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Kors et al.

[11] **3,914,347**

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[54] **PLATELET-INJECTOR VENTURI CARBURETOR FOR INTERNAL COMBUSTION ENGINES**

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[52] **U.S. Cl.**............. **261/23 A;** 261/41 C; 261/116; 261/121 A; 261/DIG. 39; 239/555

[51] **Int. Cl.**^{2} **F02M 13/04**

[58] **Field of Search**...... 261/23 A, 116, 41 C, 41 A, 261/121 A, DIG. 39; 239/555

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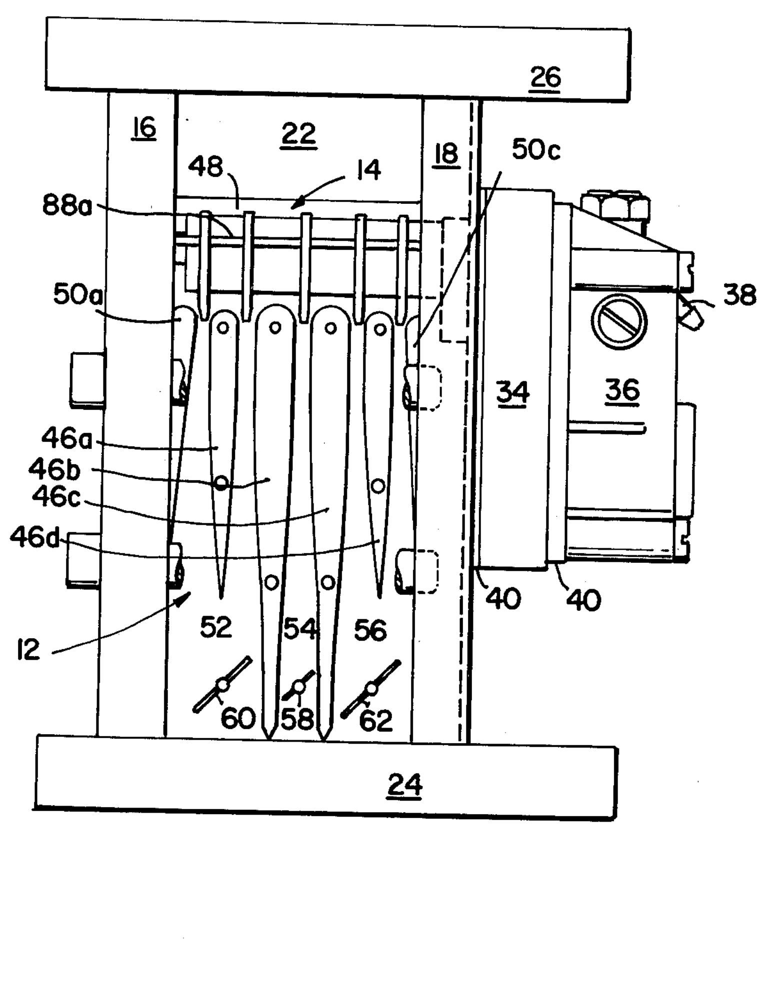
[57] **ABSTRACT**

A venturi carburetor for an internal combustion engine which provides more effective fuel atomization, mixing and vaporization to improve performance and minimize undesirable combustion emissions. Gasoline or other liquid fuel is injected into five narrow rectangular venturi diffuser sections in the form of very finely atomized droplets from eight small injection orifices located within the throat of each of the five venturis. The fuel injection assembly includes five rectangular injector plates each of which comprises a bonded assembly of individual platelets having transfer orifices and complex hydraulic flow channels precisely formed therein by photoetching. Together the platelets form a series of fuel delivery passages connecting the fuel supply with the platelet injection orifices in the venturi throat. Idle and main fuel delivery circuits are integrated into the injector assembly and multiple throttle plates are provided so that only one injector and venturi is effective during idle operation.

