United States Patent

Carter

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[54] **FUEL FEEDING APPARATUS**

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[21] Appl. No.: **56,964**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 772,551, Nov. 1, 1968, abandoned.

[52] **U.S. Cl.** ....**261/18 A**, 261/50 A, 261/84, 261/88, 261/67, 123/25 L

[51] **Int. Cl.** **F02m 9/12**

[58] **Field of Search** ....261/50 A, 18 A, 83, 85, 88, 261/84, 67; 123/25 L

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[57] **ABSTRACT**

A device for intimately intermixing a liquid fuel, air, and preferably also a metered proportion of water, for delivery to an internal combustion engine or other fuel burning mechanism, the device including a rotor to which the fuel and water are delivered for centrifugal discharge radially outwardly in finely divided mist form, with the rotor preferably carrying a large number of minute fibers projecting radially outwardly and along which the liquids flow in a manner subdividing the liquids into minute droplets. The rate of delivery of the fuel and water is regulated in accordance with the rate of flow of air through the device, and by a control structure actuable by the air.

2 Claims, 13 Drawing Figures

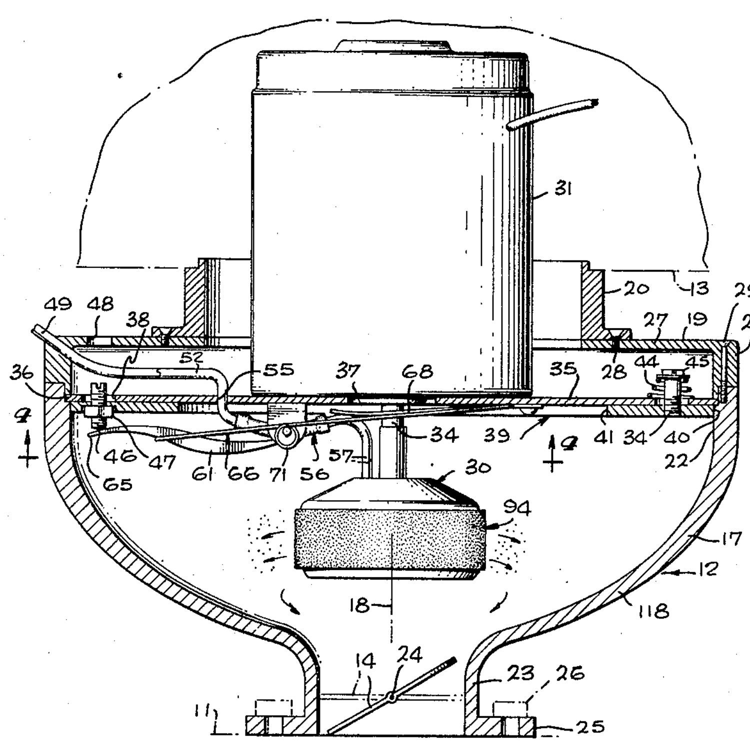

Fig. 1

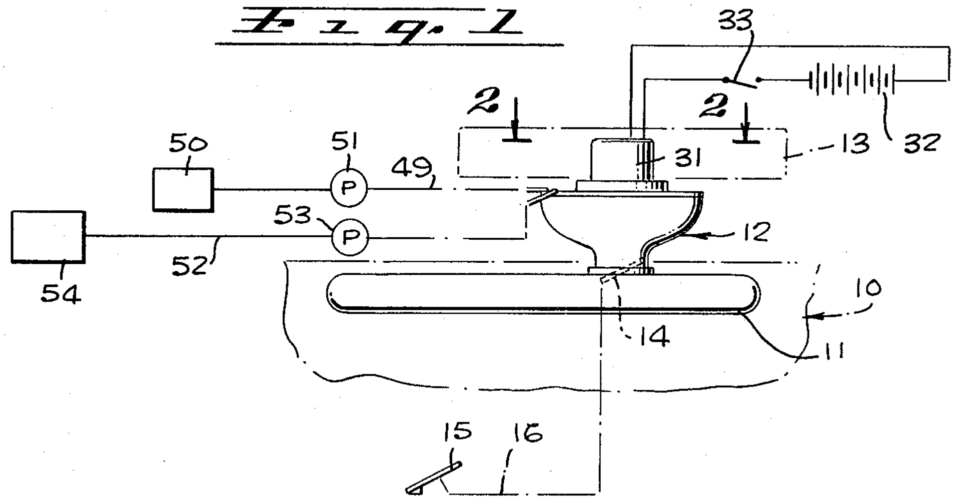

Fig. 2

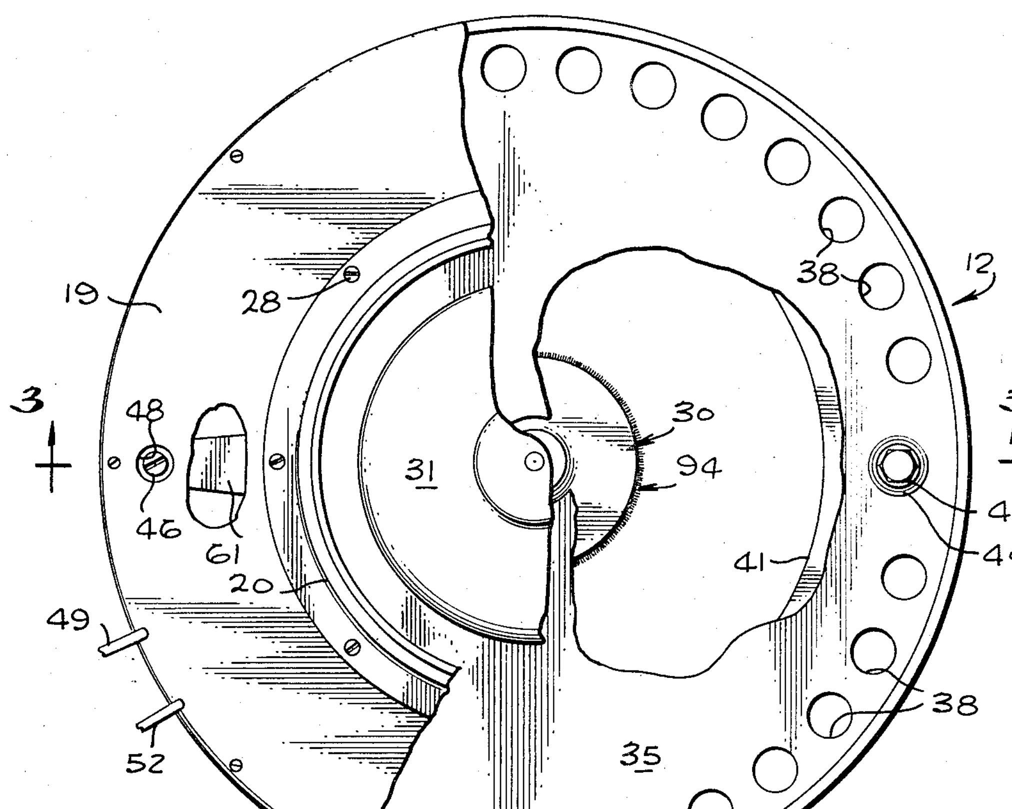

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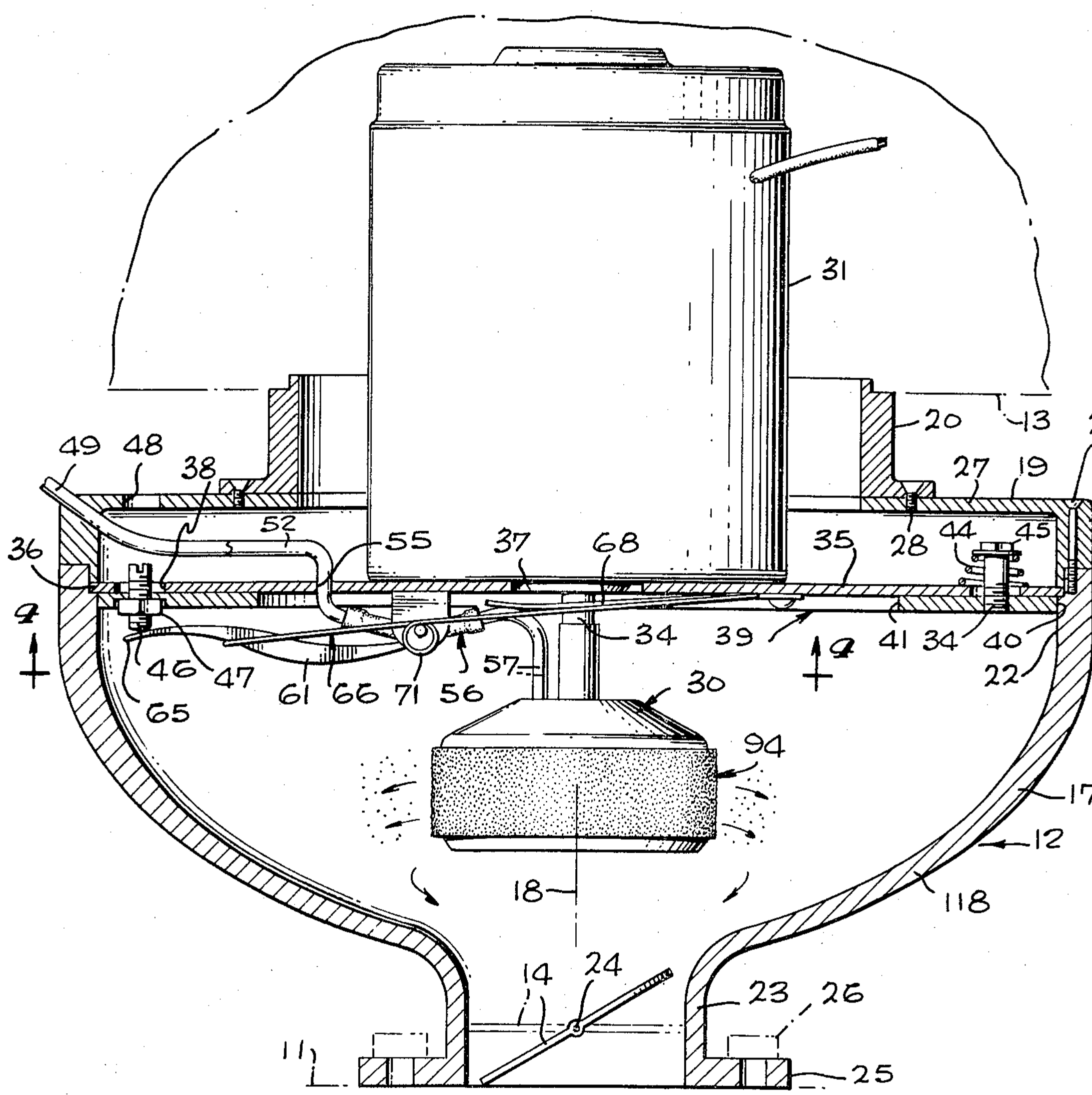
Fig. 3



