the fuel delivery pipe and finish-mixing chamber, in a forced circulation by a mechanically driven fan.

It has been found that one of the properties of coal powder, particularly from bituminous coal, is that it mixes with or impregnates air more freely and thoroughly and is better and more uniformly distributed in a cloud-like form therein when the coal powder and the air carrying it are chilled or cooled. This particular property makes coal powder especially valuable for the cold weather operation of automobiles and for the operation of airplanes at altitudes where the cold is so great that many fuels fail to volatilize, mix or explode. Furthermore, this cooling of the coal powder and the air before explosion permits the delivery of a larger molecular quantity of mixture into a cylinder of a given size, whereby a greater volume of gaseous products are developed and greater power is assured. In this way, not only is greater power obtained from the same engine, but also a great economy in the operation of the system.

On the accompanying drawings, an internal combustion engine 10 of any general or well known type is provided with an intake manifold 11 having branch connections to the several combustion chambers, here represented as cylinders which are governed as customary by appropriate valves. This internal combustion engine is provided with the usual accessories and operates a main shaft in the usual manner which need not

be more clearly shown or described. The valve gearing and elements are likewise of any customary type.

The fuel hopper 15 for the powdered coal is located in the illustration at the rear end of the engine and above its cylinder block. An endless screw 16 is located in a U-shaped trough which is open at its top to the hopper 15, and is preferably formed with its walls integral with the walls of the hopper, the inclined lower walls 15^a, 15^b and 15^c being directed at an angle inwardly and forwardly to the point of junction with the trough walls. The rotation of this endless screw 16 is employed to keep the fuel in a continuous state of agitation so that packing or lumping is prevented, and to feed it forward to a position above the discharge opening 17 in the bottom of the trough. This opening 17 communicates with a fuel pipe 19, so that the coal powder which flows through the aperture 17 falls into the pipe 19. Located in a slide channel formed between the lower walls of the U-shaped trough and the guide flanges 18 is the slide 20 which has therein a V-shaped notch 20^a (Fig. 3) for the purpose of uncovering the alined aperture 17 and the pipe opening to a greater or lesser extent according to its prevailing position. This slide plate 20 may be moved to such a position of regulation by means of the rod 21 which passes to the exterior of the casing 15.

Beneath the inclined bottom 15^b of the hopper is located a floor 22 which has the protecting end walls 22^a at the ends in prolongation of the hopper walls. Mounted on this floor is an electric motor 23 having at one end a blower or air compressor 24 which is connected to an efflux pipe 25 as described hereinafter. At its other end the motor carries a sprocket 26 engaging with a driving chain 27 which leads to the sprocket 28 on the shaft 29 of the worm 16. This shaft 29 passes through the end wall of the U-shaped trough, and thereby serves as a journal for the worm, which at its other end has a stub shaft 30 similarly passing through and journaled in the opposite end wall of the trough.

The efflux pipe 25 leads to the interior of a jacket pipe 31 which surrounds the fuel mixture pipe 19 for the downward portion of its run, and is closed with regard thereto to form a substantially air-tight chamber surrounding it. The side tap 32 leading from the fuel mixture pipe 19 through the casing 31 and open to the atmosphere at the outside thereof permits the entry into the fuel mixture pipe 19 of a cool atmospheric air which is regulated by the butterfly valve 33.

The fuel mixture pipe 19 after a short downward run is bent into an S-shaped coil with three successive horizontal runs 19^a, 19^b and 19^c which are joined by smoothly turned return bends at their ends, and finally passes into the interior of a mixing casing 34 which is substantially closed to the atmosphere but is in communication with the common pipe 35 leading to the manifold 11, so that the fuel mixture may pass to the respective cylinders.

Surrounding the horizontal runs 19^a, 19^b and 19^c and their return bends is a jacket or casing 36 which is preferably formed of a single piece of sheet metal by cutting to the appropriate shape and bending to form a box which encloses the coils 19^a, 19^b and 19^c as well as the casing 34 on all sides. The jacket pipe 31 forms a closed connection with the upper wall of the casing 36, so that air from the blower 24 passes through the pipe 31 into the casing 36.

