

EPA Evaluation of the VCD Supplemental  
Gaseous Fuel Delivery System Under  
Section 511 of the Motor Vehicle Information  
and Cost Savings Act

by

Edward Anthony Barth

September, 1983

Test and Evaluation Branch  
Emission Control Technology Division  
Office of Mobile Sources  
U.S. Environmental Protection Agency

EPA Evaluation of the VCD Supplemental Gaseous Fuel Delivery System Under Section 511 of the Motor Vehicle Information and Cost Savings Act

The Motor Vehicle Information and Cost Savings Act requires that EPA evaluate fuel economy retrofit devices and publish a summary of each evaluation in the Federal Register.

EPA evaluations are originated upon the application of any manufacturer of a retrofit device, upon the request of the Federal Trade Commission, or upon the motion of the EPA Administrator. These studies are designed to determine whether the retrofit device increases fuel economy and to determine whether the representations made with respect to the device are accurate. The results of such studies are set forth in a series of reports, of which this is one.

The evaluation of the "VCD Supplemental Gaseous Fuel Delivery System" was conducted on the application of the manufacturer. The device is designed to operate the engine of a vehicle on a mixture of gasoline and propane. The device consists of a gaseous fuel metering and control unit, a modified carburetor and associated electrical and plumbing components. It functions by replacing some of the gasoline with propane under certain operating conditions. The device causes the engine to idle on propane, cruise on gasoline, and accelerate on a mixture of the two fuels. This is claimed to be more fuel efficient. This combination of improvements in fuel efficiency and fuel substitution is claimed to save both fuel and money.

1. Title:

Application for Evaluation of VCD Supplemental Gaseous Fuel Delivery System Under Section 511 of the Motor Vehicle Information and Cost Savings Act

---

The information contained in sections two through five which follow, was supplied by the applicant.

---

2. Identification Information:

a. Marketing Identification of the Product:

VCD Supplemental Gaseous Fuel Delivery System

b. Inventor and Patent Protection:

## (1) Inventor

Scott J. Venning  
617 S. Busse Road  
Mt. Prospect, Illinois 60056

## (2) Patent

"Copy of patent and pertaining data attached." (Attachment A)

c. Applicant:

(1) VCD Fuel Systems  
617 S. Busse Road  
Mt. Prospect, Illinois 60056

(2) Scott Venning is authorized to represent VCD Fuel Systems in communication with EPA.

d. Manufacturer of the Product:

(1) VCD Fuel Systems  
617 S. Busse Road  
Mt. Prospect, Illinois 60056

## (2) Principals

Scott Venning  
617 S. Busse Road  
Mt. Prospect, Illinois 60056

Anthony Christian  
2832 NE 36th Street  
Ft. Lauderdale, Florida 33308

Ronald Dadario  
1219 SE 11th Ave.  
Deerfield Beach, Florida 33441

3. Description of Product:a. Purpose:

"To conserve fuel by supplementing gasoline with propane at advantageous times."

"The purpose of the device is to save fuel and money. Through testing we have established that idling with propane is more economical than gasoline and cruising with gasoline is more economical than propane. With the combination of idling on propane and cruising with gasoline, we have arrived with a considerable savings of fuel and money.

"Up until now, all propane converted vehicles used only propane and had no fuel or money savings, only availability to an alternative fuel when gasoline is unavailable or in shortage. Using propane only has the disadvantage of a 20% power loss.

"The VCD System also accelerates on gasoline and propane. Together, this [gives] you a leaner power circuit because the slight amount of propane used helps as does octane in fuel. We have included test results that we have performed. We feel that this system will be beneficial to the energy problem and save the public money." Attachment E.

b. Applicability:

"This system is applicable to all gasoline internal combustion engines. Test data has been compiled on the vehicles listed below:

1980-1981 GM Chevrolet	229 V6 Engine
Monte Carlo - Chev	2 BBL Rochester Carb.
Malibu - Chev	Automatic Transmission
Cutlass - Olds	H.E.I. Ignition

"This engine is randomly used in other GM vehicles such as Oldsmobile and Buick. To identify the 229 V6 Chev Engine, the 5th digit in the serial number is "K" for 1980-1981 models.

c. Theory of Operation:

"Basic Function; idles on propane, cruises on gasoline, accelerates on propane and gasoline (See Drawings Attached)." Attachment B, Figures 1 through 8.

d. Construction and Operation:

"See drawings attached", Attachment B, Figures 1 through 8.

(1) Description of Invention:

"(Fig. 7) System to be used with gaseous fuels such as propane, methane, natural gas or similar fuels. Propane, for example, starts in pressure tank (#10), passes thru shutoff (#8), thru regulator (#9), into metering unit (#12). On idling requirements, metering unit allows propane to be injected into carburetor (#1). On cruising or light acceleration, unit shuts off propane and carburetor relies on gasoline only. On acceleration, metering unit (acting as a power valve) enrichens mixture by injecting propane along with fuel.

(2) Description of Major Components of the VCD Device:

The detailed descriptions of the metering unit, idle switch, modified carburetor and system variations are given in Attachment B.

"This system is not intended for aftermarket installations for the public. The only form in consideration is to develop systems for fleet vehicles where the system can be designed and installed by trained personnel. This should enable us to omit general operating instructions and rely on instructions and descriptions as in format heading 'Description of Device.'"

e. Specific Claims for the Product:

The "Purpose of the device ... is to save fuel and money." Attachment E.

f. Cost And Marketing Information:

"This system is not intended for aftermarket installations for the public. The only form in consideration is to develop systems for fleet vehicles ..."

4. Product Installation, Operation, Safety and Maintenance:

a. Installation - Instructions, Equipment, and Skills Required:

"Parts List:	Pressure Tank	Clamps
	Regulator	Metering Unit
	Shutoff	Modified Carb.
	Hose	Wiring Diagram

"Installation: Basic Hand tools

1. Mount propane tank in trunk.
2. Run propane hose under vehicle into engine compartment.

3. Mount metering unit on firewall and connect propane hose to inlet on metering unit.
4. Remove existing carb and install modified carb.
5. Connect vacuum hose on metering unit marked P.V. to a ported vacuum source. Connect vacuum hose marked M.V. to a manifold vacuum source.
6. Connect wires as on wiring diagram.
7. Open pressure tank shutoff and adjust regulator to 1-1/2 - 2 lbs.
8. All units come pre-set. If idle speed needs adjusting, unloosen locknut on metering unit and adjust rod accordingly."

b. Operation:

The device modifies the vehicle to ... "idle on propane, cruise on gasoline, accelerate on gasoline and propane."

c. Effects on Vehicle Safety:

"This system is wired into an oil pressure switch; therefore, if the engine stopped running and was not noticed, the propane would automatically shut off as the oil pressure drops to zero.

"Vehicles that have been using propane only, have proven [it] to be a safe fuel for automobiles."

d. Maintenance:

"Maintenance on engines equipped with this system should follow regular engine maintenance procedures.

"There is no preventative maintenance on this system. With every refill of propane, check to see if the pressure is 1-1/2 - 2 lbs."

5. Effects on Emissions and Fuel Economy:

a. Unregulated Emissions:

"With propane being a cleaner fuel to burn, this system will operate within or better than EPA requirements."

b. Regulated Emissions and Fuel Economy:

The fuel economy test results provided are given in Attachments E and N.

---

The following Sections are EPA's analysis and conclusions for the device.

---

## 6. Analysis

### a. Identification Information:

#### Marketing Identification:

VCD Supplemental Gaseous Fuel Delivery System was identified as the marketing name for the product. However, the device is vehicle and engine specific and is now available for only one engine (GM 229 V-6). The three basic variations of the system (VCD Supplemental Gaseous Fuel Delivery System, types V-1, V-2, and V-3) were not evaluated. Attachments D and F.

### b. Description:

- (1) As stated in Section 3a, the primary purpose of the VCD device is to conserve gasoline and thereby save fuel and money. This is in agreement with the theory of operation and design of the device.
- (2) In Section 3b, the theory of the device was claimed to be applicable to all gasoline internal combustion engines. It was clarified that, at present, the device was not applicable to engines with feedback carburetors or fuel injection (Attachments D and F).
- (3) The theory of operation given in Section 3c is judged to be in agreement with the description of the device (Section 3d) and is able to be designed to function as described.
- (4) The description of the device given in Section 3d is judged to be adequate for the design being evaluated as well as the several variations (V-1, V-2, and V-3).
- (5) The device is claimed to save both fuel and money. These claims are in agreement with the purpose, theory of operation, and construction of the device. However, no specific numerical improvements were claimed. In response to our request for the specific claims to be made for the device, the applicant stated that the device would:
  - (a) "Reduce the cost of fuel and use of energy by 30% while idling."
  - (b) "Reduce the cost of fuel and use of energy by between 14 and 23% in normal vehicle operation."
  - (c) "Achieve these savings without a loss of power" (Attachments D, F, and G).

- (6) The cost of the device plus installation was not provided in Section 3f. In response to our request for this information, the applicant stated the cost of the system is \$700 to \$900 (Attachments D and F). However, it is not clear that all the parts necessary for installation are included in this cost.

Furthermore, these costs apparently do not include the labor for installation. EPA is unable to assess what these added costs might be since neither a detailed parts list nor detailed installation instructions were provided.

c. Installation, Operation, Safety and Maintenance:

(1) Installation - Instructions, Equipment and Skills Required:

The applicant only summarized the installation procedures and stated that, since the device was intended for fleet users, VCD would work directly with the installers (Attachments D and F). However, in our judgment, these installers would still require more detailed instructions particularly for the adjustments outlined.

(2) Operation:

Based on the statements of the applicant, it appears the device functions without requiring any special actions by the driver.

(3) Effects on Vehicle Safety:

Although the device should be able to be manufactured and installed safely, the actual safety of the device cannot be judged. Both propane and gasoline can be hazardous when not handled properly. The applicant provided no specific information on the safety standards that the construction, installation, and use of the device are designed to meet. The response of the applicant did not adequately address this issue (Attachments D and F).

(4) Maintenance:

The recommended maintenance requirements given in Section 4d are judged to be adequate.

d. Effects on Emissions and Fuel Economy:

(1) Unregulated Emissions:

The applicant submitted no data on unregulated emissions. The substitution of propane for gasoline will affect the

combustion process and emissions. However, since only a small amount of propane is used, it is judged that this change is unlikely to appreciably affect unregulated emissions.

(2) Regulated Emissions and Fuel Economy:

EPA assisted the applicant in developing test plans for testing the device at an independent lab (Attachments G, H, I, J, K, L, and M). The applicant tested the device in accordance with the Federal Test Procedure and the Highway Fuel Economy Test and submitted the data (Attachment N).\*

The applicant stated in his letter providing these data that there were numerous driveability problems when the device was tested but that he felt that these problems could be overcome through additional work (Attachment N). Also, he expected to retest in the future. However, since retesting was not done within a reasonable period and since these were the best test data available, EPA was obligated to complete the evaluation of the device with the available information (Attachment M). The results are summarized in Table I and II below.

---

\*These two test procedures are the primary ones recognized by EPA for evaluation of fuel economy and emissions for light duty vehicles. The requirement for test data following these procedures is stated in the policy documents that EPA sends to each potential applicant. EPA requires duplicate test sequences before and after installation of the device on a minimum of two vehicles. A test sequence consists of a cold start FTP plus a HFET or, as a simplified alternative, a hot start LA-4 plus a HFET. Other data which have been collected in accordance with other standardized procedures are acceptable as supplemental data in EPA's preliminary evaluation of a device.

Table I  
Summary of Test Results Submitted by Applicant  
Emissions in Grams per Mile, Fuel Economy in Miles Per Gallon

	Configuration	HC	Hot LA-4			HFET			
			CO	NOx	MPG	HC	CO	NOx	MPG
1980 Chevrolet	Baseline	.18	.39	1.38	19.0	.07	.47	1.31	24.9
3.8 liter V-6	VCD	1.21	9.85	.69	19.1	.13	2.90	.61	23.6
Veh. #3877	Average Change	+570%	+2400%	-50%	0%	+91%	+520%	-53%	-5%
1980 Chevrolet	Baseline	.20	1.20	1.64	20.1	.05	.23	1.52	26.3
3.8 liter V-6	VCD	1.15	6.76	1.43	19.7	.15	.77	1.49	25.8
Veh. #6362	Average Change	+440%	+470%	-12%	-2%	+170%	+240%	-1%	-2%

Note: MPG calculated by the carbon balance method.

Table II  
Summary of Fuel Economy Results for Table I

	Configuration	HOT LA-4				HFET			
		Carbon	GPHM	PEGPHM	EMPG	Carbon	GPHM	PEGPHM	EMPG
1980 Chevrolet	Baseline	19.0	5.34	-	-	24.9	4.01	-	-
3.8 liter V-6	VCD	19.1	4.49	1.02	18.2	23.6	4.16	.10	23.6
Veh. # 3877	Average Change	0%	-16%	-	-	-5%	+4%	-	-
1980 Chevrolet	Baseline	20.1	5.08	-	-	26.3	3.80	-	-
3.8 liter V-6	VCD	19.7	3.82	1.47	18.9	25.8	3.77	.13	25.6
Vehicle # 6352	Average Change	-2%	-25%	-	-	-5%	-1%	-	-

Fuel Carbon - Fuel economy as measured by carbon balance method.

GPHM - Gallons (gasoline) per hundred miles. This fuel consumption was measured with a volumetric instrument (Fluidyne). The results correlated well with the fuel economy results measured by the carbon balance method.