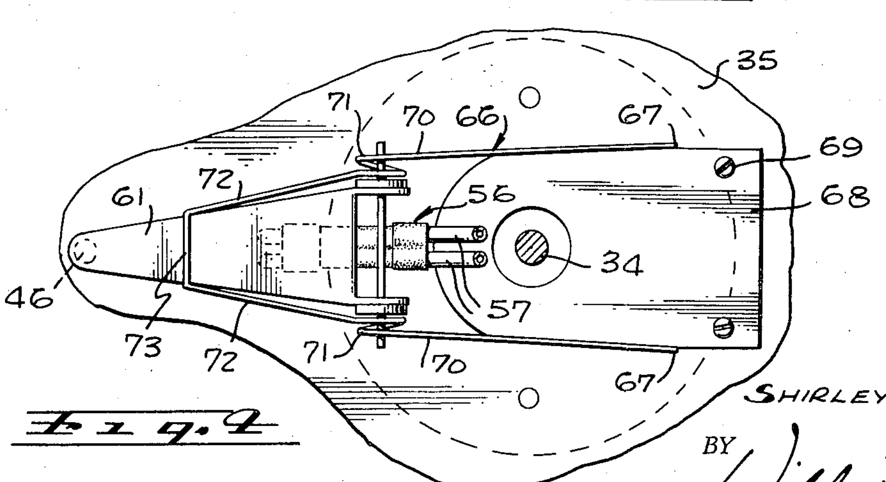


Fig. 4

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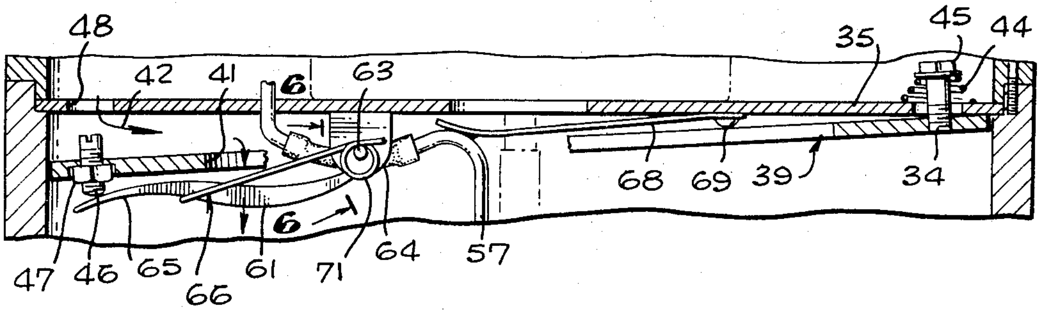
Fig. 5