11 Claims, 5 Drawing Figures



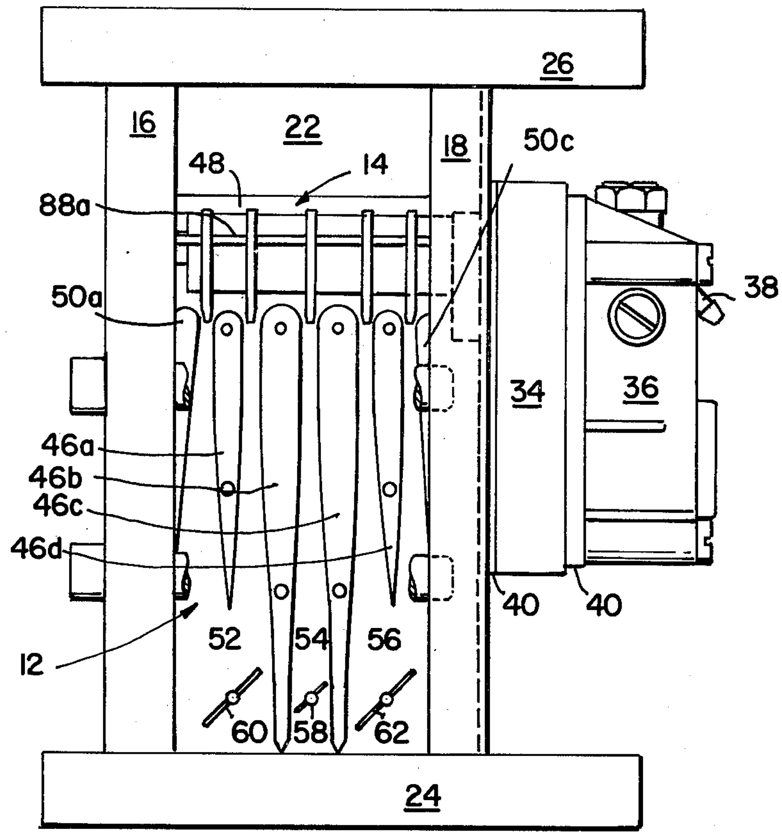

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FIG_1

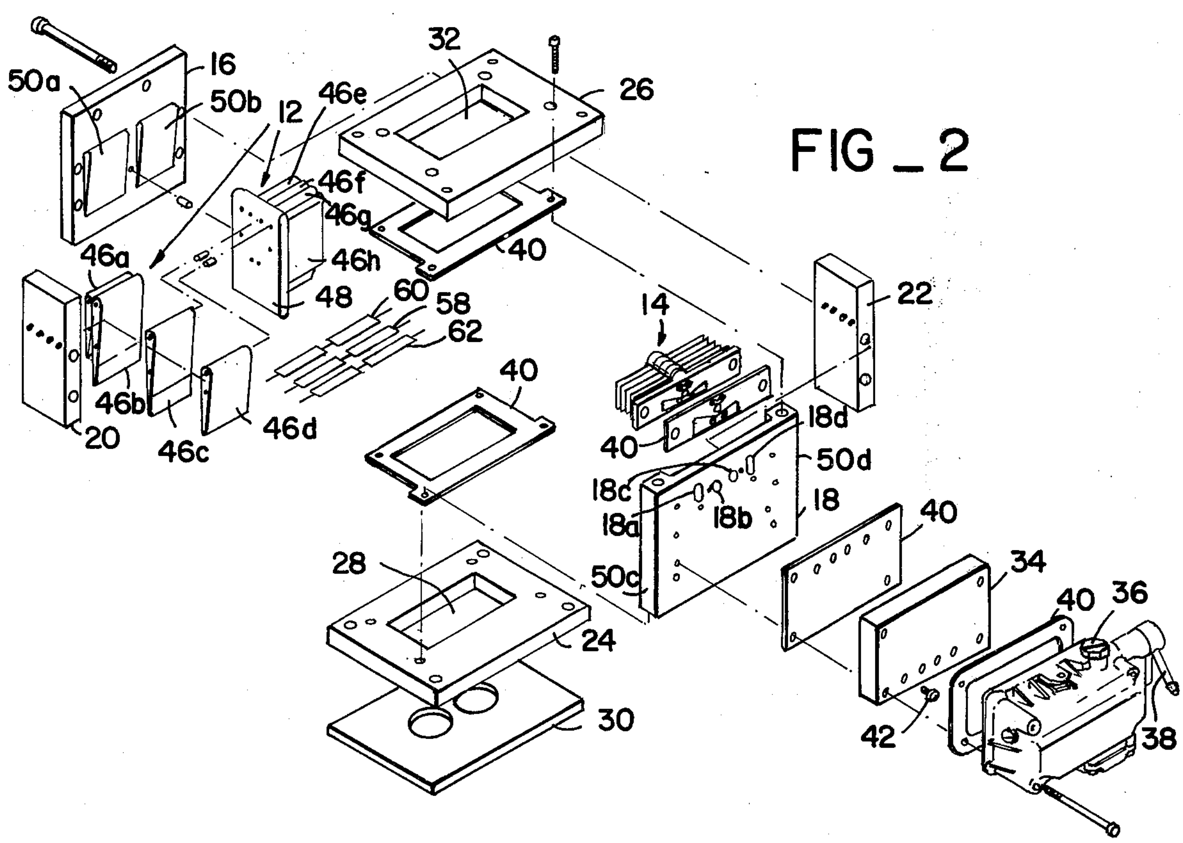
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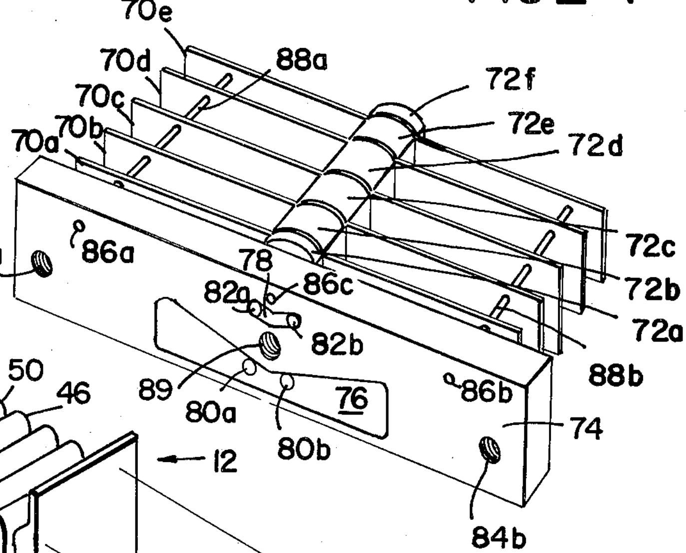
FIG_2