PEGHM - Propane Equivalent Gallons per Hundred Miles. This is the number of gallons of propane used and expressed as the equivalent number of gallons of gasoline on a BTU basis. Gasoline is 6.167 lbs/gallon and 120,750 BTU/gallon. Propane is 4.233 lbs/gallon and 20780 BTU/lb.

EMPG - Equivalent MPG for device (volumetric fuel plus propane). It equals  $1/(GPHM + PEGPHM)$  and should equal carbon balance value.

The overall conclusion after reviewing these data is that there is no economic or energy benefit for the device and that, except for nitrogen oxide, emissions increased. The emission effects noted - substantially higher hydrocarbon (HC) and carbon monoxide (CO) emissions with lower NOx emissions are characteristics of the effect of enriching the mixture of an engine that is calibrated to operate lean. This data showed that, from an energy standpoint, the vehicle with the device was not as energy efficient as the vehicle in stock condition.

The device was able to substitute propane for gasoline. When the data of Table II are compared on the economics of this substitution, the following table is obtained.

Table III  
Summary of the Energy and Economic  
Effects of Operating the VCD Device\*\*

Vehicle #3877	HOT LA-4		HFET	
Change in fuel usage	-.85 GPHM	1.02 PEGPHM	+.15 GPHM	+.10 PEGPHM
Change in fuel costs*	-\$1.19/HM	+\$1.25/HM	+.21/HM	+.10/HM
Total change in costs		+.06/HM		+.31/HM
Vehicle #6362				
Change in fuel usage	-1.26 GPHM	1.47 PEGPHM	-.03 GPHM	.13 PEGPHM
Change in fuel costs*	-\$1.76/HM	+\$1.84/HM	-.04/HM	+.16/HM
Total change in costs (increase)		+.08/HM		+.12/HM

\*Fuel costs are calculated on the basis of \$1.40 a gallon for unleaded gasoline and \$1.25 for the amount of propane that is energy equivalent to a gallon of gasoline (propane at \$.80 gallon equals \$1.05 on energy basis plus Federal and State excise taxes of \$.20 a gallon).

\*\*Abbreviations per Table II.

The following general comments also apply to this data.

- (a) Propane consumption was measured with a mass balance. Unfortunately, the resolution of this balance was approximately equal to the amount of propane used in the HFET and nearly 10% of the amount used in the FTP. Although this does not appear to have adversely affected the quality of the data, it is thought to be the major source of difference between the fuel economy values calculated for the device by the carbon balance method compared to the combination of volumetric (Fluidyne) plus weight balance (propane).

- (b) The modified carburetor used for the device tests on both vehicles was a unit that had been previously modified, tested, and used on other vehicles by the applicant. The test vehicles were baseline tested with their original carburetors.
- (c) In an attempt to overcome a stall problem with the device, the idle propane flow was increased substantially for the second vehicle, #6362. Therefore, the device calibration was not the same for both test sequences.
- (d) The stall and lean spot noted on the two test vehicles may be due to poor fuel control by the device when in transition between the idle and acceleration modes rather than a need to richen up the idle. This appears to be borne out by the fact that, after richening up the idle mixture, the second vehicle still stalled.
- (e) The applicant had previously operated the test unit on other vehicles and had noted no problems with it. If the dynamometer load is higher than road load and was the cause of the problem as he infers (Attachment N), then grades or heavy loads should also be a problem. However, there was no mention of a road load problem in the applicant's previous road testing of the device.

The applicant also submitted road test data, both with and without the device, on three other vehicles. Although these were apparently well-controlled road tests, the test variables cannot be as rigorously controlled as in lab tests. Therefore, any road test results are only an uncertain indication of the effects to expect from a device.

Because of the driveability problems, negative energy benefit, and negative economic benefit shown in testing, it appears the device is actually in the prototype, development, and testing phase rather than pre-marketing. Benefits for the device, if possible, still have yet to be demonstrated and would have to be substantial to overcome the high initial cost.

## 7. Conclusions

EPA fully considered all of the information submitted by the applicant. The evaluation of the VCD Supplemental Gaseous Fuel Delivery System was based on that information and our engineering judgment.

The device did substitute propane for some of the gasoline. Although the substitution of propane for gasoline has the potential to affect fuel economy, emissions and operating costs, neither the data submitted by the applicant nor technical analysis showed an economic or fuel economy benefit. In fact, emission levels of HC and CO were found to increase substantially. Thus, in the absence of positive test data, EPA has no reason to support the claims made for the device or to continue the evaluation on its own.

FOR FURTHER INFORMATION CONTACT: Merrill W. Korth, Emission Control Technology Division, Office of Mobile Sources, Environmental Protection Agency, 2565 Plymouth Road, Ann Arbor, MI 48105, (313) 668-4299.

## List of Attachments

- Attachment A Patent (provided with 511 Application)
- Attachment B Drawings of VCD System and description of major components of the device (provided with 511 application).
- Attachment C Letter of November 4, 1982 from EPA to Scott J. Venning of VCD Fuel Systems acknowledging receipt of 511 application request and noting it did not meet key criteria for evaluation.
- Attachment D Letter of November 29, 1982 from EPA to Scott Venning providing a review of the incomplete 511 application and requesting clarification.
- Attachment E Letter of November 29, 1982 from Scott Venning responding to EPA letter of November 4, 1982 and formally completing 511 application.
- Attachment F Letter of December 12, 1982 from Scott Venning responding to EPA letter of November 29, 1982.
- Attachment G Letter of December 15, 1982 from EPA to Scott Venning confirming information supplied and providing a test plan for the device.
- Attachment H Letter of February 22, 1983 from Scott Venning to EPA discussing proposed lab tests and containing two lab test plans.
- Attachment I Letter of February 28, 1983 from Scott Venning to EPA requesting review of a lab test plan.
- Attachment J Letter of March 16, 1983 from EPA to Scott Venning responding to letters of February 22 and 28, 1983.
- Attachment K Letter of March 18, 1983 from Scott Venning requesting review of two lab test plans.
- Attachment L Letter of April 6, 1983 from EPA to Scott Venning commenting on selection of a test lab.
- Attachment M Letter of July 11, 1983 from EPA to Scott Venning announcing intention to close out evaluation since VCD Fuel Systems had not completed the test program and submitted required data.
- Attachment N Letter of July 7, 1983 from Scott Venning providing copy of the test results at an independent lab.

VCD SUPPLEMENTAL GASEOUS FUEL DELIVERY SYSTEM  
GASEOUS FUEL DELIVERY SYSTEM

I. BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a gaseous fuel delivery system for gasoline engines. More particularly it relates to a system which supplies gaseous fuel, such as propane, methane or natural gas to the gasoline engine during idle and acceleration conditions of operation. It is an improvement of the system described in United States Patent 4,227,497.

Description of the Prior Art

The system disclosed in the aforesaid patent is intended to supply gaseous fuel to a gasoline engine during portions of the operating cycle in which gaseous fuel operation is more efficient. These selected operating conditions are idle, acceleration, and increased load.

It was determined that the use of purely mechanical means to control idle gaseous fuel supply was troublesome and inaccurate. Also, dependency upon the relative magnitudes of engine vacuum resulted in wide fluctuations in operating effectiveness. Unwanted operation of one or the other portion of the system to supply gaseous fuel when not intended further diminished overall efficiency. Importantly, it also was determined that for idle operation, modification

1 of the carburetor of the gasoline engine equipped  
for gaseous fuel supply was necessary to maximize  
efficiency.

5

#### SUMMARY OF THE PRESENT INVENTION

The present invention is intended to provide  
the advantages of gaseous fuel operation in a gasoline  
10 engine without the disadvantages of the earlier design.  
The present invention incorporates means responsive  
to engine operating conditions into the idle fuel  
supply portion to the system. It also eliminates  
variable control of gaseous fuel supply during  
15 acceleration and provides positive, electrically  
operated cutoff of the gaseous fuel supply during  
periods when such supply is unneeded. This arrangement  
eliminates the ability to automatically respond to  
variable load, but significantly improves idle and  
20 acceleration performance.

The system of the present invention is  
applicable to new as well as existing engines. It  
could be supplied as original equipment or added as  
a conversion at some later time.

25 In the preferred form, the system includes  
supply valve means responsive to absence of flow of  
air through the carburetor venturi to permit supply  
of a preselected quantity of gaseous fuel during idle  
operation of the engine and responsive to loss of  
30 intake manifold vacuum to permit supply of a preselected

1 supplemental quantity of gaseous fuel during engine  
acceleration. It further includes positive electrically  
operated valve means responsive to engine throttle  
position and manifold vacuum to insure delivery of  
5 idle or acceleration gaseous fuel supply only at the  
proper portions of the operating cycle.

The carburetor used with the system is  
arranged such that no gasoline fuel is delivered to  
the engine at idle, yet as operation is elevated above  
10 idle, a small supply of gasoline commences prior to  
termination of the idle gaseous fuel supply.

#### DESCRIPTION OF THE DRAWINGS

15

FIGURE 1 is a partially sectional view of  
the system of the present invention.

FIGURE 2 is an electrical schematic of the  
electrical components of the system.

20

FIGURE 3 is a plan view, partially in  
section, of the supply valve means of the present  
invention.

FIGURE 4 is a side view of the supply valve  
means of FIGURE 3.

25

FIGURE 5 is a top view of the base plate  
of the carburetor incorporating the system of the  
present invention.

30

FIGURE 6a and 6b are fragmentary views of  
portions of the base plate of the carburetor of FIGURE  
5.

1                   FIGURE 7 is a fragmentary side elevational  
view of a portion of the carburetor of FIGURE 5.

5                   DETAILED DESCRIPTION

                  The system of the present invention is  
applied in conjunction with the carburetor of an  
internal combustion engine utilizing gasoline fuel.  
10                It is interconnected, for example, with a dual barrel  
carburetor 10 illustrated in the drawings, which  
includes a removable base plate 12, central throats  
14 and pivotal butterfly valve plates 15 pivotally  
mounted in base plate 12 and controlled by the engine  
15                throttle linkage. Of course, a carburetor having  
additional or fewer barrels (venturis) could be  
utilized. Any suitable gasoline carburetor may be  
used, such as the products of Rochester Carburetor  
Company, a Division of General Motors Corporation.  
20                Specifics of carburetor functions to supply gasoline  
to an engine are illustrated and described in numerous  
reference works, such as, for example, "Rochester  
Carburetor", a publication of H. P. Books, P. O. Box  
5367, Tucson, Arizona 85708, printed 1973, Library  
25                of Congress Catalog Card Number 72-91 685. Reference  
is made to that publication for an understanding of  
the typical gasoline carburetor with which the present  
invention is intended to cooperate.

                  Illustrated carburetor 10 is not wholly  
30                conventional. It is modified, or in the instance

1 of original equipment, constructed differently from  
a carburetor for supplying only gasoline to an internal  
combustion engine. Carburetor 10 includes gaseous  
fuel inlet tube 16 through which the gaseous fuel  
5 is supplied in accordance with the present invention.  
This may be located above or below butterfly 15.

In accordance with the present invention,  
it is necessary to eliminate all supply of gasoline  
fuel at idle. Usually two sources exist, the main  
10 idle circuit, which includes adjustable idle fuel  
jets and in most carburetors transition slots, which  
are formed in the throat of carburetor adjacent the  
closed position of the butterfly valves.

Idle needle valves are closed so that no  
15 fuel is delivered to the idle circuit of the carburetor.  
The idle circuit is normally a passage separate from  
the throat and supplies gasoline and air even though  
the butterfly valves are closed or nearly closed.  
Fuel, metered through the idle needle valves, is the  
20 major idle fuel supply. In the present system all  
gasoline or liquid fuel supply is eliminated at idle.

As illustrated in FIGURES 5 through 7, the  
carburetor of the present invention includes transition  
slots 22, formed in throats 14 of carburetor 10, which  
25 permit quantities of gasoline to enter the carburetor  
throat 14. They generally operate to supplement idle  
fuel supply until the main carburetor jets 17 commence  
fuel delivery.

As seen in FIGURES 5, 6a and 6b, the base  
30 plate 12 of carburetor 10 has been modified to

1 significantly shorten the "transition slots" 22 which  
exist in the walls forming the throats 14, such that  
they are closed at idle and not exposed to the high  
intake manifold vacuum between the closed butterfly.  
5 Thus, no gasoline can be drawn into the carburetor  
throat. In modifying an existing carburetor 10 the  
slots 22 are conveniently restricted by inserting  
set screws 20 from the top of carburetor base plate  
12. Appropriate threaded holes 24 are formed in base  
10 plate 12 to accommodate threaded set screws 20.

It is important to note that the screws  
are positioned such that the transition slots are  
blocked when the butterfly plate is in the closed  
or idle position. That position of plate 15 at idle  
15 is as shown at 13 in FIGURE 6a. At idle no gasoline  
can be drawn into the carburetor through the shortened  
portions 23 of slots 22, because they are above the  
closed portion of the butterfly. As the butterfly  
15 are moved from the idle position, some amount of  
20 gasoline is drawn into the throats 15 through the  
shortened slots 23. This is intended to avoid any  
possible lag in operation as transition is made from  
idle to operational modes. It occurs, because as  
the butterfly 15 are pivoted toward the open or  
25 vertical position, the shortened slots 23 are exposed  
to the intake manifold vacuum.