The casing 34 is preferably formed with a closed joint at its bottom with regard to the casing 36, for example, by welding, and a screw thread is formed immediately at the entry to the cavity of the casing 34, into which a threaded plug 37 may be screwed to close off the casing 34 from the atmosphere. A stirrup or gallows 38 is rigidly mounted on the plug 37 which serves to carry an easily rotating shaft 39 having a distributing paddle wheel or fan 40 therein.

Likewise provided in the front wall of the casing 39 are two apertures, one adjacent the bottom of the casing 36 and the other adjacent its top for the escape of the effluent air from the fan 24, the jacket pipe 31 and the casing 36.

The method of operation of this device is as follows: a suitable quantity of powdered coal, preferably bituminous coal dust of very small size is placed within the hopper 15 and its cover 15^x is closed. The motor 23 is started, whereby the endless screw 16 is caused to revolve and agitate this coal dust, while at the same time the blower 24 begins to force air through the effluent pipe 25 and the jacket 31 and casing 26, finally escaping through one of the openings 41 at the front of the casing 36. If the engine operator now causes the engine to turn over as by cranking or the use of a starter, the suction prevailing in the cylinder and in the exhaust manifold will cause a draft of air to enter the pipe 32 as regulated by the valve 33, and pass into the fuel mixture pipe 19. At the same time, the agitation of the coal dust by the endless screw 16 will cause it to pass downward through the aperture 17 and the V-notch 20^a of the plate 20 according to the adjusted position of the latter, and enter the fuel mixture pipe 19. In the course of the travel of the combined fuel dust and air through this pipe in its several convolutions, a substantially thorough mixture or suspension of coal dust and air is produced, which may be denominated "quasi-gaseous" owing to the thoroughness of the suspension

or distribution. In this condition the mixture enters the larger chamber 34, and by its draft pipe there effects the operation of the fan 40, whereby a blending and thorough mixing of all passing portions of the charge is effected, so that the latter passes in an entirely homogeneous state to the outlet pipe 35 in the manifold 11. This mixture then enters the cylinders in regular firing order and it is found in practice that this mixture may be detonated or exploded by an electric spark plug and with the production of a similar effect to that of a direct gaseous or vaporous fuel mixture, such as that of gasoline in air.

The regulation of the system is effected by controlling the speed of the motor 23, the position of the sliding plate 20, and the position of the butterfly valve 33.

In the modified form of construction according to Figs. 4 and 5, the engine 10 is represented as having a crank shaft which in some usual and customary manner operates the valve or accessory shaft 12 which, for example, has the water circulating pump 13 mounted thereon, as well as the driving belt pulleys 50 and 51. The pulley 50 engages a driving belt 52 which by means of a further pulley 53 causes the rotation of a pressure fan 54 which serves to force a current of air into the open mouth of the funnel 55, and thence by the pipe 56 into the front end of a casing 36 as in the structure according to Fig. 1. The pulley 51 drives a belt 57 which by means of a pulley 58 secures the rotation of a shaft 59 which at its other end is provided with a handle 60 for manual operation at starting.

The elements contained within the casing 36 are substantially the same as those set forth in regard to Fig. 1, and in general the former description applies throughout, except for the internal construction of the fuel hopper.

The fuel hopper 60 in the present instance is provided with a bottom 61 which comprises a series of cups whose inner surfaces form portions of spheres or similar figures of revolution, and are each provided adjacent the respective lowermost point with an aperture 62 which is in alinement with a similar aperture 63 in a partition plate 64 which extends across the walls of the hopper 60 and defines a lower compartment or preliminary mixing chamber 65 thereof. The lower wall 66 of this mixing chamber 65 is inclined downwardly at such an angle that fuel will move therealong at any operating position of the automobile on a hill.

The shaft 59 passes through the walls of the hopper 60 and through the walls of the jacket 67 surrounding the same, and on the interior of the hopper carries a number of fingers 68 which in their length adapt them for movement in close contact with the surfaces of the respective cups in the bottom wall 61 of the hopper 60, as will be seen from Fig. 4.

A slide 69 is provided with a suitable number of apertures 70, corresponding to the number of cups in the bottom wall 61, each of a V-shape and adapted to lie between the bottom wall 61 and the partition 64, whereby to regulate the effective cross section of the apertures 62 and 63, according to the adjustment given to it by the forward end 71 which may be provided with a suitable handle for this purpose.