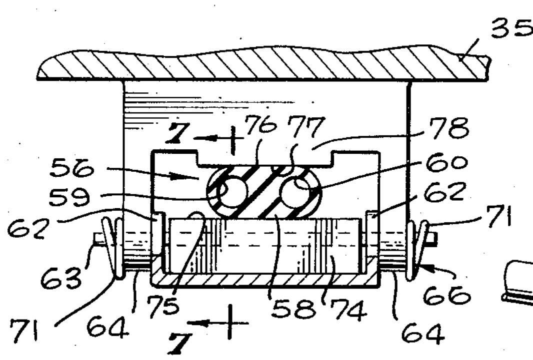


Fig. 6

Fig. 8

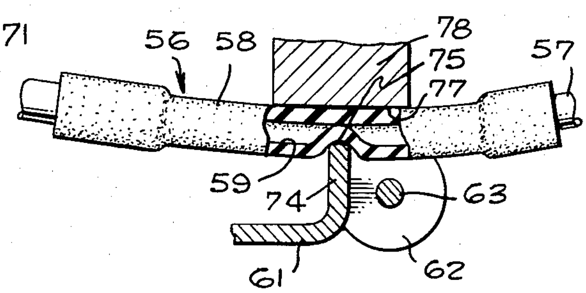


Fig. 7

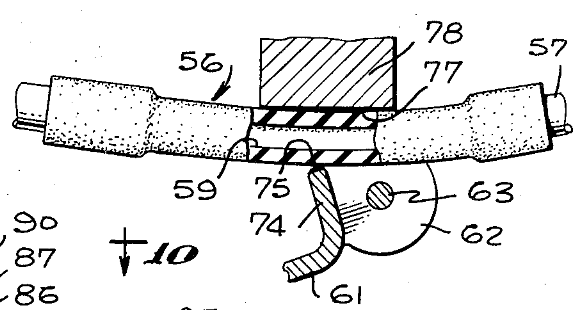
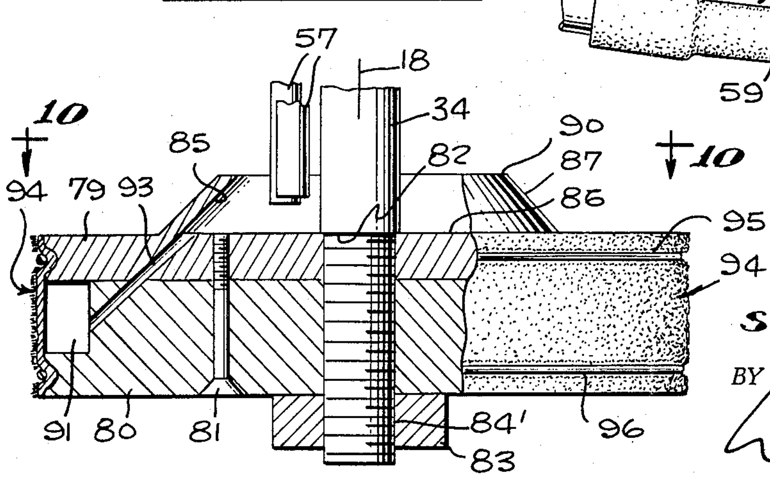


Fig. 9



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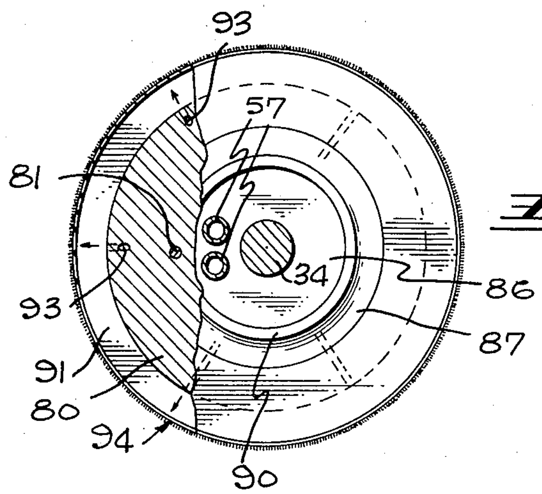
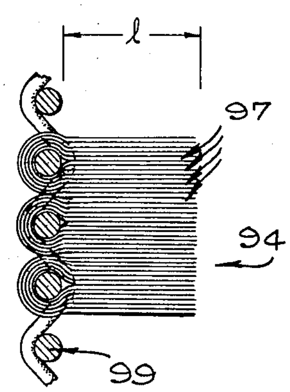


Fig. 10

Fig. 11



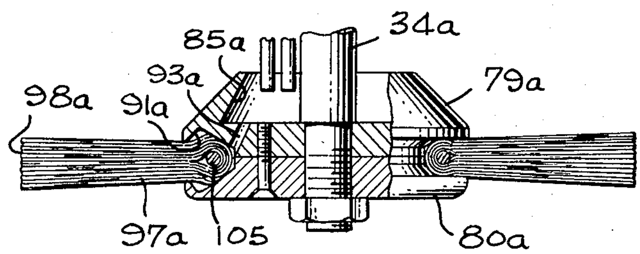


Fig. 13

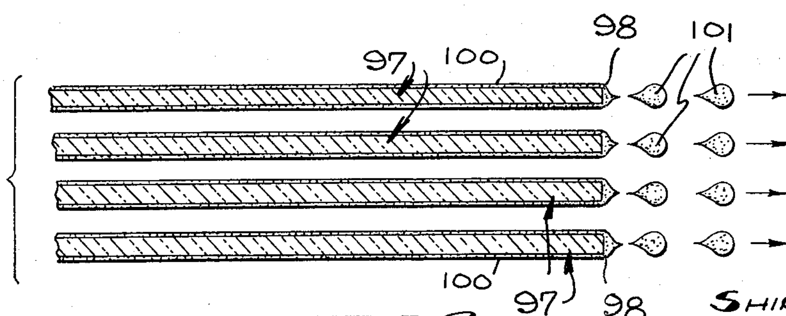


Fig. 12

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FUEL FEEDING APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of my copending application Ser. No. 772,551 filed Nov. 1, 1968 on "Fuel Feed Device," now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to devices for intermixing liquid fuel and air to produce a burnable mixture, preferably containing a metered quantity of moisture in conjunction with the air and fuel to improve the burning results. While it is to be understood that equipment of the present type can be utilized for supplying a burnable mixture for any of numerous different types of apparatus, e.g., burners and the like, the invention will be described primarily as applied to, and is in certain particular respects especially designed for, the preparation of a burnable mixture in a carburetor type of structure for an internal combustion engine or other fuel burning engine.

Though numerous different types of carburetors and other units for preparing a combustible mixture have been devised in the past, none of these prior arrangements with which I am familiar has proven totally acceptable in actual practice. The carburetors currently in use on motor vehicles do not intermix the fuel and air as thoroughly as would be desired, with the result that much of the fuel accumulates on the walls of the intake manifold and other intake passages, and the mixture ultimately reaching the cylinders is not of accurately predeterminable proportions. Further, the proportion of fuel introduced into the air stream varies under different operating conditions, such as acceleration, deceleration, etc., with resultant waste of much of the fuel, inefficiency in operation, and emission of large amounts of unburned hydrocarbons and similar contaminants into the atmosphere. Attempts to overcome the operational disadvantages of conventional carburetors have resulted in the development of numerous extremely complex and expensive types of carburetor accessories, which themselves have been less than optimum in functioning, and have been so expensive as to virtually preclude their use on any standard vehicle.