The power valves of the carburetor 10 are  
also eliminated. This is done by removing, or in  
the case of original equipment, excluding the typical  
30 power valves found in a carburetor which enrichens

1 the fuel mixture under load. This substantially  
reduces the amount of liquid fuel which will enter  
the carburetor on acceleration.

5 The fuel delivery system illustrated in  
the embodiment in FIGURES 1 through 8, includes a  
pressure vessel 26 for storage of a gaseous fuel  
supply, a shut-off valve 28, adjustable pressure  
regulator 30 with gauge 32, supply valve means 34,  
and connecting delivery conduits 36. The fuel utilized  
10 may be propane, methane, natural gas or similar suitable  
gaseous fuel. The vessel 26 may be placed in any  
suitable location, for example, in automotive  
applications it may be placed in the trunk, or  
between the frame rails.

15 Regulator 30 and gauge 32 are utilized to  
set an appropriate supply pressure for delivery of  
gaseous fuel to the supply valve means 34 at essentially  
constant preset pressure. As can be appreciated,  
the pressure level will vary with the size of the  
20 engine with which the system is associated. Typically,  
a system for an engine of 200 cubic inch displacement  
will operate satisfactorily at 1.5 to 2.0 psig. (pounds  
per square inch, gauge) supply pressure.

25 Fuel supply line 36 provides a connection  
between regulator 30 and supply valve means 34.  
Interposed in line 36 is a normally closed solenoid  
valve 38 connected to the electrical power supply  
of the engine, which in this embodiment includes  
battery 41. Solenoid 38 is operated by oil pressure  
30 switch 39 which closes the electrical circuit and

1 permits solenoid 38 to open only when the engine is  
cranking and has developed oil pressure.

As best seen in FIGURE 3, supply valve means  
34 includes a housing or body 35 forming two separate  
5 valves, idle fuel valve 42 and acceleration fuel valve  
44. Supply line 36 delivers gaseous fuel through  
two separate inlet passages 46 and 48. These passages  
respectively connect to two separate discharge passages  
10 50 and 52 across orifice defining valve seats 54 and  
56.

Each of the valves 42 and 44 includes rod  
58 slidably supported in bores formed in body 35.  
Tapered lower portions of the rods form valve plugs  
64 and 65 which coact with valve seats 54, 56 to open  
15 and close communication between passages 46 and 50  
and passages 48 and 52. The plugs are tapered to  
provide adjustability of effective orifice size of  
the annular opening between plug and seat when the  
valves are in the open position. The maximum diameter  
20 of the tapered portions exceeds the orifice size of  
the seats 54, 56 so that when the valves are in the  
closed position the orifices are completely closed.

Upper ends of rods 58 are threaded into  
adjustment nuts 66 which are adjustable to vary the  
25 length of the rod, nut combination, and consequently  
the effective orifice size of the annulus between  
seats 54, 56 and plugs 64, 65. It has been determined  
that the effective orifice size (equivalent circular  
orifice) for the valve 42 is in the range of .040  
30 to .070 inches diameter and the effective orifice

1 size for the valve 44 is in the range of .060 to .080  
inches diameter. Springs 67 operate against washers  
69 and urge valve rods 58 toward the open position.

5 Each of the rods 58 is connected to a vacuum  
pulloff 74, 76, through connectors 58. These vacuum  
motors operate, as will be explained, to seat the  
tapered plugs 64, 65 against seats 54, 56 under  
appropriate operating conditions. These devices are  
well known and commercially available from F&B Mfg.  
10 Co., Catalogue No. 30-3. F&B Mfg. Co. is located  
at 4248 West Chicago Avenue, Chicago, Illinois.

Vacuum pulloff 74 is connected via conduit  
79 to the port 81 in venturi or throat of carburetor  
10. Port 81 is located as would be a vacuum advance  
15 port in the throat of a carburetor. It is positioned  
upstream of the butterflies 15 such that when the  
throttle is closed and butterflies 15 are positioned  
as shown in FIGURES 1 and 6, the butterflies are between  
the port 81 and the intake manifold. When the butterflies  
20 are moved to an open position, port 81 is exposed  
to intake manifold vacuum and the flow of air through  
the throat 14.

Conduit 79 senses ported vacuum, that is,  
vacuum created as a result of flow of air through  
25 the venturi flowing over port 81 and operates to pull  
rod 58 of idle fuel valve 42 closed when there is  
sufficient air flow through the carburetor throat.  
This occurs when the engine is operating other than  
at idle conditions. At idle, the ported vacuum orifice  
30 81 is blocked or disposed above the butterfly and

1 it does not experience the intake manifold vacuum  
below the butterfly 15. Hence, there is no flow  
across it and no ported vacuum. Spring 67 urges valve  
42 open. Vacuum pulloff 74 is sized such that upon  
5 experiencing a ported vacuum in excess of about 4-  
6 inches of mercury, it will operate against spring  
67 and close idle valve 42.

It should be understood that vacuum is a  
negative valve. That is, a vacuum near zero, measured  
10 in inches of mercury, is a smaller or lesser vacuum  
than a vacuum of 4 or 10 inches of mercury.

Vacuum pulloff 76 is connected via conduit  
80 to the intake manifold 82 of the engine incorporating  
the supplemental fuel delivery system. It senses,  
15 and responds to, manifold vacuum to pull the valve  
rod 58 of acceleration fuel valve 44 closed when  
manifold vacuum exists, such as during idle and cruise  
operation. Vacuum pulloff 76 is sized such that upon  
experiencing an intake manifold vacuum in excess of  
20 about 4-6 inches of mercury, it operates against  
spring 67 to close acceleration fuel supply valve  
44.

Discharge port or passage 50 of idle fuel  
valve 42 communicates through conduit 83 to normally  
25 closed idle solenoid valve 84. Discharge port or  
passage 52 of acceleration fuel valve 44 communicates  
through conduit 86 to normally closed acceleration  
solenoid valve 88. These valves then communicate  
through conduit 90 to gaseous fuel inlet tube 16 in  
30 carburetor 10. The solenoid valves may be Skinner

1 #BZ DA 1052 valve or like valves from other sources.  
Skinner valves are made by Skinner Electric Valve Co.,  
New Britain, Connecticut.

5 Microswitch 92, as best seen in FIGURE 4,  
is mounted upon bracket 93 connected to body 35 of the  
supply valve means 34. It is a two position electrical  
switch with contacts A and B which may be alternately  
energized. A suitable switch is a UNIMAX 3TMT 15-4  
available from G-C Electronics, Rockford, Illinois.  
10 It senses the position of washer 69 of acceleration  
valve 44 to operate the switch between contacts A and  
B and alternately supply power to solenoids 88 and 84.  
As shown in FIGURE 4, bracket 93 is attached to the  
body 35 with bolts 97 received in slotted holes 99.  
15 This permits vertical adjustment of the switch for  
purposes as will be explained. Also, in the illustrated  
embodiment solenoids 84 and 88 are normally closed valves;  
that is, they are closed when de-energized. As can  
be appreciated, appropriate circuit modification could  
20 readily be accomplished and normally open valves used.

At idle, vacuum pulloff 76 experiences high  
vacuum in the range of 15-17 inches of Mercury. This  
holds valve 44 closed and seats plug 65 against seat  
56. Feeler 94 of switch 92 senses the closed position  
25 of valve 44 and as illustrated by the schematic of  
FIGURE 2, connects with contact B to make power  
available to idle solenoid 84 which opens conduit 83  
to conduit 90. At the same time, solenoid 88 is de-  
energized. This closes conduit 86 from conduit 90 to  
30 preclude any flow of gaseous fuel through acceleration

1 valve 44 during idle, even if plug 65 is not tightly  
sealed against seat 56.

When intake manifold vacuum drops below 4-  
6 inches of mercury, such as during conditions of  
5 acceleration, spring 67 of valve 44 moves plug 65 away  
from seat 56. Feeler 94 senses the lower position of  
rod 58 of that valve and in accordance with the circuit  
of FIGURE 2, makes contact at A. Power is no longer  
available to solenoid 84 which opens and blocks possible  
10 flow of gaseous fuel through conduit 83 to conduit 90.  
Contact A energizes solenoid 88 which permits passage  
of gaseous fuel through conduit 86 to conduit 90.

When operating at a stable or steady state  
condition above idle, both pulloffs 84 and 76 experience  
15 sufficient vacuum to close respective valves 42 and  
44 so that no gaseous fuel is supplied to the carburetor  
10. Also, the closed position of valve 44 is sensed  
by switch 92 to close solenoid 88, though this action  
does again make power available to solenoid 84.

20 To insure operation of the idle fuel supply  
valve 42 only at idle conditions, a second microswitch  
95 is positioned upon carburetor 10 to sense the position  
of the throttle linkage. A UNIMAX #2HB113-1 is a suitable  
switch for this application. As best seen in FIGURE  
25 7, normally open microswitch 95 is positioned on a  
bracket 96 with actuator arm 98 disposed to contact  
throttle linkage 100. Movement of linkage 100 away  
from idle as shown by arrow 102 causes linkage 100 to  
move away from actuator 98 and open microswitch 95.  
30 Switch 95 is connected in series with switch 92 and

1 and solenoid 84 as shown in FIGURE 2.

Starting is initiated by cranking with any suitable cranking motor. This develops sufficient engine oil pressure to close switch 39 to connect the electric circuit to the battery 41. The normally closed solenoid valve 38 is energized and gaseous fuel is made available to the supply valve means 34.

Starting normally requires more air flow into the engine than is available with a closed throttle, so throttle linkage 100 is operated to at least partially open butterfly 15. This permits air to enter the intake manifold 82 through venturi 14, which draws gasoline through main jet 17. Throttle movement also supplies gasoline for starting through conventional accelerator pumps (not shown) in the carburetor.

At the commencement of engine start-up, both vacuum pulloffs 74 and 76 experience zero vacuum and, hence, valves 42 and 44 are open across the orifice seats 54 and 56. The open position of valve 44 positions switch 92 such that contact A is converted to the power source and power is supplied only to solenoid 88. Some gaseous fuel, therefore, is at least initially supplied on startup through the acceleration valve 44.

After the engine starts, sufficient intake manifold vacuum develops, i.e., 4-6 inches of mercury, and pulloff 76 closes valve 44. This causes switch 92 to close contact B and open contact A to supply power to solenoid 84 and de-energize solenoid 88. Gaseous fuel flow through valve 44 is terminated.

30 Additionally, there is no flow through valve 42, even

1        though electrical energy is available to solenoid 84  
because switch 95 is open during starting as a result of  
the open position of throttle butterfly 15. Once the  
engine starts, flow of air through venturi 14 creates  
5        sufficient ported vacuum, i.e., 4-6 inches of mercury,  
at port 81 of conduit 79 to close valve 42. Also, throttle  
linkage 100 is in other than the idle position and switch  
94 remains open.

10        Placement of the throttle in the idle position,  
as illustrated in the drawings, severely restricts air  
flow into the engine. This air flow passes through the  
slight annulus between throats 14 and butterflies 15, or  
through holes drilled in the butterflies for that purpose.  
Throttle plates 15 are nearly against screws 20 in the  
15        shortened transition slots 22. The open portions 23 are  
above the butterflies. No fuel enters through the  
shortened slots.

20        Restricted flow causes loss of ported vacuum,  
i.e., to less than 4 inches of mercury. Intake manifold  
vacuum increases substantially to the range of 17-18 inches  
of mercury. Pulloff 74 no longer operates against spring  
67 and, therefore, the valve 42 opens permitting flow  
across orifice seat 54 into conduit 83. At the same time,  
pulloff 76 operates against spring 67 to close valve 44.  
25        Switch 92 senses the closed position of the valve and  
connects electrical power to contact B, energizing and  
opening solenoid 84 and closing solenoid 88.

30        Linkage 100 is in the idle position and, therefore,  
switch 95 is also closed, which permits the closure of  
contact B of switch 92 to energize and open solenoid 84.

1 Gaseous fuel is permitted to flow into the carburetor  
through conduit 90 and inlet tube 16.

5 Modified transition slots permit elevation of  
the power level of the engine from idle without lag or  
sudden drop in engine output. As butterfly valve 15 is  
opened, the shortened portions 23 of the slots are  
exposed to intake manifold vacuum and the air flowing  
through venturi 14 draws gasoline from the reduced size  
transition slot. Also, as the butterfly 15 open above  
10 the port 81, it is exposed to intake manifold vacuum.  
Also, air flow past butterfly 15 increases. These  
factors increase ported vacuum and commence closure of  
gaseous idle fuel valve 42. As throttle linkage is moved  
from idle, switch 95 opens and de-energizes solenoid 84,  
15 further insuring termination of gaseous fuel supply  
through conduit 83. Transition slots 23, however, permit  
gasoline flow as soon as butterfly 15 are moved above  
the set screws 20. This opens slots 23 to intake manifold  
vacuum and allows liquid fuel to be delivered simultaneously  
20 with, or immediately prior to termination of idle gaseous  
fuel supply.

Under normal load, butterfly 15 are open to  
a position dependent on load requirements. Air flow  
through venturi 14 creates sufficient ported vacuum, i.e.,  
25 over 4-6 psig. inches of mercury, to cause pulloff 74  
to hold valve 42 closed. There is also sufficient intake  
manifold vacuum, i.e., in excess of 4-6 inches of mercury,  
to cause pulloff 76 to hold valve 44 closed. Electrically,  
switch 92 closes contact B, thus de-energizing solenoid  
30 88 and making power available to solenoid 84. Throttle

1 linkage 100, however, is out of the idle position.  
Hence, switch 95 is open and solenoid 84 remains de-  
energized. Under These conditions, fuel is supplied  
solely in liquid form through carburetor 10.