FIG_4



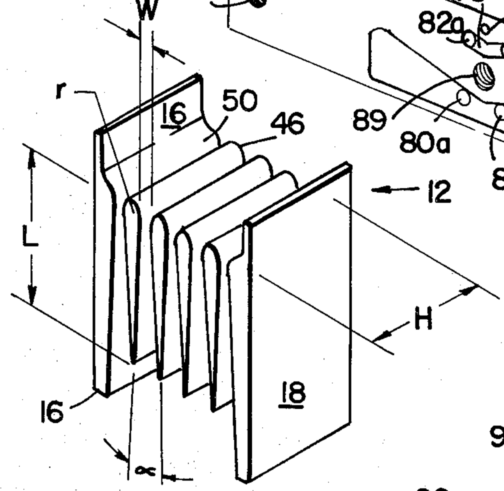


FIG_3

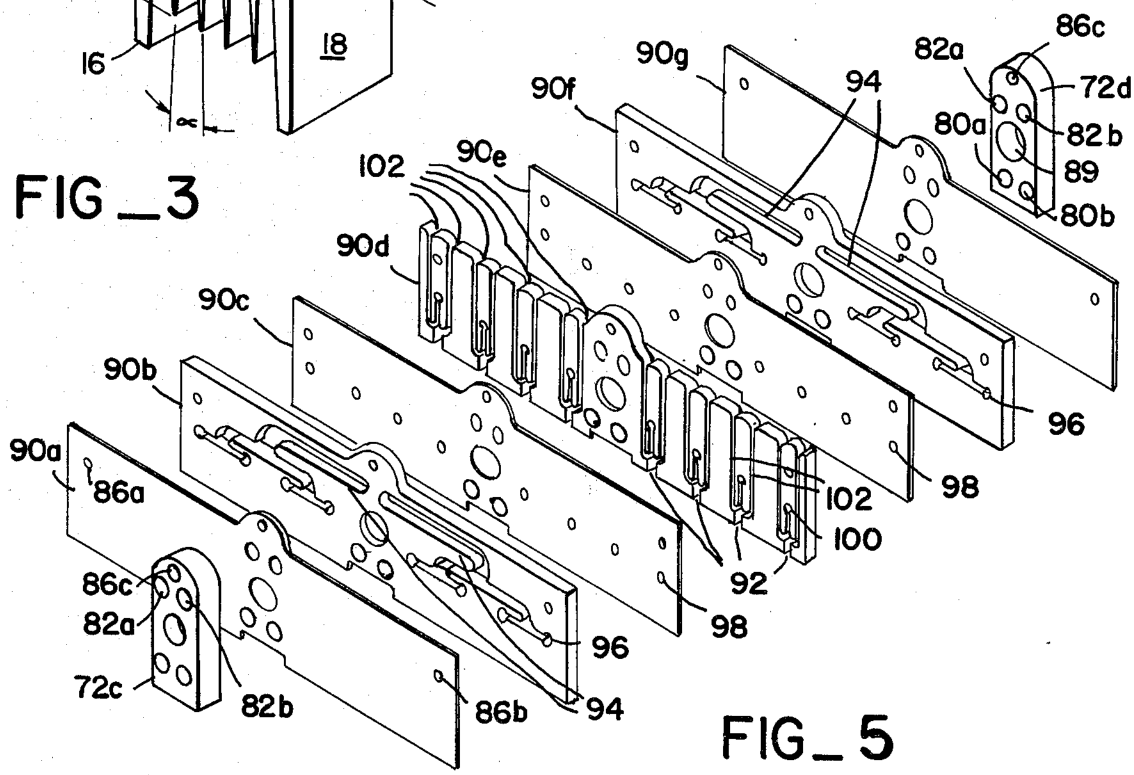


FIG_5

PLATELET-INJECTOR VENTURI CARBURETOR FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The dual requirements of low allowable combustion exhaust emission levels established by government and high combustion efficiency required by industry impose design criteria which state-of-the-art internal combustion systems cannot meet. The platelet-venturi carburetor of the present invention provides the capability for an internal combustion automotive engine to meet both emission and performance criteria.