SUMMARY OF THE INVENTION

A fuel feed device constructed in accordance with the present invention is capable, with an extremely simple structure, of producing a burnable mixture whose proportions are very accurately predeterminable and controllable, and whose proportions do not vary under different operating conditions. Further, in a device of the present type, the intermixture of the fuel and air, and preferably also a proportional quantity of water, is so intimate as to assure maintenance of that intermixture, without separation of the fuel and water from the air, while the mixture is passing through the inlet passages and into the cylinders, so that fuel and/or water do not separate out on those inlet passages, and so that the mixture is in its most readily combustible form at the time of actual burning.

The intimate mixture of the fuel and air is attained by use of a rotor structure which is driven at a relatively high rate of speed, so that fuel fed to the interior of the rotor is delivered radially outwardly in centrifugal manner, and is discharged centrifugally from the rotor in the form of a finely divided mist, which is then mixed with a stream of air flowing to the engine. The rotor preferably carries a large number of fine fibers, which project radially outwardly with respect to the axis of the rotor, and along which the fuel flows as it moves radially outwardly under centrifugal action. The fuel discharges from the rotor in the form of extremely minute droplets, which are small enough and light enough to be effectively suspended in the air stream, and be carried axially with the air without contacting a surrounding wall of the device, and which do not appreciably agglomerate during flow of the air to the engine cylinders. In a preferred arrangement, the rotor may include a porous sheet of material, desirably woven fabric, extending annularly about the axis of the rotor and presenting a nap projecting radially outwardly and defining the mentioned fibers.

The delivery of fuel and water to the rotor is controlled by an element positioned in the path of air flow through the device and adapted to be actuated to different positions varying in accordance with the rate of such air flow. Thus, the fuel and water delivery are controlled automatically, to always produce a mixture with the air of optimum proportions. The fuel and water regulation valve structure may be a pinch valve unit, actuated by an air flow responsive flapper device.

Certain particular features of the invention relate to a preferred critical relationship between the size of the air actuated element and the area of the air flow path at the main throttle valve of the device, which relationship is highly important for assuring against hunting and fluttering of the air actuated element and controlled fuel valve in use. More particularly, the air deflected element should have an area exposed to the force of the flowing air which is at least about ten times as great as the minimum effective cross-sectional area of the air flow path at the main throttle valve when the latter is fully open.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and objects of the invention will be better understood from the following detailed description of the typical embodiments illustrated in the accompanying drawings, in which:

FIG. **1** is a fragmentary essentially diagrammatic representation of a carburetor device constructed in accordance with the invention, and shown positioned on an engine;

FIG. **2** is an enlarged view of the carburetor taken partially on line **2—2** of FIG. **1**, and partially on lower planes to illustrate the interior portions of the carburetor;

FIG. **3** is a further enlarged vertical section taken primarily on line **3—3** of FIG. **2**;

FIG. **4** is a fragmentary view taken on line **4—4** of FIG. **3**;

FIG. **5** is a fragmentary vertical section taken in the plane of FIG. **3**, but showing the fuel and water regulating flapper element in an open position;

FIG. **6** is an enlarged fragmentary essentially vertical section taken on line **6—6** of FIG. **5**;

FIG. **7** is a vertical section taken on line **7—7** of FIG. **6**;

FIG. **8** is a view similar to FIG. **7**, but showing the liquid supply pinch valve in closed condition;

FIG. 9 is a vertical axial section through the rotor of FIG. 1, with a portion of the rotor being shown in elevation;

FIG. 10 is a reduced scale view taken on line 10—10 of FIG. 9;

FIG. 11 is a greatly enlarged somewhat diagrammatic representation of the velvet-type fiber carrying material of the device, taken on line 11—11 of FIG. 10;

FIG. 12 is a further enlarged representation of the fibers, and the manner in which droplets form at their outer extremities; and

FIG. 13 is a vertical section through a variational type of rotor.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference first to FIG. 1, I have illustrated diagrammatically at **10** an internal combustion engine whose intake manifold is illustrated at **11**, and which utilizes a carburetor **12** constructed in accordance with the invention. An essentially conventional circular air cleaner **13** may be positioned on the carburetor, for cleaning the air flowing to the engine, but will not be described in detail. The butterfly type throttle valve **14** of the carburetor is actuated by the usual accelerator pedal **15**, through a conventional linkage represented diagrammatically at **16**.

As seen best in FIG. 3, the carburetor **12** includes a hollow body **17**, which is desirably annular about a vertical axis **18**, and which may be formed sectionally of a first lower and main bowl section **118**, a cover **19**, and an upwardly projecting tubular section **20** to the upper edge of which is mounted the air cleaner **13**. Lower section **17** of the carburetor body may taper downwardly from an upper relatively large diameter cylindrical portion **22** to a reduced diameter essentially cylindrical portion **23** within which the butterfly valve **14** is mounted to pivot about a shaft or axis **24** from the broken line closed position of FIG. 2 to an open position such as that shown in full lines. A lower flange **25** of section **17** of the carburetor body may be suitably secured by bolts **26** to the intake manifold **11**, to deliver an air-fuel-water mixture into that intake manifold.