5 On acceleration, throttle 100 is operated to  
further open butterfly 15. This results in a loss of  
intake manifold vacuum. As that parameter reduces to  
4-6 inches of mercury or less, vacuum pulloff 74 no  
longer is capable of holding valve 44 closed against  
10 the action of spring 67. As valve 44 opens, switch 92  
operates to contact A and energize solenoid 88. Solenoid  
84 is disconnected from the source of power and is  
therefore closed.

Opening of valve 44 permits gaseous fuel to  
15 pass between orifice valve seat 56 and plug 65 into passage  
or conduit 86. Since solenoid 88 is open, gaseous fuel  
is permitted to flow into conduit 90 and delivery tube  
16 to supplement gasoline drawn into carburetor 10 through  
jet 17. Use of gaseous fuel to supplement gasoline under  
20 acceleration is advantageous because gaseous fuel is of  
a higher octane and enrichens the total fuel mixture using  
less fuel than if operated on liquid fuel alone.

Once steady state load conditions are reached,  
throttle butterflies 15 are moved toward a more closed  
25 position and intake manifold vacuum again exceeds 4-6  
inches of mercury. This closes valve 44 to shut-off  
acceleration gaseous fuel supply. Also, this movement  
operates switch 92 to contact B, de-energizing solenoid 88.  
Since throttle linkage 100 is not in the idle position,  
30 switch 95 causes solenoid 84 to remain de-energized and

1 no gaseous fuel is supplied to the engine until a  
condition of idle or acceleration is re-established.

It has been determined that under certain  
conditions of light acceleration intake manifold vacuum  
5 does not fall below the minimum at which spring 67 of  
valve 44 can fully override pulloff 76. At the same  
time, ported vacuum may also drop with the possibility  
that valve 42 may move slightly open.

Microswitch 92 is mounted on body 35 by bracket  
10 93 such that it may be adjusted vertically. In this way  
it may be adjusted to respond to different positions of  
washer 69 dependent upon operating characteristics desired.  
Positioning of switch 92 vertically with respect to valve  
44 dictates when switch 92 will close contact A, and,  
15 hence, energize solenoid 88 and de-energize solenoid 84.  
This switch may be positioned to respond to slight movement  
of rod 58, or may be moved vertically lower to respond  
only when the valve rod has nearly reached the end of its  
opening travel. If positioned in its vertically upward  
20 maximum location, it will respond to movement of valve  
stem 58 of valve 44 as soon as intake manifold vacuum begins  
to reduce below 4-6 inches of mercury, which represents  
the commencement of opening of plug 65 from seat 56. If  
positioned at the vertically lowermost position, it will  
25 not sense movement of valve rod 58 by spring 67 until the  
annulus between plug 65 and seat 56 is fully open. This  
would, for example, require reduction of intake manifold  
vacuum to 2-3 inches of mercury. In this way, opening of  
solenoid 88 can be controlled to occur at a predetermined  
30 desired condition of acceleration.

1                    Various features of the present invention have,  
                     hence, been disclosed in connection with the illustrated  
                     embodiments of the present invention.  However, numerous  
                     modifications may be made without departing from the  
5                    spirit and scope of the invention as defined by the appended  
                     claims.

                     //  
                     //  
                     //  
10                   //  
                     //  
                     //  
                     //  
                     //  
                     //  
15                   //  
                     //  
                     //  
                     //  
                     //  
20                   //  
                     //  
                     //  
                     //  
                     //  
25                   //  
                     //  
                     //  
                     //  
                     //  
30                   //

CLAIMS

## WE CLAIM:

1. A gaseous fuel delivery system for an internal combustion engine normally operable on liquid fuel, the combination comprising:

a.) idle delivery means responsive to engine operating conditions to supply gaseous fuel to said engine when said engine is operating at idle;

b.) acceleration delivery means responsive to engine operating conditions to supply gaseous fuel to said engine when said engine is accelerating;

c.) conduit means communicating said idle and acceleration delivery means to a source of gaseous fuel and to said engine.

2. A gaseous fuel delivery system as claimed in Claim 1 wherein said system includes:

a.) means responsive to ported vacuum created by flow of air into said engine to open and close said idle delivery means;

b.) means responsive to the vacuum in the intake manifold of said engine to open and close said acceleration delivery means.

3. A gaseous fuel delivery system for an internal combustion engine as claimed in Claim 1 wherein said system includes:

means closing communication from said idle

1 delivery means to said conduit to the engine  
when said acceleration delivery means is open,  
and opening communication from said acceleration  
delivery means to said conduit to the engine  
5 said means further opening communication from  
said idle delivery means to said conduit to  
the engine when said acceleration delivery means  
is open and closing communication from said  
acceleration delivery means to said conduit  
10 to the engine.

4. A gaseous fuel delivery system as claimed  
in Claim 1 wherein said idle delivery means includes  
an idle fuel delivery valve and said acceleration  
delivery means includes an acceleration fuel delivery  
15 valve.

5. A gaseous fuel delivery system as claimed  
in Claim 4 wherein said system includes:  
a vacuum pulloff connected to said idle fuel  
delivery valve responsive to ported vacuum  
20 created by flow of air into said engine to  
open and close said idle delivery means and  
a vacuum pulloff connected to said acceleration  
fuel delivery valve responsive to intake  
manifold vacuum of said engine to open and  
25 close said acceleration delivery valve.

6. A gaseous fuel delivery system as claimed  
in Claim 5 wherein said system includes:  
a.) an idle solenoid valve intermediate  
said idle delivery valve and said  
30 engine;

- 1                   b.) an acceleration solenoid valve in-  
intermediate said acceleration delivery  
valve and said engine; and
- 5                   c.) means responsive to the opening and  
closing of said acceleration delivery  
valve to open said acceleration solenoid  
valve and close said idle solenoid valve  
when said acceleration delivery valve  
is open and to close said acceleration  
10                   solenoid and open said idle solenoid  
when said acceleration delivery valve  
is closed.

7. A gaseous fuel delivery system as claimed  
in Claim 6 wherein said system further includes means  
15                   responsive to the position of the throttle of said  
engine to permit opening of said idle solenoid valve  
only when said engine throttle is at the idle position.

8. A gaseous fuel delivery system as claimed  
in Claim 7 wherein said means responsive to the opening  
20                   and closing of said acceleration delivery valve and  
said means responsive to the idle position of said  
throttle of the engine are electrical switches  
connected to said solenoid valves and adapted to connect  
to a source of electrical power.

9. A gaseous fuel delivery system for an  
25                   internal combustion engine as claimed in Claim 5  
wherein said vacuum pulloff connected to said idle fuel  
delivery valve opens said valve when the ported vacuum  
is about 4 to 6 inches of mercury or less.

30                   10. A gaseous fuel delivery system for an

1 internal combustion engine as claimed in Claim 5 wherein  
said vacuum pulloff connected to said acceleration fuel  
delivery valve opens said valve when said engine intake  
manifold vacuum is about 4 to 6 inches of mercury or  
5 less.

11. A gaseous fuel delivery system as claimed  
in Claim 10 wherein said vacuum pulloff connected idle  
fuel delivery valve opens said valve when the ported  
vacuum is about 4 to 6 inches of mercury or less, and  
10 said vacuum pulloff connected to said acceleration fuel  
delivery valve opens said valve when said engine intake  
manifold vacuum is about 4 to 6 inches of mercury or  
less.

12. A gaseous fuel delivery system for an  
15 internal combustion engine, operable on liquid fuel,  
comprising:

- a.) a supply of gaseous fuel under pressure;
- b.) a gaseous fuel delivery valve means  
having:
  - 20 (1) an idle fuel delivery valve;
  - (2) an acceleration fuel delivery  
valve;
- c.) means responsive to engine operation  
to control opening and closing of  
25 said fuel delivery valve means including:
  - (1) means responsive to ported vacuum  
to open and close idle fuel delivery  
valve;
  - (2) means responsive to intake manifold  
30 vacuum to open and close acceleration

1

fuel delivery valve;

5

d.) Conduit means communicating said gaseous fuel from said supply to said delivery valve means and from each said idle fuel delivery valve and acceleration fuel delivery valve to said engine;

10

e.) electrically operable solenoid valve means arranged for alternate opening and closing comprising:

(1) idle solenoid valve means adapted to open and close said conduit means from said idle fuel delivery valve to said engine;

15

(2) acceleration solenoid valve means adapted to open and close said conduit means from said idle fuel delivery valve;

20

said means responsive to engine operation further including switch means to alternately open one said solenoid valve means and close the other thereof in response to opening and closing of said acceleration fuel delivery valve, said switch means opening said acceleration solenoid valve when said acceleration fuel delivery valve is open, closing said idle solenoid valve and, opening said idle solenoid valve when said acceleration fuel delivery valve is closed, said closing acceleration solenoid valve.

25

30

13. A gaseous fuel delivery system for an internal combustion engine as claimed in Claim 12 including solenoid valve means, interposed in said conduit from said supply to said delivery valve means and switch means responsive to oil

1 pressure in said engine to operate said solenoid valve means to  
permit gaseous fuel flow only when oil pressure exists in said  
engine.

5 14. A gaseous fuel delivery system for an internal  
combustion engine as claimed in Claim 12 further including  
idle switch means responsive to the position of the throttle  
of said engine to permit opening of said idle fuel delivery  
valve only when said throttle is in the idle position, closing  
said valve when said throttle is other than at the idle position.

10 15. Gaseous fuel delivery system for an internal  
combustion engine as claimed in Claim 14 wherein said:

idle fuel delivery valve and said acceleration  
fuel delivery valve each include an orifice  
defining valve seat,

15

a slidable rod having a plug at one end thereof  
surrounded by said valve seat to define a  
flow orifice therebetween, each said rod  
being movable engaging said plug with said  
orifice seat to close said valve.

20

16. A gaseous fuel delivery system for an  
internal combustion engine as claimed in Claim 15 wherein  
said idle fuel delivery valves include means urging said plug  
to an open position, and a vacuum pulloff connected to sense  
ported vacuum to close said valve when said ported vacuum  
25 exceeds a predetermined minimum, allowing said valve to open  
when said ported vacuum falls below said predetermined  
minimum.

30 17. A gaseous fuel delivery system for an internal  
combustion engine as claimed in Claim 15 wherein said

1 acceleration fuel delivery valve includes means urging said  
plug to an open position, a vacuum pulloff connected to sense  
intake manifold vacuum to close said valve when said intake  
manifold vacuum exceeds a predetermined minimum, allowing said  
5 valve to open when said ported vacuum falls below said  
predetermined minimum.

18. A gaseous fuel delivery system for an internal  
carburetor engine as claimed in Claim 16 wherein gaseous fuel  
is supplied to said fuel delivery valve means at from 1 1/2  
10 to 2 pounds per square inch and said orifice defined by said  
idle fuel delivery valve is equivalent in size to a circular  
opening housing a diameter of .040 to .070 inches.

19. A gaseous fuel delivery system for an internal  
combustion engine as claimed in Claim 17 wherein gaseous fuel  
15 is supplied to said gaseous fuel delivery valve means at  
from 1 1/2 to 2 pounds per square inch and said flow orifice  
defined by said acceleration fuel delivery valve is equivalent  
in size to a circular opening having a diameter of .060 to  
.080 inches.

20 20. A gaseous fuel delivery system as claimed in  
Claim 16 wherein said pulloff closes said idle fuel delivery  
valve when ported vacuum exceeds 4-5 inches of mercury.

21. A gaseous fuel delivery system as claimed in  
Claim 17 wherein said pulloff closes said acceleration fuel  
25 delivery valve when said intake manifold vacuum exceeds  
4-6 inches of mercury.

//

//

//

30

//

1

ABSTRACT

A gaseous fuel delivery system for a gasoline  
5 engine having a gaseous fuel delivery valve means  
comprising an idle fuel delivery valve and an  
acceleration fuel delivery valve. Means responsive  
to air flow through the carburetor throat controls  
operation of the idle fuel delivery valve. Means  
10 responsive to intake manifold vacuum controls operation  
of the acceleration fuel delivery valve. Electrically  
operable alternately open idle and acceleration solenoid  
valves are interposed in separate delivery conduits  
from the idle and acceleration fuel delivery valves.  
15 Means responsive to the opening of the acceleration  
fuel delivery valve opens the acceleration solenoid  
valve and closes the idle solenoid valve, reversing  
the respective valve positions on closing of the  
acceleration fuel delivery valve. An idle switch  
20 responsive to idle position of the throttle prevents  
opening of the idle solenoid valve except when the  
throttle is in the idle position.

The engine carburetor is arranged such that  
no gasoline is delivered for idle operation. Idle  
25 needle valves are closed, or eliminated. Transition  
slots are sized to be operational only as the throttle  
moves from the idle position and supply no fuel when  
the throttle is at idle.

//

30

//

with full power of substitution and revocation, to prosecute this application  
and to transact all business in the Patent and Trademark Office connected  
therewith.

I hereby declare that all statements made herein of my own knowledge  
are true and that all statements made on information and belief are believed to  
be true; and further that these statements were made with the knowledge that  
willful false statements and the like so made are punishable by fine or imprison-  
ment, or both, under Section 1001 of Title 18 of the United States Code and that  
such willful false statements may jeopardize the validity of the application or  
any patent issued thereon.