Conventional venturi carburetors such as used with automotive engines exhibit decreasing vaporization efficiency at higher air flow rates (e.g. above 40 SCFM). This is a direct result of the dual fuel delivery circuit design of such carburetors. At lower air flow rates only the idle circuit is operational producing a relatively fine gasoline droplet distribution. At higher flow rates however, the boost venturi becomes operational resulting in the formation of significantly larger gasoline droplets. Conventional carburetors produce maximum droplet sizes over an air flow range from 30–70 SCFM where flow is changing from the idle to main fuel delivery circuits. Good operation over this region is essential, however, since it represents a large percentage of total driving conditions.

The primary variables effecting fuel droplet size have been found to be the injector orifice diameter, local air velocity and fuel temperature. By minimizing the individual injector orifice size and using a large number of relatively small orifices, the present invention achieves fine scale fuel atomization. This approach to fuel injection in combination with the unique venturi design of the present invention also achieves more uniform mixing as well as more complete vaporization of the air-fuel mixture.

Further, it has been established that diffusion droplet burning (with its inherent near stoichiometric temperature flame front) and local mixture ratio non-uniformities are major factors in the production of excessive NO_x emissions. The fine atomization and uniform mixing provided by the platelet-venturi carburetor will thus significantly reduce NO_x emission in internal combustion engines. Also, because of its superior vaporization characteristics, it will permit chokeless operation to minimize unburned hydrocarbons and carbon monoxide. Finally, the platelet-venturi carburetor is based on a design characterized by a minimum number of moving parts resulting in high production volume capability.

SUMMARY OF THE INVENTION

The platelet-venturi carburetor is basically a carburetor which combines the venturi diffuser principle of fuel atomization, mixing and vaporization with platelet fuel injection technology recently developed in connection with gas-liquid mixing devices used for liquid fuel rocket engines.

The conventional venturi carburetor introduces fuel into a cylindrical venturi passage at its throat (i.e. point of minimum cross-sectional area) in the form of relatively large droplets. The fuel is either aspirated into the venturi by the difference in static pressure between the venturi and the fuel feed source (typically a float bowl) or is injected under pressure. Generally, aspiration of the fuel is preferred for automotive applications.

Air is drawn through the venturi by the pumping action of the pistons. The exact point of injection is determined by the required mixture ratio control over the throttle range. The large velocity difference between the air and fuel in the throat region causes atomization and dispersion of the fuel droplets. Lateral pressure forces within the diffuser section of the venturi passage act to disperse the droplets such that a generally uniform mixture of vaporized fuel and air is produced at the diffuser exit.

In the platelet-venturi carburetor of the present invention, the venturi geometry has been optimized in the form of a plurality of narrow diffuser sections of rectangular cross-section to achieve greater uniformity of the air fuel mixture and a corresponding increase in vaporization efficiency. In addition, the fuel is introduced into the venturi throat via a number of very small orifices in the platelet injector assembly. The combination of many small injection orifices with the air shear effects produced within the venturi diffuser produces fine scale droplet atomization over the entire operating range of the carburetor. The resulting increase in the efficiency of atomization, mixing and vaporization leads to more complete combustion which is required for low exhaust emission levels.

The capability of the platelet-venturi carburetor to produce fine scale atomization and mixing is a direct result of a platelet injector design which is realizable through photoetch fabrication techniques allowing precise location of the extremely fine orifices and complex channel shapes. The precise location of each orifice and the large quantity of elements per unit area result in excellent mass and mixture ratio control within the intake manifold. The lack of restriction on distribution complexity due to the photoetch process permits flexibility of design to meet a wide variety of shapes and envelope requirements.