The powdered coal in the hopper 60 is agitated by the fans 68 during rotation of the shaft 59 and delivers coal through the apertures 62, 63 according to the prevailing position of the slide plate 69, so that coal dust falls into the chamber 65 and therein is brought into contact with air which is passing through the aperture 73 adjacent the upper end of the inclined bottom wall 66 of the chamber 65. This preliminary mixture passes through an aperture 74 at the bottom of the chamber 65 and through a slide plate 75 which has a V-shaped regulating aperture of a nature similar to that indicated at 20 in Figs. 1 to 3, and thereby passes in the mixed form into the fuel mixture pipe 19, whence it moves to the manifold 11 and into the engine for explosion therein.

For the purpose of regulating the slide plate 75 is provided a pedal 76 having a return spring 77 for actuating a crank lever 78 pivoted to the under side of the foot-board of the automobile and connected by a link 79 with a second crank member 80 which operates upon the slide plate 76, as will be clearly seen in Fig. 4.

The method of operation of this device is as follows: The agitator fingers 68 are caused to operate by manual means to bring a small quantity of coal powder into the the lower chamber 65. The engine is then started by a starting system or by a hand crank, whereby further movement is afforded to the fingers 68 and the fan 54 is caused to drive a blast of air into the funnel 55, and thence through the casing 36, thus cooling and maintaining the pipes 19, 19^a, 19^b and 19^c, and the casing 34 therein (as in Fig. 1) cool, so that no preliminary distillation of the bituminous coal or other fuel will occur. This air passes upwardly in the pipe jacket 31 and through the offset 31^a thereof into the space within the protecting jacket 67, since it passes upwardly and to an exhaust: or from which it may escape through the opening 73 into the chamber 65 and there mingle with the powdered coal to form the fuel mixture.

In each form of execution, it will be noted that all elements of the fuel mixture system, including the pipe 19 and its horizontal

section 19a, 19b and 19c, and the casing 34 are positively protected by an air layer from the radiant heat evolved from the engine: and furthermore that this air itself shall be maintained as cold as possible, so that distillation is carefully avoided, and it has been found in practice that an engine may be so operated with even the highest volatile bituminous coal without caking or gassing within the fuel mixture pipe or associated parts.

It is particularly apparent that the invention is not limited solely to the forms of execution which have been illustrated, but that it may be modified in many ways within the scope of the appended claims.

What I claim is:

1. The method of operating an internal combustion prime mover which comprises suspending finely powdered coal in a current of air, cooling the fluid mixture, delivering the same into the combustion space of said prime mover in a homogeneous quasi-gaseous condition, and igniting the same by an electric spark.

2. The method of preparing a fuel mixture for an internal combustion prime mover which comprises suspending finely powdered coal dust in a current of air and cooling the mixture.

3. The method of preparing a fuel mixture for an internal combustion prime mover which comprises delivering coal dust into a moving current of air, causing the mixture to traverse a tortuous path while subjected to cooling and intimately mingling of the constituents of the mixture.

4. In a fuel feeding system for an internal combustion prime mover, a fuel hopper for pulverized solid fuel, a valve to regulate the discharge of the pulverized fuel from said hopper, an air conduit, said hopper discharging through an aperture into a current of air in said conduit, means to cool said conduit and its contents, a mixing chamber connected to said conduit to intimately mingle the fuel dust and air whereby a homogenous quasi-gaseous suspension is formed, and a conduit from said mixing chamber to the inlet of the prime mover.

5. In a fuel feeding system for internal combustion engines, a hopper to contain pulverized solid fuel, an endless screw in the bottom of said hopper to maintain said fuel from caking, an air cooling and heat insulating conduit, a blower to force air through said conduit, a motor and connections therefrom to actuate said blower and said screw, a fuel mixture pipe to receive the mixed air and pulverized fuel and located within said conduit, a mixing chamber communicating with said pipe, and a fuel delivery conduit from said mixing chamber to the inlet of said engine.

6. In a fuel feeding system for an internal combustion engine, a fuel mixture pipe having a tortuous path, said pipe having an air current therethrough in consequence of the suction of said engine, means to deliver pulverized solid fuel into said pipe, a spaced heat insulating jacket surrounding said pipe, and means to deliver the mixture of fuel and air into the engine combustion space.