First inventor SCOTT VENNING

Signature *Scott Venning*

Date 8-12-82

Residence 617 S. Busse Road, Mt. Prospect, Illinois 60056

Citizenship United States

Address 617 S. Busse Road

Mt. Prospect, Illinois 60056

Second joint inventor DENNIS DISCOUNT

Signature *Dennis Discount*

Date Sept 5, 1982

Residence RT106, Jericho, New York 11753

Citizenship United States

Address RT106, Jericho, New York 11753

Third joint inventor \_\_\_\_\_

Signature \_\_\_\_\_

Date \_\_\_\_\_

Residence \_\_\_\_\_

Citizenship \_\_\_\_\_

Address \_\_\_\_\_

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE  
DECLARATION AND POWER OF ATTORNEY

42

As a below named inventor; I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the invention entitled:

GASEOUS FUEL DELIVERY SYSTEM

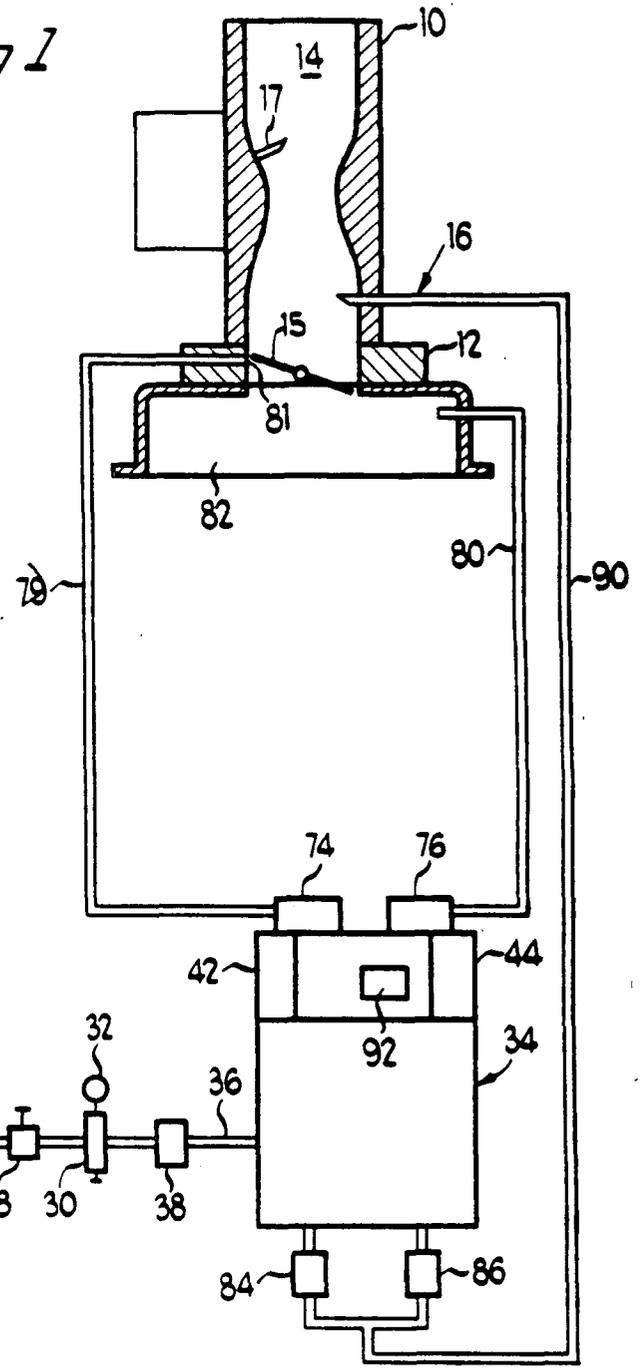
---

described and claimed in the attached specification; that

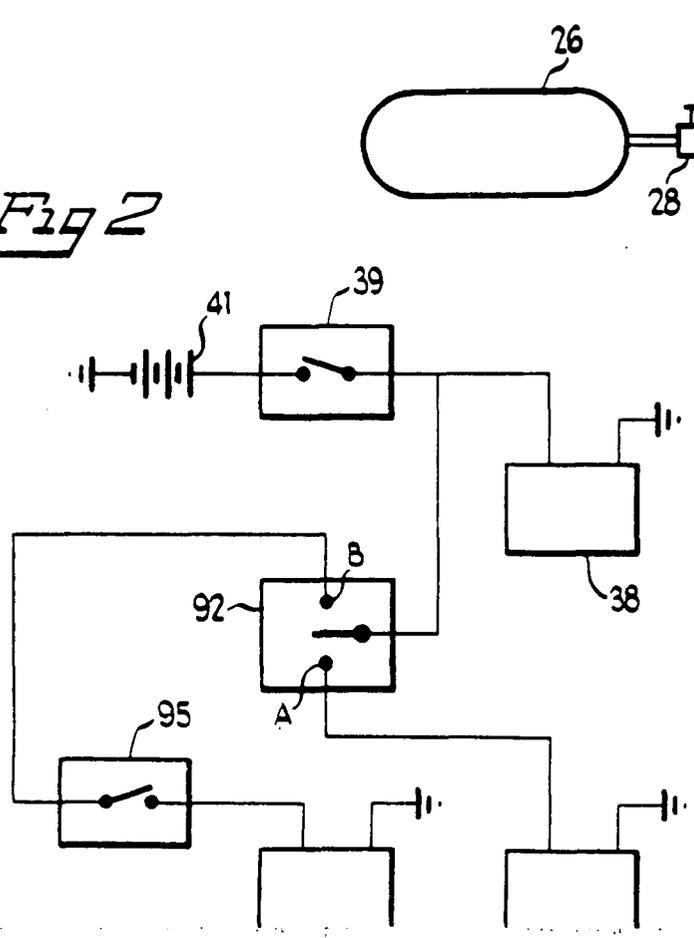
I do not know and do not believe that the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application, that I acknowledge my duty to disclose information of which I am aware which is material to the examination of this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows:

And I hereby appoint Robert V. Jambor, Registration No. 23,080, Dorsey L. Baker, Registration No. 24,888, Comer W. Walters, Registration No. 22,370 and Jay G. Taylor, Registration No. 25,799, whose address is Haight, Hofeldt, Davis & Jambor, 3614 Mid Continental Plaza, 55 East Monroe Street, Chicago, Illinois 60603, telephone number (312) 263-2353, my attorneys or agents

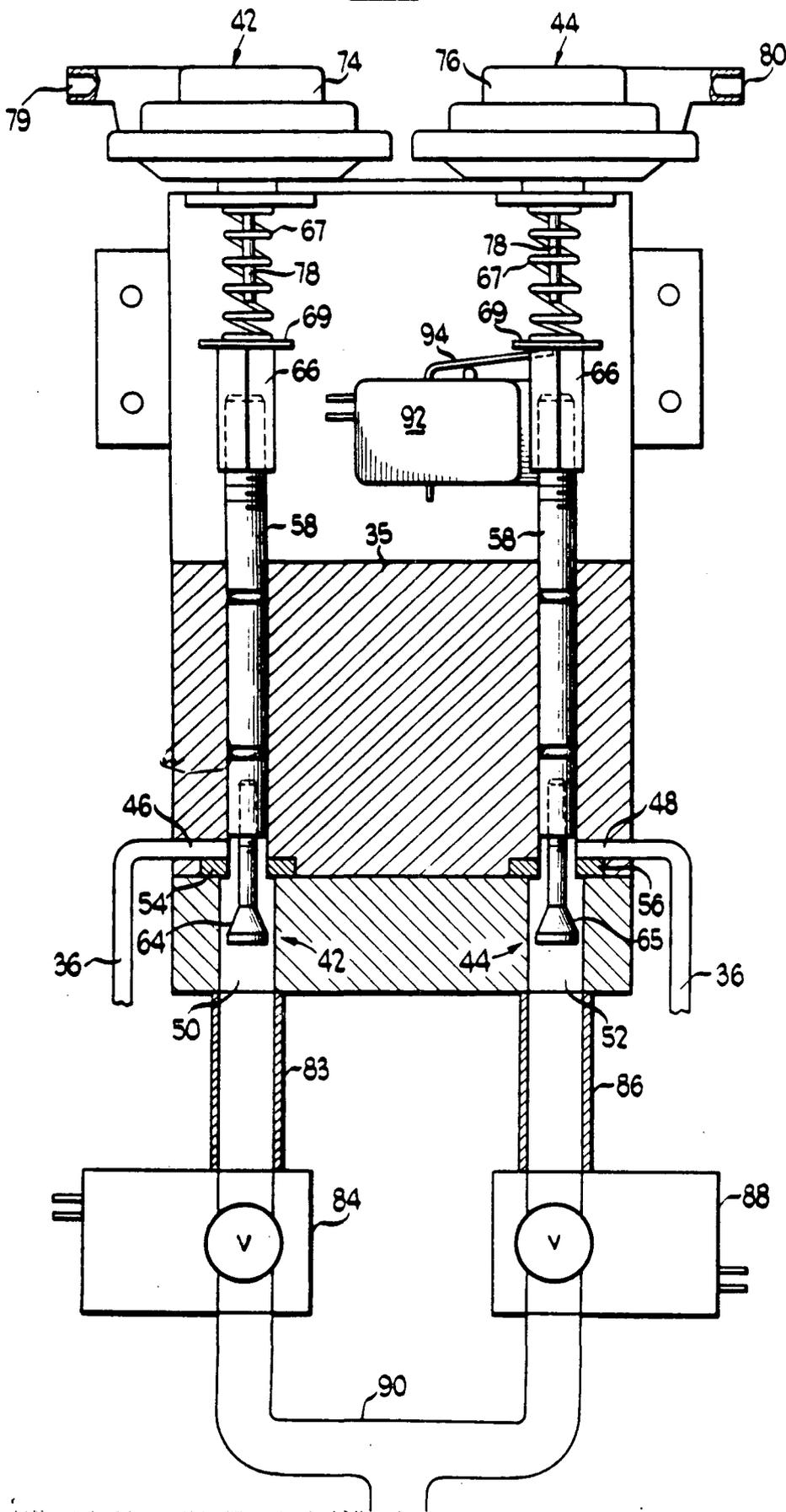
*Fig 1*



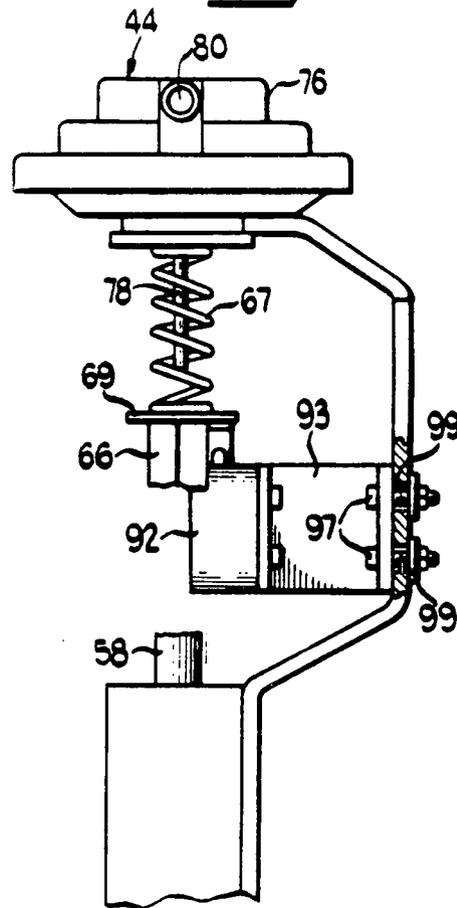
*Fig 2*

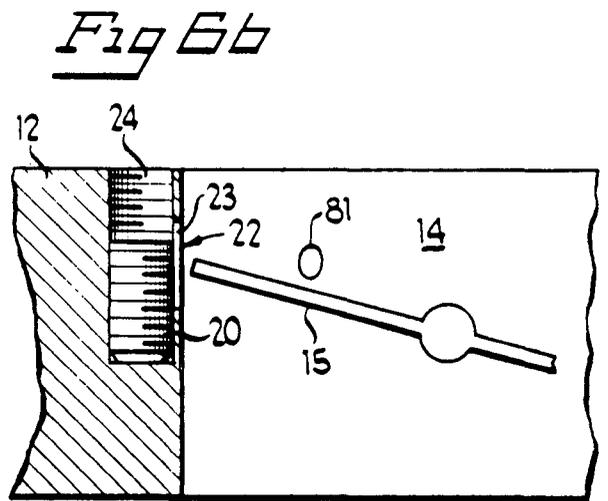
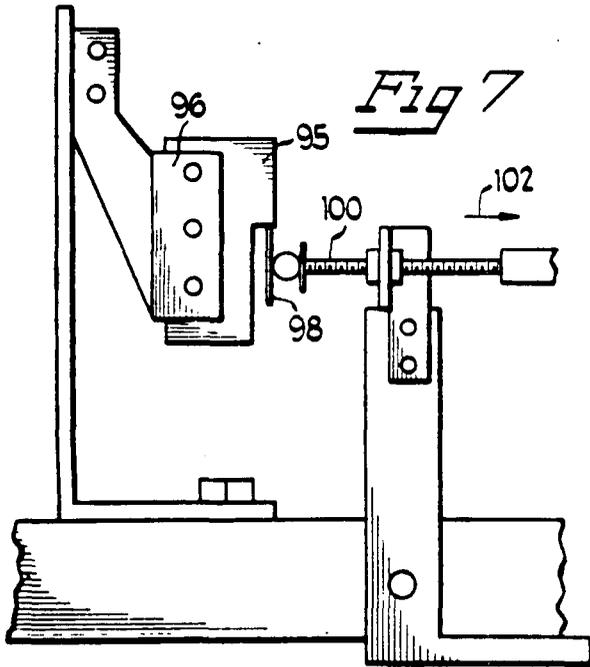
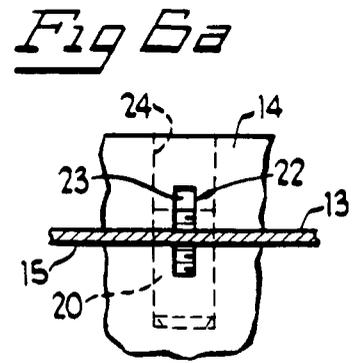
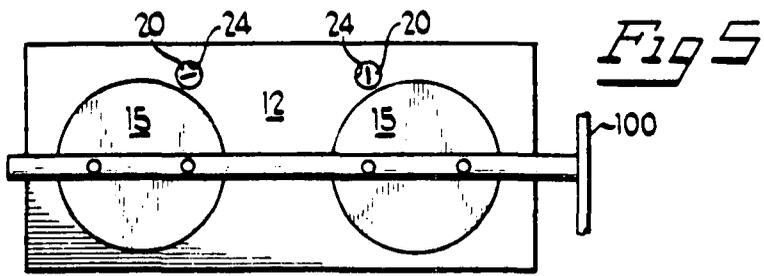