While the platelet-venturi carburetor is shown and described below in the context of an internal combustion automotive engine, it will be appreciated that the inventive concept can be easily applied to external combustion power plants, including jet engines, gas turbines, and even oil fired boilers.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevational view of a preferred embodiment of the platelet-venturi carburetor of the present invention;

FIG. **2** is an exploded perspective view of the carburetor of FIG. **1** illustrating the platelet-injector and venturi assemblies;

FIG. **3** is a perspective view of a generalized version of the rectangular venturi assembly used in the carburetor of the present invention;

FIG. **4** is a perspective view of the platelet-injector assembly of the carburetor including five individual injectors and associated fuel distribution manifold;

FIG. **5** is an exploded perspective view of the central platelet injector of the assembly of FIG. **4** which functions as the idle circuit injector.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings with specific reference to FIGS. **1** and **2**, an exemplary embodiment of the platelet-venturi carburetor of the present invention is shown. The central elements of the carburetor both in terms of construction and operation are the venturi assembly **12** and the platelet injector assembly **14.** These units are contained within a generally cubic carburetor housing formed by back plate **16,** mounting plate **18,** side plates **20** and **22,** base plate **24** and top plate **26.** Base plate **24** bolts onto a conventional two-barrel automobile engine intake manifold and is provided with a central rectangular aperture **28** which connects the two rectangular "barrels" of the platelet-venturi carburetor with the corresponding circular induction ports of the intake manifold (not shown) through an adapter plate **30.** Top plate **26** is likewise provided with a central rectangular aperture **32** which receives air intake through a conventional air filter device (not shown) mounted directly above the carburetor. FIG. **1** shows the carburetor with side plate **20** removed in order to more clearly show the internal arrangement of the individual platelet injectors and venturi vanes.

Attached to the exterior side of mounting plate **18** is a conventional fuel metering block **34** and float bowl **36.** The float chamber and metering block may be of the type such as used in the Holley carburetor Model No. 4643B, used by the Ford Motor Company. Float bowl **36** receives fuel through inlet fitting **38** from an external fuel tank via a fuel line (not shown). Gaskets **40** seal the assembled carburetor against fuel leakage.

In overall operation, air enters the carburetor through air intake **32** in top plate **26** and is mixed in the diffuser sections of venturi assembly **12** with finely atomized fuel droplets issuing from a total of 40 small orifices in the platelet injectors of assembly **14.** Fuel passes from float chamber **36** through metering jets **42** in metering block **34.** There are four jets, one pair for the two idle circuit fuel distribution channels and one pair for the two main circuit fuel distribution channels. The fuel flows up through passages in the metering block then out of the block into mounting plate **18.** Passages in the mounting plate conduct the fuel into the distribution manifold of the platelet injector assembly **14.**

Venturi assembly **12** defines two carburetor "barrels" each of which is composed of five narrow rectangular diffuser sections where the finely atomized fuel droplets are mixed with the incoming air and the mixture is vaporized. Each of the ten rectangular diffuser sections is formed by the confronting divergent surfaces of two adjacent venturi vanes ***46a–46h*** together with the interior surface of either side plate **20** or **22** and central venturi divider plate **48.** The four exterior venturi surfaces are formed by curved projections ***50a–50d*** formed on the interior surfaces of back plate **16** and mounting plate **18.**

The venturi vanes comprise airfoils having a profile which tapers gradually in the direction of air flow so that adjacent vane surfaces form a gas diffuser of gradually increasing rectangular cross-sectional flow area.

In general, the criteria for selecting the venturi geometry are that it must provide as high an air velocity as possible for good fuel atomization and vaporization and that the stagnation pressure loss within the diffuser be minimized. Referring now to the generalized venturi section of FIG. **3** the design parameters which have a bearing on the stagnation pressure loss are the diffuser angle of divergence α, the throat width W, the throat length H, the diffuser length L, and the leading edge radius *r*. Packaging constraints limit the venturi length L to about 2.00 in. Experimental testing has disclosed that the stagnation pressure loss increases with increasing air flow rate and decreases with venturi throat width. This dependence on throat width is due to boundry layer blockage since in the case of narrower throat width the boundry layer occupies a larger percentage of the total flow area.

Suitable values for the venturi design parameters with five diffuser sections per barrel have been experimentally determined as follows: venturi length L:2 in.,α half angle:3½°, venturi throat width, W:0.100 in. While a larger throat width would result in a smaller pressure drop as discussed above, it has been found that the spatial distribution of the fuel is not as good with a larger throat. The pressure drop requirement is met by using multiple venturis to provide the required open area for the maximum flow condition. A venturi section constructed as described resulted in a diffuser pressure loss of 1.5 in. hg. at the maximum flow of 350SCFM. It was estimated that diffuser inlet and exit losses would not exceed 1.5 in. hg. so that the overall pressure drop should not exceed 3.0 in. hg. at 350 SCFM with five venturi sections having defined individual throat dimensions of 0.10 in. width by 1.50 in. length.