7. In a fuel feeding system for an internal combustion engine, a receptacle to contain pulverized solid fuel, a discharge conduit connected with the bottom of said receptacle, means to maintain the fuel in agitation to prevent caking, means to deliver an air current through said conduit, and regulating means to govern the cross-section of passage between said receptacle and said conduit, said means including a sliding plate having a triangular aperture therethrough to control the inlet to said conduit.

8. In a fuel feeding system for internal combustion engines, a receptacle to contain pulverized solid fuel, said receptacle having a narrow trough-like bottom with a plurality of apertures therethrough, a partition beneath said receptacle to form a mixing space, a conduit to admit air into said mixing space, a shaft passing through the said receptacle in spaced relationship to its bottom, and a plurality of agitating devices secured to said shaft to maintain said fuel against caking during the rotation of said shaft, and means connected with the engine to drive said shaft.

9. In a fuel feeding system for an internal combustion engine, a receptacle to contain pulverized solid fuel, said receptacle having a bottom comprising a plurality of cups of the form of bodies of revolution, a shaft extending through said receptacle concentric with the surfaces of said cups, and agitating fingers connected to said shaft and located within said cups, said cups each having an aperture therethrough for the delivery of fuel from said receptacle.

10. In a fuel feeding system for internal combustion engines, a receptacle to contain pulverized solid fuel, the bottom of said receptacle being formed with several individual cups each having an aperture through its bottom, a mixing chamber beneath said receptacle to receive the pulverized fuel passing through said apertures, a conduit leading from said mixing chamber to the intake of the engine, an air inlet conduit to said mixing chamber, a regulating valve to control the effective cross-section of said apertures, and a regulating valve to control the effective cross-section of entry of the fuel mixture from said mixing chamber to said intake conduit.

11. In a fuel feeding system for an internal combustion engine, a receptacle for pulverized solid fuel, means including a mixing chamber and an air conduit thereto to mix the fuel from said receptacle with air,

a fuel mixture pipe to receive the mixture from said mixing chamber, said pipe having a tortuous path, and terminating in a conduit leading to the intake of the engine, a jacket surrounding said tortous path, an air fan driven from the engine, means whereby the air from said fan is caused to pass into and through said jacket, a further jacket surrounding said receptacle and mixing chamber and constituting part of said air inlet conduit to said mixing chamber, and means whereby the air from said first jacket passes to said second jacket.

12. In a fuel feeding system for an internal combustion engine, a receptacle to contain pulverized solid fuel, said receptacle having a bottom comprising several cups with upward concaved surfaces of revolution, a shaft passing concentric to said surfaces of revolution, agitating fingers on said shaft, each of said cups having a discharge aperture at its bottom, and a slide plate having triangular openings adapted to come beneath said apertures, and means to move said plate with regard to said cups whereby the effective cross-section of the said apertures is regulated by the position of said openings.

13. In a fuel feeding system for an internal combustion engine, a receptacle to contain pulverized solid fuel, means to mix said fuel with air in predetermined quantities, a receiving chamber in the path of movement of said mixture from said mixing means to the intake of the engine, and means in said receiving chamber actuated by the flow of said mixture to further agitate said mixture in its said course.

14. In a fuel feeding system for an internal combustion engine, a receptacle to contain pulverized bituminous coal as a fuel, means to mix said coal with air in predetermined quantity and deliver the mixture of the intake of the engine, and a heat insulating jacket surrounding said receptacle and said means whereby to maintain said fuel and mixture cool substantially until its entry into said engine.

15. In a fuel feeding system for an internal combustion engine, means to mix pulverized solid fuel and air in predetermined quantities, a receiving chamber open at its bottom, into which the fuel mixture is admitted near the bottom, a conduit from the top of said receiving chamber to the intake of the engine, a plug closing said bottom opening of said receiving chamber, a gallows rigidly mounted on said plug to extend into said chamber, and a fan pivotally mounted in said gallows to further agitate said mixture in its passage through said receiving chamber.

In testimony whereof, I affix my signature.

HORACE VAN DEVENTER.