*Fig 3*



*Fig 4*





## Major Components of the VCD Device

## 1. Description of Metering Unit:

"(Fig. 1) Propane enters metering unit (#20). On idle requirements, idle vacuum pulloff (connected to ported vacuum) is allowing tapered needle valve (#21) to be opened, allowing propane to travel thru idle solenoid (#2) then into carburetor. At the same time, micro switch (#27) is electronically closing accel solenoid (#16) and keeping idle solenoid (#2) open. Entering cruising stage of vehicle, ported vacuum develops, pulling idle vacuum pulloff closed, in turn, closing tapered needle valve (#21) idle side. Upon acceleration, accel vacuum pulloff, losing manifold vacuum, opens tapered needle valve (#22) accel side, allowing propane to pass thru accel solenoid (#16) then into carburetor. Meanwhile, micro switch (#27) electronically shuts off idle solenoid (#2) and opens accel solenoids (#16). If returning to idle mode, manifold vacuum will come up, closing accel side and ported vacuum will drop, opening idle side. Simultaneously, (electronically thru micro switch #27) idle solenoid will open and accel will close.

## 2. Idle Switch Description:

"(Fig. 6) During moderate acceleration the vacuum may fall to 8" - 4". The vacuum pulloff will start opening at 4" - 6". If the vacuum does not fall to 4" or below, accel side will not open fully and activate micro switch. In this condition, idle side and accel side are slightly open, but since the micro switch only opens and closes solenoids opposite of each other, the idle solenoid is open and propane will flow until vacuum falls below 4" and opens accel side completely, causing micro switch to open accel solenoid and closing idle side.

"If vacuum was regained instead of falling, it would close both vacuum pulloffs.

"The idle switch keeps the idle solenoid closed by throttle position, solving the problem of moderate accelerating conditions not fully opening accel side.

"The micro switch on the unit is adjustable in location. To raise switch, propane would flow sooner under accel conditions (opening solenoid sooner). To lower switch, would delay propane to more extreme conditions. The lower the switch is located, [the more] the idle switch becomes a necessity. If the micro switch is lowered, the vacuum pulloffs can open farther when low vacuum conditions occur [thereby] not allowing micro switch to be activated."

### 3. Carburetor Modifications:

"(Fig. 4 & 5) Idle circuit must be closed off only allowing a portion of the transition slot to be used. Propane inlet can be installed in carburetor throttle bore, thru manifold or base plate. Idle switch must be installed and able to be adjusted for near closed throttle position. Power valve must be eliminated and main jetting should be made to adjust for leaner conditions."

### 4. General:

"(Fig. 1) For idle mixture, tapered needle valve (#21) idle side, is adjustable by threaded shaft and locking nut (#25). Power to unit is run thru an oil pressure switch so propane cannot flow without engine running with oil pressure. If engine died and [the] key [is] left on, oil pressure would drop, cutting off propane to eliminate an unsafe condition. Micro switch (#27) is adjustable for synchronizing idle and accel solenoids."

### 5. Variations of System:

- a. System V-1: "Mechanical system, idles on propane, cruises and accelerates on gasoline."

"Standard carburetor with propane idle circuit only. Carburetor preparation includes idle switch, transition slot modifications and propane inlet. Metering device using only idle side. This system uses standard functions of carburetor except for the economic advantage of idling only with propane."

"This system uses a switch to activate an electronic solenoid with reference to throttle location. The solenoid has removable jets to adjust the volume of propane."

"When the throttle is closed, the switch electronically opens the solenoid. As the throttle is brought off of the idle position, the switch closes the solenoid cutting off the propane and resumes on gasoline like a conventional carburetor."

"This system uses the following items:

- Pressure Tank
- Shut Off
- Safety Switch - Activated by Oil Pressure
- Fuel Line
- Electronic Solenoid
- Jet
- Micro Switch
- Modified Carburetor
- Idle Switch

Modified Transition Slots  
Propane Entry Tubes"

b. Metering Unit for V-2 and V-3

"This unit will give the same results as original unit but is greatly simplified. Using adjustable vacuum switches in place of vacuum pull-offs, the vacuum requirements can be adjusted. As far as metering propane, moving needles and seats are replaced with jets and can be changed for desired orifices. Solenoids control propane flow and are activated electronically by vacuum switches."

c. System V-2

"Vacuum system, idles on propane, cruises and accelerates on gasoline.

"This system uses a vacuum switch that is adjustable for vacuum requirements. This switch is connected to ported vacuum. When the throttle is closed, there is no vacuum going to the vacuum switch, so the vacuum switch produces a closed circuit, opening the electronic solenoid letting propane into the carburetor. As the throttle is opened, ported vacuum arrives to the vacuum switch, opening the circuit, closing the electronic solenoid. The propane is cut off and the carburetor proceeds to the conventional gasoline operation.

"The idle switch (micro switch) is used on this system because, under load, the vacuum drops and will open the solenoid. The idle switch lets the system be operational only under near-closed throttle position letting the system operate only when idling.

"The system using the vacuum rather than a mechanical means is a more accurate method.

"This system uses the following items:

- Pressure Tank
- Shut Off
- Regulator
- Safety Switch - Activated by Oil Pressure
- Fuel Line
- Adjustable Vacuum Switch
- Electronic Solenoid
- Jet
- Micro Switch
- A body with passages on which to mount vacuum switch and solenoid.

Modified Carburetor  
 Idle Switch  
 Modified Transition Slots  
 Propane Entry Tubes"

d. System V-3

"Vacuum system, idles on propane, cruises on gasoline, accelerates on propane and gasoline.

"This system used the same principle to idle. For acceleration the power valve in the carburetor is bypassed and a second stage is added to the system. This requires another vacuum switch and solenoid.

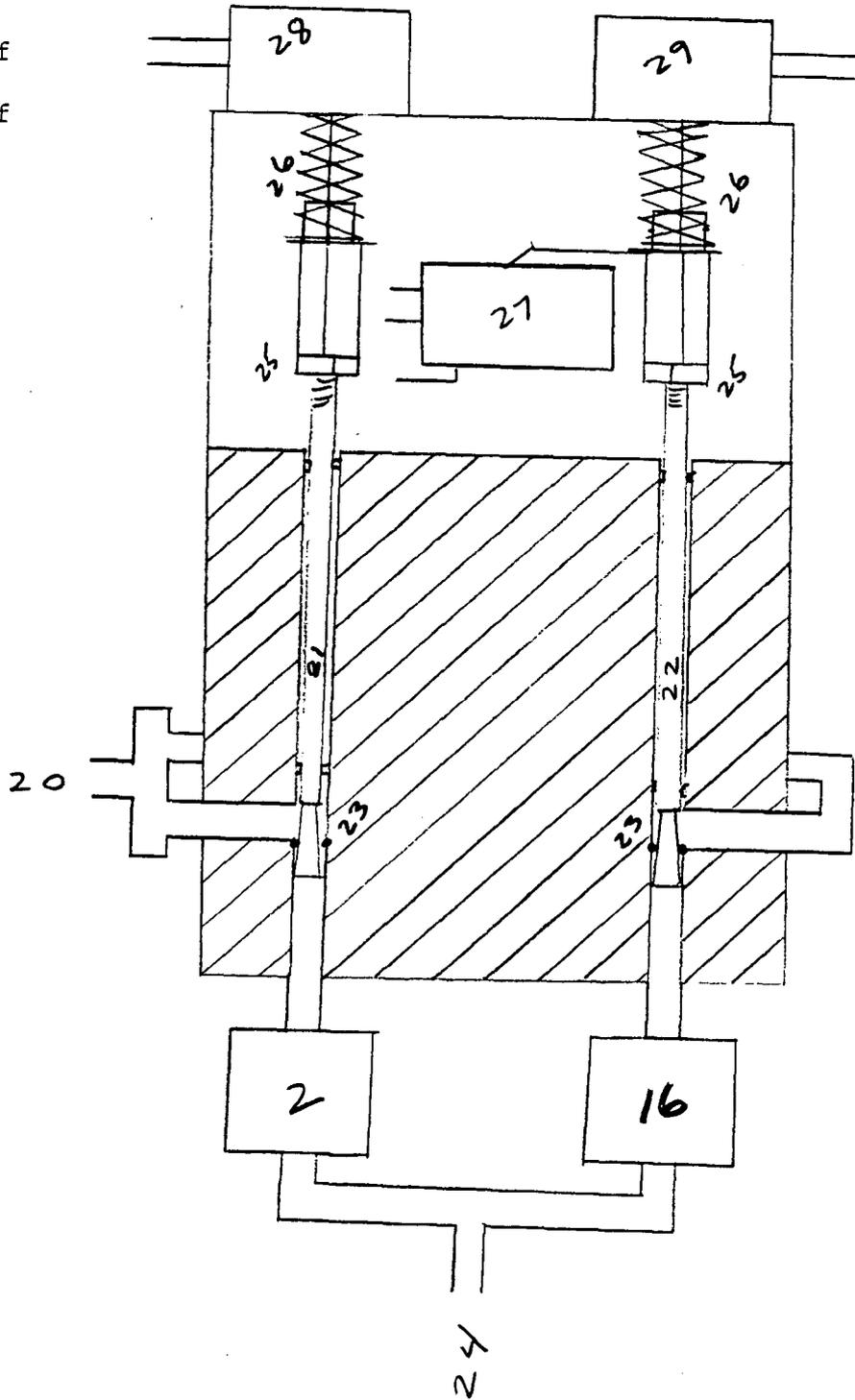
"The accel side of the system runs off of manifold vacuum. When the load requirements of the engine become greater and the vacuum falls to 4", the vacuum switch opens the accel solenoid which is jetted also, and delivers propane to the already present gasoline mixture to enrichen the mixture acting as a power valve. Less fuel can be used this way because the propane added to the gas mixture has higher octane than a conventional system.

"This system uses the following items:

Pressure Tank  
 Shut Off  
 Regulator  
 Safety Switch - Activated by Oil Pressure  
 Fuel Line  
 2 - Adjustable Vacuum Switches  
 2 - Electronic Solenoids  
 2 - Jets  
 Micro Switch  
 A body with passages on which to mount vacuum switches and solenoids.  
 Modified Carburetor  
 Idle Switch  
 Modified Transition Slots  
 Propane Entry Tubes  
 Plugged Power Valve and Power Circuit"

- 2- Idle Solinoid
- 16- Accel Solinoid
- 20- Propane Inlet
- 21- Tapered Valve (idle side)
- 22- Tapered Valve (accel side)
- 23- Seat
- 24- Propane Supply to Carb
- 25- Locking Nut
- 26- Spring
- 27- Micro Switch
- 28- Vacuum Pulloff (idle side)
- 29- Vacuum Pulloff (accel side)

FIG. 1



(NO FIGURE 2 WAS PROVIDED)

FIG. 3

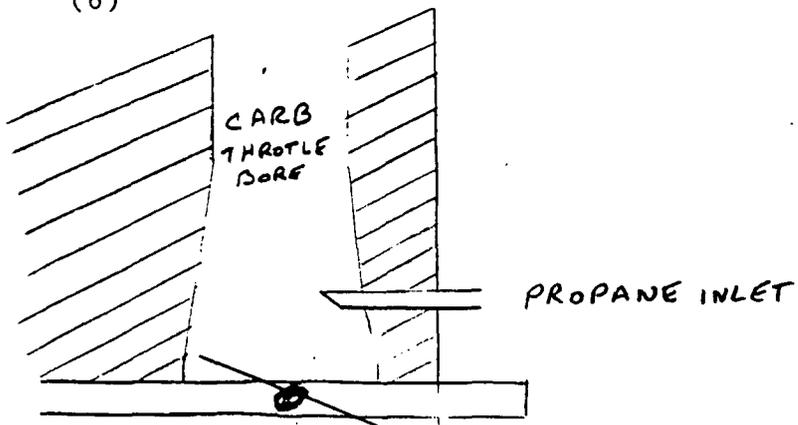


FIG. 4

TOP VIEW  
BASE PLATE

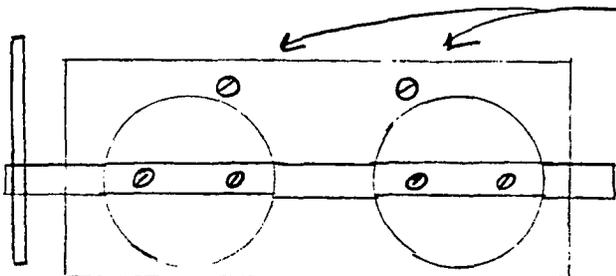
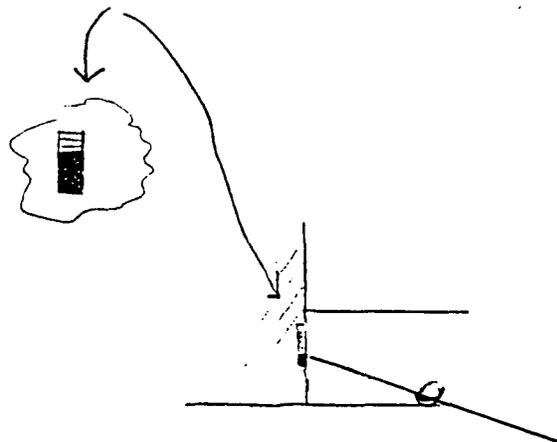