As has been described the five venturi sections in each barrel of the carburetor are formed by four vanes **46** together with corresponding half-vane sections **50** formed in back plate **16** and mounting plate **18** and the planar interior surfaces of side walls **20** and **22** together with the planar surfaces of venturi central divider plate **48.** It will be seen from an inspection of FIGS. **1** and **2** that the center two venturi vanes in each barrel (***46b***, 46*c*, 46*f* and ***46g***) have a greater length extending downwardly past the termination of the exterior vanes. The reason for this is that the lower portion of the central vanes in conjunction with the interior surfaces of carburetor walls **16, 18, 20** and **22,** and the exterior surfaces of central divider plate **48** form three fuel induction passages **52, 54** and **56.**

Rectangular throttle valve **58** is disposed within central passage **54** while the outer passages **52** and **56** are respectively provided with similar throttle valves **60** and **62.** As best seen in FIG. **2** each of the three throttle valves is formed in two sections, one for each barrel, with a central rod portion which fits beneath divider plate **48.**

The purpose of this three duct configuration is to eliminate the need for the conventional dual fuel delivery circuit used in existing carburetors which produce undesirably large fuel droplets during acceleration. The idle circuit is formed by obstructing the outer passages **52** and **56** by closure of throttle valves **60** and **62** while central throttle valve **58** is maintained in an open position. In this condition only the center venturi section in each barrel is operable, thus providing one-fifth of the total fuel distribution area.

As will be discussed in detail below in connection with FIGS. **4** and **5,** the fuel supply to the central platelet injector is isolated from the fuel supply to the main circuit injectors so that the fuel supply to the main injectors may be cut off during idle operation.

Platelet injector assembly **14** is shown in expanded detail in FIG. **4.** The injector assembly comprises five injector units ***70a–70e***. Spacer blocks ***72a–72f*** are interposed between the individual injector plates to maintain their relative spacing and also conduct fuel to the injectors. The dual circuit fuel distribution system is integrated into the injector assembly as follows.

Fuel distribution manifold **74** acts both as a mounting block by which the injector assembly is secured to mounting plate **18** and also distributes the incoming fuel to the idle and main fuel delivery circuits in the assembly. As discussed above in connection with FIGS. **1** and **2**, fuel is conducted from float bowl **38** through metering block **34** which has four outlet orifices. These orifices align with ports **18***a* through **18***d* in mounting block **18** (FIG. **2**). The exterior ports **18***a* and **18***d* have an elongate shape so that the fuel issues therefrom on the interior side of mounting plate **18** at a slightly lower level on the plate with respect to the central two circular ports **18***b* and **18***c*.

When injector manifold **74** is assembled to mounting plate **18** via two screws which engage threaded holes **84***a* and **84***b* the exterior elongate ports **18***a* and **18***d* in the mounting plate are enclosed within the periphery of V-shaped recess **76** in manifold **74.** Thus, all fuel issuing from ports **18***a* and **18***d* will be collected within recess **76** and directed to the lower two fuel delivery passages **80***a* and **80***b*. Passages **80***a* and **80***b* are part of the main fuel distribution circuit and as will be seen serve as the fuel supply for the four outboard injector units **70***a*, **70***b*, 70*d* and **70***e*.

In a similar manner manifold recess **78** collects fuel issuing from interior ports **18***b* and **18***c* in mounting plate **18** and directs the fuel to the upper two fuel delivery passages **82***a* and **82***b* which are part of the idle circuit and supply fuel only to central injector **70***c*.

Each of the individual injectors **70***a* and **70***e* and spacer blocks **72***a*–**72***f* are provided with a centrally located four port pattern which is essentially identical to that formed in manifold **74** by passages **80***a*–*b* and **82***a*–*b*. The individual injector plate and spacers are secured together and attached to manifold **74** by means of an elongate bolt, the shank of which passes through aligned centrally located apertures **89** formed in the individual injectors and spacer blocks and the threads of which engage a threaded hole in the manifold. Thus, when the injectors and spacers are assembled and secured to the manifold the aligned four-port pattern in the manifold, injectors and spacer blocks form the two upper channels **82***a* and **82***b* and the two lower channels **80***a* and **80***b*. The upper two channels supply fuel to the two injection circuits in the central idle injector **70***c* while the lower two channels supply fuel to the two injection circuits in each of the four main injectors **70***a*, 70*b*, **70***d* and **70***e*.

Injector manifold **74** and each of the injector plates **70***a* through **70***e* are provided with aligned apertures **86***a* and **86***b* which receive alignment rods **88***a* and **88***b*. These rods extend through the manifold and the injectors and insure that the components of the assembly are maintained in a fixed relation to one another. A third alignment rod not visible in FIG. **4** is inserted through aligned apertures **86***c* in the manifold, injector plates and spacer blocks.

The internal construction of the centrally located idle circuit injector plate **70***c* is shown in FIG. **5.** With the exception of the distribution platelets **90***b* and **90***f* to be discussed below, injector **70***c* is identical to the main circuit injector plates **70***a*, 70*b*, 70*d* and **70***e*.