Section **19** of the carburetor body may have a vertically extending cylindrical portion **26'** resting on and forming a continuation of portion **22** of section **17**, and terminating upwardly in an annular inturned flange **27** to which upwardly projecting tubular section **20** is secured by screws **28** or the like. Sections **17** and **19** are suitably secured together in annularly sealed relation with respect to one another by appropriate screws or other fasteners **29**. In flowing toward the engine, air enters the upper end of upper tubular section **20** of the carburetor body, and flows downwardly within that body for discharge past butterfly valve **14** of the engine.

Fuel and water are fed into the air stream by a rapidly turning rotor **30** driven continuously and at a uniform rate of speed by a motor **31**. This is typically and desirably an electric motor, driven by the battery **32** of the vehicle (FIG. 1), under the control of the usual ignition key switch **33**, which, besides serving its conventional function of energizing the ignition circuits, also closes the circuit to motor **31** and commences rotation of the motor when the ignition is turned to its "on" position.

The driven shaft **34** of motor **31** (FIG. 3) projects downwardly along the previously mentioned central vertical axis of the carburetor body, and turns about that axis with the rotor. The housing of the motor is mounted stationarily within the carburetor body (desirably projecting upwardly therefrom as shown), with the mounting preferably being effected by attachment of the motor housing to the upper side of an annular horizontal rigid, typically metal, plate **35**, whose annular peripheral edge **36** is retained and clamped tightly between opposed shoulders on the two body sections **17** and **19**, in a manner forming an annular fluid tight seal between plate **35** and the carburetor body. Plate **35** contains a central opening **37** through which shaft **34** projects downwardly. The plate also contains a large number of circularly spaced identical circular apertures **38** (FIG. 2) near the periphery of the disk, and through which air flows downwardly past the downwardly deflectible flapper element.

Element **39** may be considered as a flat annular part formed of sheet metal or the like, and having a peripheral edge **40** of a diameter slightly less than the internal diameter of portion **22** of body section **17**. Internally, element **39** has a circular edge **41** of a diameter considerably less than the minimum diameter (about axis **18**) of air passing apertures **38** in plate **35**, so that in its FIG. 3 closed position, element **39** closes the apertures **38** and prevents flow of air downwardly therethrough. When swung downwardly to an open position such as that shown in FIG. 5, element **39** opens the apertures **38** to the downflow of air through these apertures and radially inwardly as indicated by the arrow **42** of FIG. 5, to then flow downwardly past inner edge **41** of element **39** and toward butterfly valve **14**. Element **39** is spring urged upwardly, and swings downwardly against the tendency of its return springs to different positions varying in accordance with the rate of air flow through the apparatus as controlled by the butterfly valve **14**.

At its right edge as seen in FIGS. 2, 3 and 5, element **39** may carry a screw or pin **34'**, which is threadedly and rigidly connected into an opening in element **39**, and projects upwardly through one of the apertures **38** in plate **35**. An upwardly tapering spiral coil spring **44** is disposed about screw **34'**, and bears upwardly against a head **45** of the screw and downwardly against plate **35** to yieldingly resist downward swinging movement of element **39**. At the diametrically opposite side of element **39** (left side of the figures), element **39** adjustably carries a second screw **46**, which may typically be threaded into a nut **47** rigidly welded or otherwise secured to element **39**, with this screw **46** being accessible for adjustment through one of the apertures **38** in plate **35**, and through a registering aperture **48** formed in the top wall of the carburetor body (FIG. 3), to enable adjustment of the proportion of liquid delivered into the air by rotor **30** at idle.

Liquid fuel, e.g., gasoline, kerosene, diesel, fuel, or any other readily combustible liquid fuel, is delivered to the device through a line **49** (FIGS. 1 and 3), from the usual fuel tank **50** and fuel pump **51**. Similarly, water for mixture with the fuel is fed to the device through a line **52**, leading from a pump **53** which draws water from an appropriate water tank **54**. The two pumps **51** and **53** may be substantially the same as conventional fuel pumps, being driven by the cam shaft of the engine itself when the latter is in operation, to thus continuously supply fuel and water under pressure to the carburetor.

Lines **49** and **52** may enter the device through appropriate openings in cover section **19** of the carburetor body, and may then pass downwardly through apertures **55** in plate **35** (FIG. **3**) for connection to a deformable pinch valve element **56**, whose discharge end leads into a pair of tubes **57**, which are mounted stationarily by a part **68** secured to plate **35**, and which lead downwardly into the interior of rotor **30**. Pinch valve **56** has the configuration illustrated in FIGS. **6**, **7** and **8**, including a single unitary elastomeric element **58** formed of rubber or the like (desirably neoprene). This element **58** contains two identical parallel elongated passages **59** and **60** (FIG. **6**) through which the fuel and water respectively flow into the two depending discharge lines **57**.