FIG 5

TRANSITION SLOT



IDLE SWITCH

FIG. 6

UNIMAX  
SWITCH  
2HBF113-1

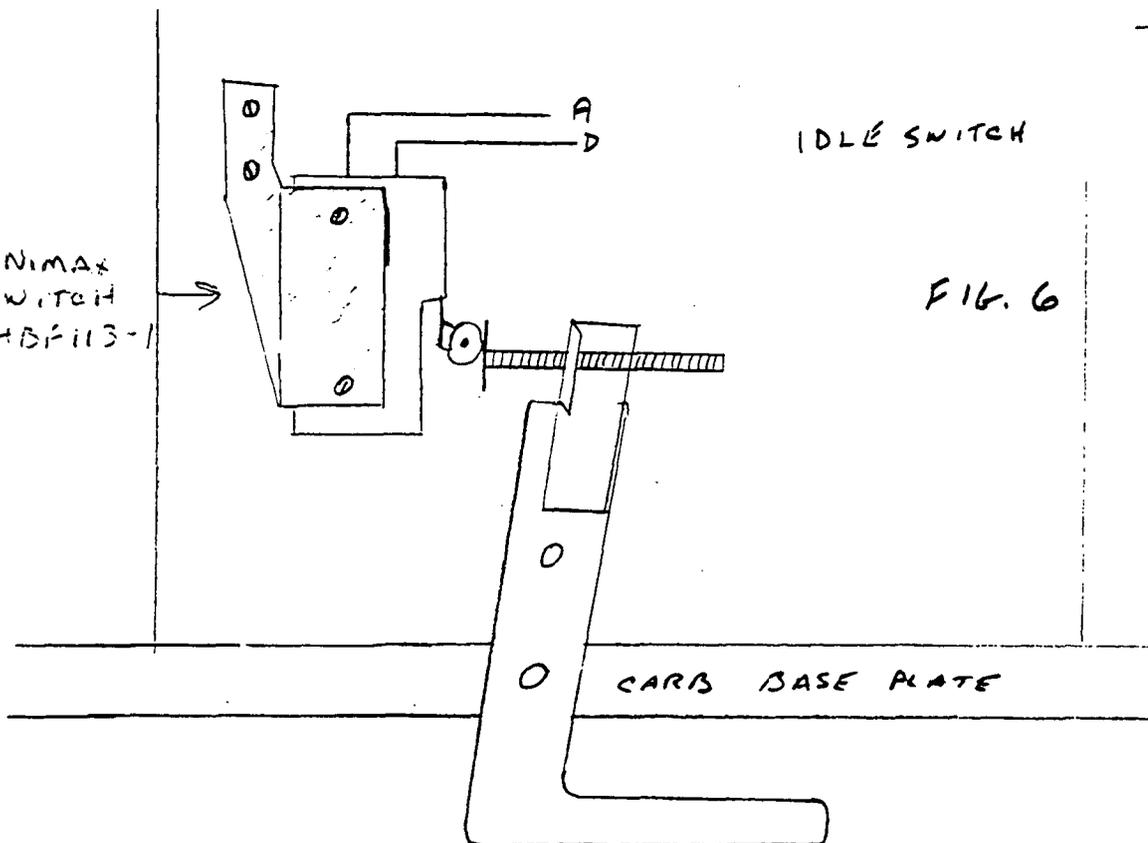
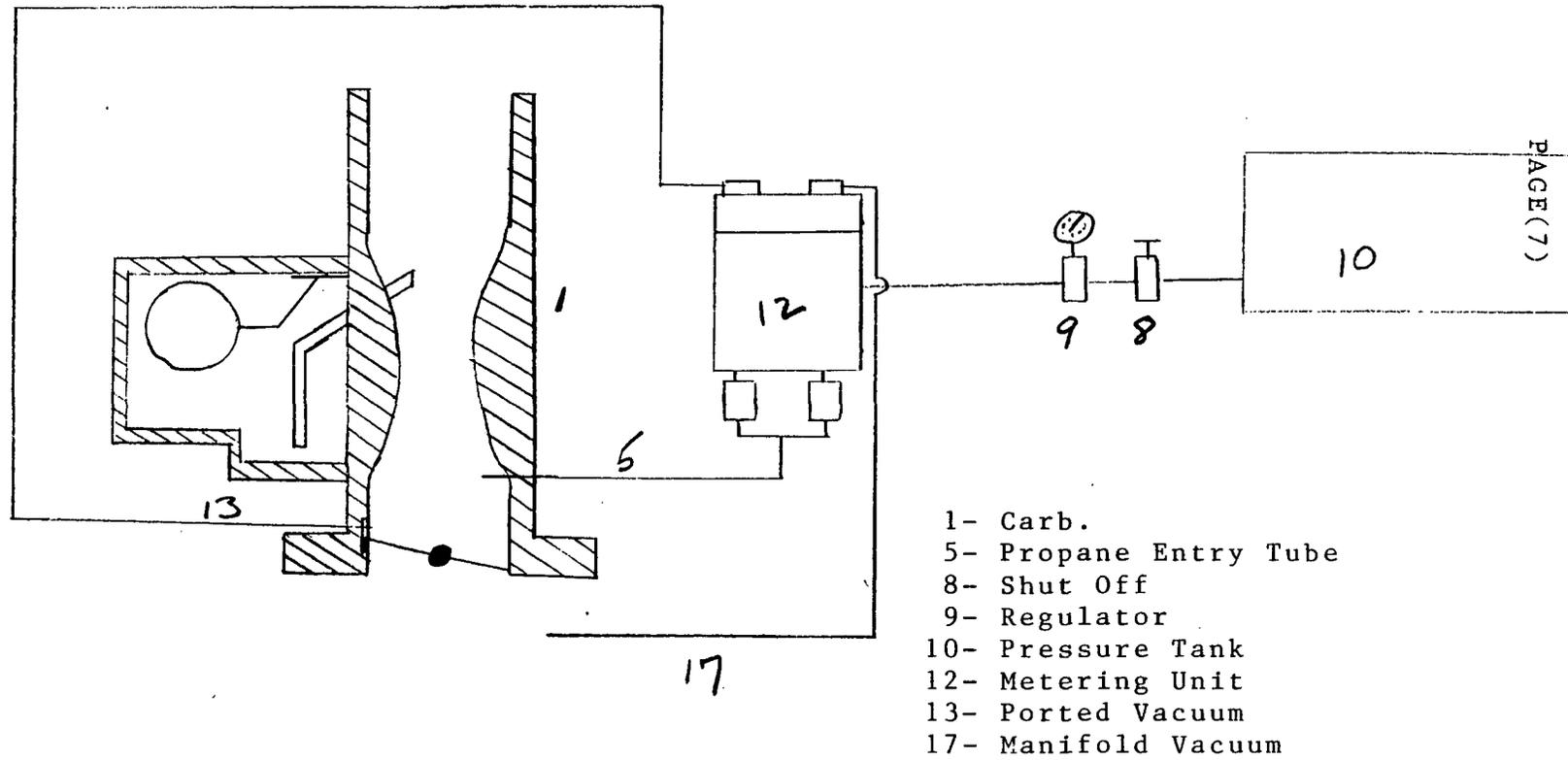
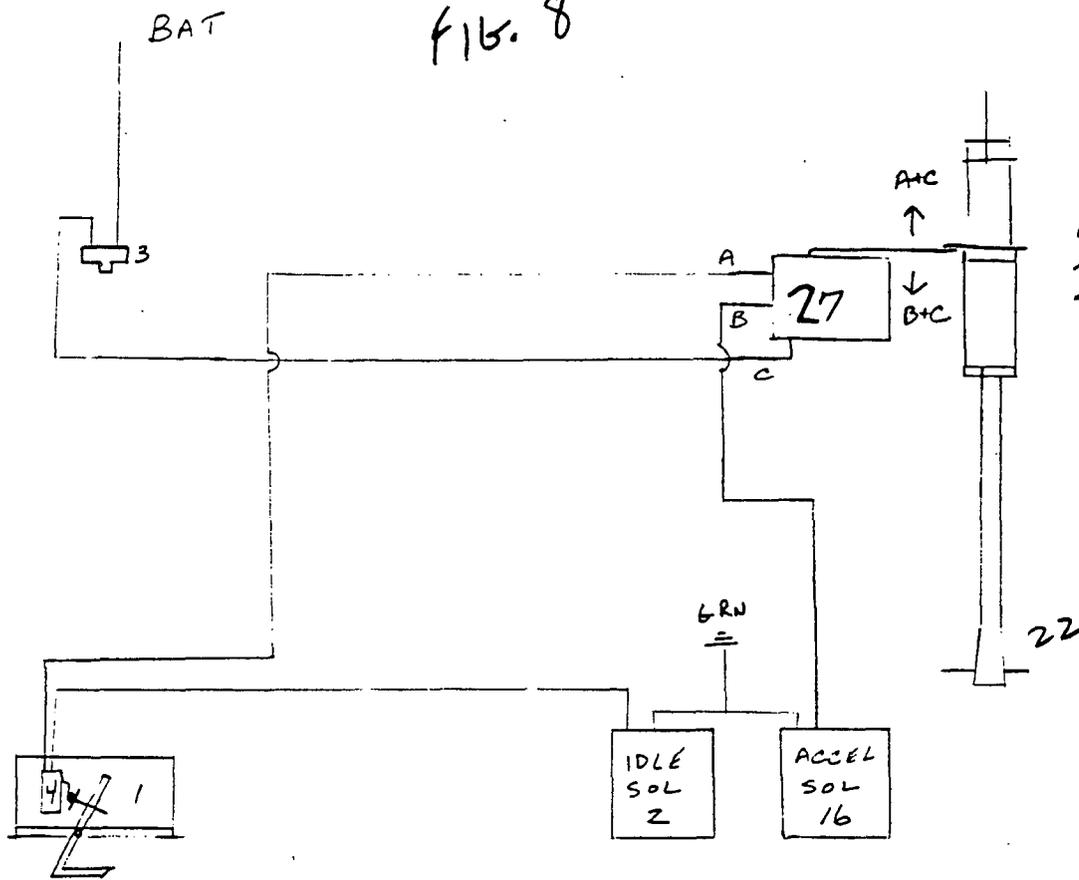


FIG 7



IN IDLE POSITION

FIG. 8



- 1- CARB 53
- 2- IDLE SOLINOID
- 3- OIL PRESSURE SW
- 4- IDLE SWITCH
  
- 16- ACCEL SOLINOID
- 27- MICROSWITCH
- 22- ACCEL VALVE

- #4 SWITCH - CLOSED CIRCUIT
- #2 IDLE SOL - ACTIVATED AND OPEN
- #27 MICROSWITCH - CONTACT A+C CLOSED
- #16 ACCEL SOLINOID - NO POWER - CLOSED
- #22 ACCEL VALVE - UP + CLOSED



ANN ARBOR, MICHIGAN 48105

November 4, 1982

OFFICE OF  
AIR, NOISE AND RADIATION

Mr. Scott J. Venning  
617 South Busse Road  
Mount Prospect, IL 60056

Dear Mr. Venning:

On October 13 we received your letter of September 29 in which you applied for an EPA evaluation of your "VCD Supplemental Gaseous Fuel Delivery System". Our Engineering Evaluation Group has made a preliminary review of your application and has determined that it does not meet the key criteria necessary for an evaluation. Namely, that you do not claim either a fuel economy or emission benefit for your device.

As stated in the package of documents I sent you, our authority and obligation to evaluate devices is limited to those devices for which either an emission or fuel economy benefit is claimed. Your application claims only that the device substitutes propane for gasoline and will not raise the emissions of a vehicle to levels exceeding the statutory limits. Therefore, at this time, we cannot further process your application.

The data that you submitted indicated that your device might be able to reduce fuel costs and save energy. If you feel that these results are representative of the benefits that would be achieved in a controlled test of the type described in our package, you could make specific emission or fuel economy claims based on this data. As an alternative, you could either conduct the appropriate testing or perform an engineering analysis and then base the specific claims on this testing or analysis.

Although we cannot now process your application, if you do decide to test, we will be happy to assist you in developing a test plan that would also satisfy the requirements for testing at an independent lab. Also, since several items in your application will require clarification or additional information when we resume the evaluation process, I will advise you of these items shortly so that the evaluation may proceed efficiently after the claims issue is satisfactorily resolved. If I can be of any further assistance, please contact me at (313) 668-4299.