Injector **70***c* is composed of seven platelets **90***a*–**90***g* which are bonded together to form a series of hydraulic flow passages and transfer orifices. This fuel distribution circuit connects the two idle circuit fuel delivery passages **82***a* and **82***b* in upstream spacer block **72***c* and downstream spacer block **72***d* with eight small injection orifices **92** in injection platelet **90***d*. As discussed above the central injector **70***c* is a part of the idle circuit only. Thus, the lower two fuel delivery passages **80***a* and **80***b* are not connected to injection orifices **92** and instead fuel in these passages passes completely through the injector via two aligned apertures in the central lower portion of each of platelets **90***a* through **90***g*. Conversely, in the case of the main circuit injectors **70***a*, 70*b*, 70*d* and **70***e* it is the lower two fuel delivery passages **80***a* and **80***b* which are connected to the injector platelet orifices and the upper two fuel delivery passages pass directly through the injectors.

The structure and function of the individual platelets **90***a*–**90***g* will now be discussed. Cover platelets **90***a* and **90***g* form the outer fluid tight housing for injector **70***c*. As discussed the cover platelets include the recurring four port fuel passage pattern as well as the central bolt receiving aperture **89** and the three alignment rod apertures **86***a*–**86***c*. When manifold vacuum increases fuel in the idle circuit delivery passage in either spacer block **72***c* or spacer block **72***d* is drawn by aspiration through the upper pair of apertures in cover platelets **90***a* and **90***g* respectively. Distribution platelets **90***b* and **90***f* are each provided with two sets of fuel distribution channels **94.** These channels direct fuel passing through the upper ports of cover plates **90***a* and **90***g* to eight centrally aligned outlet ports **96** and thereafter through transfer ports **98** in transfer platelets **90***c* and **90***f* to eight injection channels **100** in injector platelet **90***d*. Each injector channel **100** also receives air via two air-bleed channels **102** entering the injection channel on either side. The fuel and air is mixed in mixer section **104** just upstream from injection orifice **92.**

The addition of a small amount of air to each of the fuel injection channels **100** via two opposing air bleed channels **102** significantly improves the carburetor performance over conventional designs. It has long been recognized that a small amount of air premixed with fuel before injection into the main air stream reduces the effect of surface tension and causes fuel flow to approximate the compressible flow characteristics of the air at high flow conditions. The net result is to reduce the fuel flow sensitivity to temperature and air flow rate such that a more uniform air fuel ratio is obtained over the range of operating conditions. In conventional carburetor design the air bleed passages introduce air into a pre-mixing section considerably upstream of the venturi throat. This results in a lack of fuel control due to the possibility of separation of the air-fuel mixture within the distribution channels.

In the present invention the air is introduced into each fuel orifice within the platelet very near the point of injection of the fuel into the venturi. This is far superior in providing uniform air-fuel mixture in that both fuel and air flows are controlled right up to the injection point. A further advantage of introducing the air bleed very near the fuel injection point is that it prevents fuel flow pulsations which are inherent in conventional carburetors. An incidental benefit is some initial atomization and vaporization of the fuel.

It has been experimentally determined that the particular configuration of the air-bleed passages shown in FIG. **5** wherein the air enters the fuel channel from both sides results in an oscillatory flow condition wherein the fuel stream moves back and forth across the channel at very high frequencies on the order of

3000 to 4000 cycles per second. These oscillations allow the fuel to flow freely at low suction pressures and also produce a significant amount of initial atomization at the higher air flow rates. It has also been found desirable to bevel the downstream edges of the platelet injectors to reduce the blockage area in the venturi throat and minimize the pressure drop within the diffuser. Fuel is aspirated out of the platelet injection orifices by the reduced pressure in the venturi throat created by the high velocity air passing through the venturi.

An additional reduction in emission levels can be achieved by further maximizing the fuel vaporization process within the carburetor by heating the air fuel mixture. This can be accomplished, for example, by electrical heating means within the platelets or by recycling a percentage of the combustion product through the carburetor to provide the necessary heat of vaporization. Thus, the heat transfer mechanism can be either by conduction through the heated platelets or by direct mixing of the exhaust gases with the fuel. The latter approach is preferred since exhaust gas recirculation (ERG) is a currently popular technique for reducing NO_x emissions.

The construction of the individual platelets for the main injectors **70***a*, 70*b*, 70*d* and **70***e* is essentially identical to that of idle injector **70***c* with the sole exception that the distribution platelets thereof corresponding to platelet **90***b* have the fuel distribution channels **94** inverted top to bottom to communicate with the main fuel circuit flow within lower delivery channels **80***a* and **80***b*.

The photoetch fabrication process by which the complex channel shapes the precisely located orifices are formed is particularly well adapted to low cost mass production techniques. Once the basic artwork and negatives have been made the manufacture of the platelets is a repetitive process requiring little supervision. Quality control requirements are almost nonexistent since each platelet is a faithful reproduction of the photographic negative. The assembly of the sequence numbered platelets is almost foolproof and can be rapidly accomplished by low cost labor. The final assembled product is readily inspected by visual methods for acceptability.