Pinch valve element **56** is constrictable from its open position of FIG. **7** to its closed position of FIG. **8** by swinging movement of an actuating lever **61** from its FIG. **5** position to its FIG. **2** position. This lever is mounted for its swinging movement by two bearing lugs **62** on the lever, containing aligned apertures through which a horizontal mounting shaft **63** extends, with the shaft also extending through registering aligned openings in a pair of support lugs **64** rigidly attached to and projecting downwardly from the underside of plate **35**. The left end portion **65** of lever **61** engages the previously mentioned adjustable screw **46** carried by element **39**, to swing the lever downwardly in accordance with the downward movement of element **39**. Lever **61** is suitably spring returned upwardly, as by an elongated generally U-shaped spring **66** (FIGS. **3**, **4** and **5**), having two ends **67** bearing upwardly against the underside of plate **35**. From their ends **67**, the two arms of spring **66** extend at **70** to the location of a pair of coils **71** disposed about and acting downwardly against shaft **63**, and then converge at **72** to the location of a cross piece **73** which bears upwardly against lever **61**.

As seen best in FIGS. **6**, **7** and **8**, lever **61** has at its right extremity an upturned flange **74**, having an upper horizontal edge **75** which is adapted to engage and deform pinch valve **56** in response to swinging movement of the lever. At its upper side the top horizontal surface **76** of the pinch valve may bear upwardly against a horizontal undersurface **77** of a rigid backing part **78**, suitably secured to the underside of plate **35**. The pinch valve and its actuating parts are desirably so constructed as to regulate the flow of water and fuel in exact proportion to one another. Screw **46** is so adjusted as to cause lever **61** to substantially close both of the fluid passages **59** and **60** when element **39** is in its upper FIG. **3** position, and to commence opening of those passages when element **39** is deflected downwardly to any extent beneath its FIG. **3** position, with the rate of liquid flow through passages **59** and **60** being proportional to the rate of air flow downwardly past element **39**.

Rotor **30** is so constructed as to have a large number of small diameter fibers projecting radially outwardly from its periphery, to effect maximum subdivision of the water and fuel into minute droplet form as these liquids are discharged radially outwardly from the rotor. A preferred structure for the rotor is illustrated in FIG. **9**, in which the rotor is shown as having a rigid body formed of two typically metal annular sections **79** and **80** centered about axis **18**, and secured together by evenly circularly spaced screws **81**. Body **79–80** and the remainder of the rotor are of course balanced about axis **18**, to rotate rapidly without vibration. The body is secured rigidly to the lower end of motor shaft **34**, as by clamping section **79** against an annular shoulder **84** on the motor shaft, by means of a nut **83** connected onto the threaded lower end **84'** of the shaft. To assure rotation of the rotor with the shaft, these parts may be appropriately keyed together.

At its upper side, the rotor body **79–80** forms a circular upwardly opening liquid receiving compartment or chamber **85**, into which the metered fuel and water are fed through feed lines **57** from the pinch valve **56**. This annular chamber preferably has a horizontal bottom wall **86**, and a frustoconical annular side wall **87** which tapers upwardly to a reduced diameter upper inlet opening **90**. The two liquids flow generally radially outwardly from the bottom of chamber **85** through appropriate circularly spaced passages **93** formed in the body of the rotor and to an outer annular groove or compartment **91**. The passages thus introduce the liquids into this compartment **91** at a series of evenly circularly spaced locations.

Extending about the periphery of rotor body **79–80**, there is provided an annular piece of woven fabric **94**, of a vertical extent corresponding to that of the peripheral portion of the rigid body, and with the upper and lower edge portions of the fabric **94** being clamped to the body by annular clamping rings **95** and **96**. Thus, the fabric **94** bridges across compartment **91**, so that any liquid leaving the rotor must pass through the porous fabric. The fabric is chosen to present a multitude of radially outwardly projecting fibers **97** (FIGS. **11** and **12**), of very small diameter, which are distributed in very closely spaced relation across the entire surface of the fabric. For best results, the individual fibers do not contact one another at their outer extremities **98**. The fibers are of a substance which is impervious to the fuel and water, and is desirably non-inflammable and is otherwise capable of withstanding high temperature backfire conditions without damage, and which additionally has sufficient strength to maintain its integrity and resist wear and deterioration under long periods of use. The currently preferred material for the fibers, and for the fabric which carries the fibers, is glass, though various other materials may be used, such as tetrafluoroethylene polymer, the silicones, the acrylics, nylon, and other resinous plastic substances. The diameters or maximum transverse dimensions of the individual fibers should preferably be not greater than about 10 denier, and for best results not over about 5 denier, optimally between about one-half denier and 2 denier. The effective length *l* of the fibers (see FIG. **11**), i.e., their free length outwardly beyond the backing fabric or other carrying structure, may vary for different particular uses, preferably being between about one thirty-second and three-fourths of an inch.

To attain the desired arrangement of radially outwardly projecting fibers, I find a fabric having a velvet type weave to be very satisfactory. More particularly, this velvet material has a woven backing as illustrated at **99** in the greatly enlarged somewhat diagrammatic representation of FIG. **11**, with U-shaped bundles of the fibers **97** being doubled about and retained by the fibers of the fabric backing, so that their outwardly projecting ends serve the purpose of the liquid distributing fibers.