While a preferred embodiment of the invention has been shown and described above it will be appreciated by those skilled in the art that the basic principles of the invention can be implemented using a variety of specific structural forms. For example, rather than being arranged in parallel with the venturi sections the individual injector plates may be disposed at right angles thereto. Other similar variations or modifications of the invention will become apparent to the reader and the preceding embodiment is to be considered exemplary only.

What is claimed is:

1. A carburetor for an internal combustion engine comprising a venturi assembly defining a plurality of air diffuser channels of narrow rectangular cross-sectional flow area and a fuel injector assembly including a plurality of generally rectangular injector plates each having a plurality of small fuel injection orifices at the lower portion thereof, each of said injector plates comprising a plurality of platelet elements together defining fuel flow passages interconnecting a fuel source with said injector orifices, said injector plates being so positioned with respect to said diffuser channels that said orifices are located therein at the throat portion thereof to introduce fuel thereat in the form of finely atomized droplets.

2. The carburetor of claim **1** wherein said fuel flow passages include a plurality of injector channels connected to said injection orifices, a mixing area between said injector channels and said orifices and a plurality of air bleed passages communicating with said mixer section.

3. In a venturi carburetor of the type having a plurality of diffuser sections for mixing and vaporizing an air fuel mixture, the improvement comprising:

a plurality of vanes of generally rectangular shape and tapered profile, adjacent surfaces of said vanes defining a diffuser section of narrow rectangular cross-sectional air flow area, and

fuel injection means for introducing fuel into said venturi sections in the form of finely atomized droplets, said injection means including a plurality of injector plates each having a plurality of small injection orifices centrally disposed within a corresponding one of said venturi sections at the throat thereof.

4. The carburetor of claim **3** wherein certain ones of said vanes extend downwardly below the termination of adjacent vanes forming a plurality of fuel induction channels.

5. Apparatus of claim **4** wherein each of said induction channels is provided with throttle means for selective operation thereof.

6. The combination of a platelet fuel injector assembly and a multiple venturi carburetor wherein said venturis have an elongate cross-sectional flow area and including a plurality of injector plates of laminar construction each including a plurality of platelets having small hydraulic flow passages formed therein terminating at a plurality of injection orifices, said injector assembly being so disposed within said venturis to locate a plurality of said orifices within each of said venturis along the major axis thereof and fuel delivery means connecting said injection orifices with a fuel source.

7. The injector assembly of claim **6** wherein said fuel delivery means includes dual fuel distribution channels, one of said channels communicating with one of said injector plates and the other of said channels communicating with the remainder of said injector plates.

8. A carburetor for an internal combustion engine comprising:

venturi means defining at least one air flow passage of elongate cross-sectional flow area and having a throat section and a diffuser section and

platelet fuel injector means associated with said venturi passage and including a plurality of small fuel injection orifices disposed within said venturi throat section, said platelet fuel injector means further comprising at least one injector plate disposed within said venturi passage so that said injection orifices are disposed along the major axis thereof, said injector plate being of laminar construction wherein a plurality of platelet elements having fuel flow channels and transfer orifices formed therein are bonded together to define fuel flow passages connecting an external fuel source with said injection orifices.

9. The carburetor of claim **8** further comprising a plurality of rectangular throttle plates disposed within said venturi passages to selectively control the air flow therethrough.

10. A carburetor for an internal combustion engine comprising:

venturi means defining at least one air flow passage having a throat section and a diffuser section and platelet fuel injector means associated with said venturi passage and including a plurality of small fuel injection orifices disposed within said venturi throat section, said platelet fuel injector means further comprising at least one injector plate of laminar construction wherein a plurality of platelet elements having fuel flow channels and transfer orifices formed therein are bonded together to define fuel flow passages connecting an external fuel source with said injection orifices, said injector plates further having a plurality of air bleed passages formed therein and wherein each of said fuel flow passages has at least one of said air bleed passages connected thereto in proximity of said orifices.

11. A carburetor for an internal combustion engine comprising:

venturi means defining at least one air flow passage having a throat section and a diffuser section and platelet fuel injector means associated with said venturi passage and including a plurality of small fuel injection orifices disposed within said venturi throat section, said platelet fuel injector means further comprising at least one injector plate of laminar construction wherein a plurality of platelet elements having fuel flow channels and transfer orifices formed therein are bonded together to define fuel flow passages connecting an external fuel source with said injection orifices, said fuel injector means further having fuel distribution means associated with said injector plates and comprising two isolated fuel delivery circuits, one of said circuits communicating only with a selected one of said plates and the other of said circuits communicating with the others of said plates.

* * * * *