To now describe the manner of operation of the device illustrated in FIGS. **1** through **12**, assume that the ignition key has been turned and that motor **31** is therefore driving rotor **30** rapidly and continuously at a uniform rate of speed (desirably at least about 3,000 rpm, and for best results between about 4,000 rpm and 4,500 rpm). Also assume that throttle valve **14** is initially closed, and that element **39** is in its FIG. **3** closed position. If the internal combustion engine **10** is then started, with partial opening of the throttle valve **14**, the vacuum of the engine commences to draw air downwardly through the interior of the carburetor body, and element **39** is therefore actuated downwardly by the air to a partially open position similar to that shown in FIG. **5**. The extent of opening of element **39** depends upon the rate of flow of the air downwardly through the carburetor. This downward deflection of element **39** acts through lever **61** to partially open the previously closed liquid passages **59** and **60** in pinch valve element **56**, to allow water and fuel to flow into rotor **30** at a rate proportional to the rate of flow of the air downwardly through the carburetor. This water and fuel are thrown radially outwardly within the rotor body through passages **93**, and then through the porous fabric **94**. These liquids then flow outwardly, still under centrifugal action, along the surfaces of the very small dimension fibers **97**, as indicated at **100** in FIG. **12**, to ultimately form minute droplets **101** of water and fuel discharging into the air at the periphery of the rotor and in the form of a finely divided mist. These droplets are of such extremely finely divided form (usually under 1 micron in maximum dimension) as to have insufficient mass to continue their radially outward movement to the location of the outer peripheral wall of the carburetor body. Instead, these minute droplets are immediately withdrawn downwardly by the stream of air, for passage past the butterfly valve **14** and through the intake manifold of the engine to the cylinders. The finely divided particles remain in suspended form along this entire course of travel, and into the engine, and do not coalesce on the surfaces of the carburetor walls or intake passages, to thus result in optimum combustion in the cylinders. Also, when the fuel burns in the cylinders, the moisture present in the mixture converts to steam, which by its expansion adds to the power applicable to the pistons. Additionally, the absorption of some of the generated heat by the moisture prevents the development of excessive temperatures in the cylinders.

FIG. **13** shows a variational type of rotor which may be employed in the system, and which includes a two-section rigid rotor body **79*a***, **80*a***, secured to and driven by a motor shaft **34*a*** and forming an annular peripheral groove **91*a*** within which an annular series of elongated fibers **97*a*** are received in doubled essentially U-shaped positions. The fibers are retained in their illustrated positions by an annular clamping wire or ring **105**, with the individual fibers extending radially outwardly and terminating at radially outer extremities **98*a***. Fuel and water are fed into a compartment **85*a*** in the rotor body, to flow outwardly therefrom through passages **93*a***, into the groove **91*a***, for contact with the fibers **97*a***, so that the liquids may flow radially outwardly along these fibers for ultimate discharge in finely divided droplet form from the tip ends **98*a*** of the fibers.

While it is preferred in each of the forms of the invention that the individual fibers be slightly spaced from one another, it is found in actual practice that satisfactory results can be attained even though adjacent fibers are in most instances in direct contact.

With reference again to FIGS. **2**, **3** and **5**, it is noted that the upper surface of the air deflectible element **39**, which surface is exposed to and actuable by the downward force of air entering the carburetor housing through apertures **38**, desirably has an effective area (in a horizontal plane, i.e., transversely of the direction of air flow thereagainst), which is relatively large as compared with the effective horizontal cross-sectional area of the air flow passage within lower throat **23** of the carburetor body at the location of throttle valve **14**. In the particular arrangement illustrated in FIG. **3**, the horizontal area of element **39** is more than 10 times the minimum effective transverse cross-sectional area of the air passage at the throttle valve when the throttle valve is fully opened. To attain an effective fuel controlling operation, this ratio should preferably be at least about 10:1. If the element **39** is not thus made relatively large in effective area as compared with the most restricted portion of the air passage at the throttle valve, there is a decided tendency for element **39** to hunt or flutter in a manner introducing unwanted variations into the rates of air, fuel and water flow, and thus detracting from the operational characteristics of the device.

I claim:

1. A fuel feed device comprising a hollow housing through which air flows in passing to a fuel burning unit; a throttle valve for regulating the rate of flow of air through said housing; a rotor in the housing along the path of air flow therethrough and operable to feed fuel into the air for admixture with the air; a motor for driving said rotor rapidly about an axis and energized by power other than the power of air flowing through the housing; an element, in addition to said rotor and the other previously recited elements, positioned in the path of said air flow and deflectible by the flowing air to positions varying in accordance with the rate of air flow through the housing; means for delivering liquid fuel to said rotor at a location to be fed thereby into said flow of air, said last mentioned means including valve means actuable by said element to regulate the rate of fuel delivery to the rotor in accordance with said deflection of said element; a plate mounting said motor and rotor and disposed generally horizontally across the path of said air, said plate containing a series of circularly spaced apertures generally about the location of said motor and rotor; said element being essentially annular and disposed at the underside of said plate in a position closing said apertures and mounted to swing downwardly about essentially one side edge of the element to open the apertures; spring means yieldingly urging said element upwardly to closed position; said valve means including a flexible pinch valve body containing a passage for said fuel and a second passage for delivering water to said rotor for admixture with the fuel and air; and mechanism actuable by said element to close said passages in the pinch valve body in response to upward swinging movement of said element.

2. A fuel feed device as recited in claim 1, in which said mechanism includes a lever mounted pivotally to the underside of said plate and having a first end deflectible downwardly by said element and a second end adapted to engage and deform said pinch valve body.

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