Sincerely,

Handwritten signature of Merrill W. Korth in cursive.

Merrill W. Korth  
Device Evaluation Coordinator  
Test and Evaluation Branch



ANN ARBOR, MICHIGAN 48105

November 29, 1982

OFFICE OF  
AIR, NOISE AND RADIATION

Mr. Scott J. Venning  
617 S. Busse Road  
Mount Prospect, IL 60056

Dear Mr. Venning:

As promised in my letter of November 4, I am writing to discuss your application for an EPA evaluation of the "VCD Supplemental Gaseous Fuel Delivery System."

Our Engineering Evaluation Group has conducted a preliminary review of your application and has identified several areas besides the emission or fuel economy issue that appear to require clarification prior to further processing. Our comments below address each section individually.

1. Section 2a. - Marketing Identification. Your application identified several versions of the device but did not clearly define the evaluation status of each. I have listed these versions and the status that we assume applies to each.
  - a. "VCD Supplemental Gaseous Fuel Delivery System" - It is a mechanical system that causes an engine to idle on propane, cruise on gasoline, and accelerate on a mixture of propane and gasoline. Your application applies to this version. This is the version that will be tested and to which the submitted test data applied.
  - b. "V-1" - This is a mechanical system that causes the engine to idle on propane while still cruising and accelerating on gasoline. This is a simplified version of the device and is not to be evaluated. The description of this version was supplied for background purposes only.
  - c. "V-2" - This is a vacuum system that causes the engine to idle on propane while still cruising and accelerating on gasoline. This is also a simplified version of the device and is not to be evaluated. The description of this version was supplied for background purposes only.
  - d. "V-3" - This is a vacuum system that causes an engine to idle on propane, cruise on gasoline, and accelerate on propane and gasoline. This version is functionally similar to the VCD Supplemental Gaseous Fuel Delivery System. While the application also applies to this version, you do not plan to test it.

2. Section 3b. - Applicability. Your application states that the system is applicable to all gasoline internal combustion engines. However, after reviewing the application, it appears that the system is not applicable to fuel injected engines or ones with throttle body injection. Therefore, we assume the device is not applicable to these engines.

Is the device applicable to vehicles using feedback carburetors?

The application identified only one engine family for which the device actually exists (the 229 CID GM V-6 engine). If you have developed the system for other engine families, please identify these combinations.

3. Section 3c. - Theory of Operation. It appears the modifications to the carburetor have leaned it out by reducing or eliminating the contributions of the idle circuit and power enrichment circuits to off idle conditions. Is this the case? Since vehicles that use feedback carburetors will select a factory pre-programmed fuel/air ratio, will the device cause the vehicle to function as you wish when using it on a vehicle which is so equipped?
4. Section 3d. - Construction and Operation. When accelerating, the VCD accelerator circuit injects propane whenever the intake manifold vacuum drops below 4 to 6 inches (Hg). Is the same setting used for all vehicle/engine combinations, e.g., for 4, 6, and 8 cylinder engines?

For the system described in paragraph 1a. above, do the mechanical valves modulate the propane flow or simply turn the flow from off to full on?

5. Section 3e. - Specific Claims. As I noted in my letter of November 4, this evaluation process only applies to devices which claim either an emissions or fuel economy benefit. No such benefit was claimed in the application.
6. Section 3f. - Cost and Marketing. What is the cost of the device including all parts necessary for installation? How is the device to be marketed? Has the device completed development? Is the device now produced and marketed?
7. Section 4a. - Installation. The application only summarizes this critical area.
  - a. The procedures and setpoints for adjusting the propane flow and micro switches were not given. Please describe.

- b. The safety of the installation is crucial. In lieu of detailed instructions, a statement of the applicable industry standards and practices that are adhered to in installing the system is necessary.
  - c. What is the typical total time required for installation and checkout of the device?
8. Section 4b. - Operation. The modifications to the carburetor greatly reduce the amount of gasoline available for starting. Since propane is only provided after the engine is cranking, some details on starting are needed.
- a. At what oil pressure does the propane safety switch allow propane to flow?
  - b. How many seconds after the start of cranking does the typical vehicle reach this oil pressure and thus allow propane to flow?
  - c. Does this time delay for propane flow remain constant for all ambient temperatures?
  - d. Are there any cold starting problems related to this system?
  - e. At what ambient temperatures has the system been successfully started?
9. Section 4c. - Safety. What industry safety standards does the system meet?
10. Section 5b. - Regulated Emissions and Fuel Economy. No description of the test methods or procedures was given. I presume these were either city or highway road tests. While such tests are useful in the preliminary evaluation of a device when sufficient details are provided, a strictly controlled test of the type described in the package we sent you previously is required to most accurately assess the worth of a product.

Assuming you are able to satisfactorily resolve the problem of fuel economy or emission benefits, it will be necessary for you to undertake testing at an independent laboratory. In order to efficiently assist you, I will need your timely reply. Please respond by December 17. If I can be of any further assistance, please call me at (313) 668-4299.

Sincerely,

*Merrill W. Korth*  
Merrill W. Korth  
Device Evaluation Coordinator  
Test and Evaluation Branch

VCD FUEL SYSTEMS

617 S. BUSSE ROAD • MT. PROSPECT, IL 60056 • (312) 593-2184

ATTACHMENT E

November 29, 1982

Merrill W. Korth  
EPA  
Motor Vehicle Emission Laboratory  
2565 Plymouth Rd  
Ann Arbor, Mi 48105

Dear Mr. Korth;

Pertaining to the APPLICATION FOR EVALUATION OF A FUEL ECONOMY RETROFIT DEVICE UNDER SECTION 511 OF THE ENERGY POLICY AND CONSERVATION ACT format dated September 29, 1982, I am sending an amended section.

DESCRIPTION OF DEVICE:

- A. Purpose of the device: this system is to save fuel and money. Through testing we have established that idling with propane is more economical than gasoline and cruising with gasoline is more economical than propane. With the combination of idling on propane and cruising with gasoline, we have arrived with a considerable savings of fuel and money.

Up until now, all propane converted vehicles used only propane and had no fuel or money savings, only availability to an alternative fuel when gasoline is unavailable or in shortage. Using propane only has the disadvantage of a 20% power loss.

The VCD System also accelerates on gasoline and propane. Together, this enables you a leaner power circuit because the slight amount of propane used helps as does octane in fuel. We have included test results that we have performed. We feel that this system will be beneficial to the energy problem and save the public money.

Sincerely,



SCOTT VENNING

SV:d  
Encl.

Test Results (Regulated Emissions and Fuel Economy):

Test #1	1980 Monte Carlo	Stock Form:
	V6 229 C.I.	16.5 MPG
	Air Conditioning	Air conditioning on
	Automatic transmission	

With VCD System - 100 Mile Tests

Test-A	22.8 MPG	
	2.29 Lbs Propane	
Test-B	24.0 MPG	\$1.26 Gasoline per gal.
	2.35 Lbs Propane	.25 Propane per lb.
Test-C	23.4 MPG	
	2.4 Lbs Propane	

Comparison:

Stock Form	VCD System
16.5 MPG	22.8 MPG
6.06 Gal. Gasoline	4.38 Gal. Gasoline
\$7.63 Gasoline Cost	\$5.47 Gasoline Cost
	.57 Propane Cost
	\$6.04 Total Cost

\$7.63  
6.04  
 \$1.59 = 20.7%

Test #2 1980 Malibu  
 V6 229 C.I.  
 Air Conditioning  
 Automatic transmission

Stock Form:  
 16.2 MPG  
 Air conditioning on

With VCD System - 100 Mile Tests

Test-A 23.3 MPG  
 3.29 Lbs Propane

\$1.26 Gasoline per gal.

Test-B 23.3 MPG  
 2.98 Lbs Propane

.25 Propane per lb.

Test-C 23.6 MPG  
 3.8 Lbs Propane

Comparison:

Stock Form  
 16.2 MPG  
 6.17 Gal. Gasoline  
 \$7.77 Gasoline Cost

VCD System  
 23.3 MPG  
 4.29 Gal. Gasoline  
 \$5.40 Gasoline Cost  
 .82 Propane Cost  
 \$6.22 Total Cost

\$7.77  
6.22  
 \$1.55 = 20%

Test #3 1980 Malibu  
 V6 229 C.I.  
 Air Conditioning  
 Automatic transmission

Stock Form:  
 17.9 MPG  
 Air conditioning on

With VCD System - 100 Mile Tests

Test-A 24.8 MPG  
 3.2 Lbs Propane

\$1.26 Gasoline per gal.

Test-B 23.6 MPG  
 3.0 Lbs Propane

.25 Propane per lb.

Test-C 25.1 MPG  
 3.1 Lbs Propane

Comparison:

Stock Form  
 17.9 MPG  
 5.58 Gal. Gasoline  
 \$7.03 Gasoline Cost

VCD System  
 24.8 MPG  
 4.03 Gal. Gasoline  
 \$5.07 Gasoline Cost  
 .80 Propane Cost  
 \$5.87 Total Cost

\$7.03  
5.87  
 \$1.16 = 16.5%

Test #4 (Same car as in Test #3)

1980 Malibu  
V6 229 C.I.  
Air Conditioning  
Automatic transmission

IDLING ONLY TEST: (400 RPM In Gear - Air Conditioning On)

Test-A

Stock 31.5¢ 1 Quart Gasoline - 25 Min. 40 Sec.

Propane 22.5¢ 410 Grams - 25 Min. 40 Sec.

29% Savings With Propane

Test-B

Stock 31.5¢ 1 Quart Gasoline - 25 Min. 10 Sec.

Propane 21.8¢ 397 Grams - 25 Min. 10 Sec.

30.8% Savings With Propane

## VARIATIONS OF SYSTEM:

Standard carburetor with propane idle circuit only. Carburetor preparation includes idle switch, transition slot modifications and propane inlet. Metering device using only idle side. This system uses standard functions of carburetor except for the economic advantage of idling only with propane.

METERING UNIT: V-2 and V-3

This unit will give the same results as original unit but is greatly simplified. Using adjustable vacuum switches in place of vacuum pull-offs the vacuum requirements can be adjusted. As far as metering propane, moving needles and seats are replaced with jets that can be changed for desired orifices. Solenoids control propane flow and are activated electronically by vacuum switches.

**VCD FUEL SYSTEMS**

617 S. BUSSE ROAD • MT. PROSPECT, IL 60056 • (312) 593-2184

ATTACHMENT F

December 12, 1982

Merrill W. Korth  
EPA  
Motor Vehicle Emission Laboratory  
2565 Plymouth Road  
Ann Arbor, Mi 48105

Dear Mr. Korth;

Pertaining to your letter dated November 29th, I hope the following answers will resolve any questions that had developed.

1. Section 2A - I plan to test only the VCD Supplemental Gaseous Fuel Delivery System. The other systems are variations and were included as background information only.

V-3 and a system with only the idling on propane modification utilized are to have further testing in the future

2. Section 3B - Applicability. This system will not be applicable to fuel injected engines. We feel if this system proves to be as economical as believed, engines that are fuel injected could be converted or a system using this theory could be developed.

(Feedback carburetor) If you are referring to a feedback carburetor as a system using a computer tied into the carburetor, as in 1981 and later GM engines, we feel the VCD system could be adapted but testing would be necessary.

The VCD System we tested was used on various 229 CID GM V-6 engines. Some testing was performed on 350 CID CHEV V-8 4 BBL carb engines. We also started developing a system for Ford 351-M engines. We would like to test with the GM V-6 229 as all of our testing and research has been directed to these engines.

(2)

3. Section 3C - Theory of Operation. The idle circuit has been converted to propane only. Power enrichment has been accomplished by the addition of propane and not additional gasoline. With the VCD Propane System in a standard carburetor, the main jetting can be leaned without experiencing any lean driving conditions. Leaning the main jetting is not necessary in this system but will further fuel economy.

Using a feedback computer carburetor, we feel that the main jetting will have to remain the same but the most significant savings will come in the idling only on propane and accelerating on both propane and gasoline. Setting up the system this way, the fuel/air ratio can remain the same but using different fuels that prove more economical at specific times.

4. Section 3D - Construction and Operation. As far as injecting of propane under acceleration, we have had this system on Chev 350 CID V-8 4BBL engines and found the vacuum requirements the same as in other installations. By adjusting the micro switch, connected to the accel side, you can speed up or delay propane for under load requirements. (see detailed explanation in format Pg 3 last para).

The mechanical valves do not modulate. They move to fixed positions. In the V-3 system, they are simplified by using only removable jets.

5. Section 3E - Specific Claims. A letter was sent to you dated November 29th, 1982 referring to this matter.
6. Section 3F - Cost and Marketing. The cost of this system at this point is approximately \$700.00 - 900.00. This device is to be marketed to manufactures of motor vehicals and possibly to large fleets. The VCD Supplemental Gaseous Fuel Delivery System has completed development. The V-3 and a system using only the idling on propane modification are still under development. We have only prototypes produced at this time. This is why we need to have our system evaluation by the EPA. This will put us in a position to continue to develop our later systems including V-3 system and idling on propane only modification system, adapting and testing on computer feedback carburetor engines.
7. Section 4A - Installation. This system is not intended for the public to purchase and install themselves. It is to be used by auto manufactures and large fleets. This will enable us to work specifically with the type of vehicle and with the personnel installing the systems.

3)

- A. Propane flow (idle side) is accomplished by synchronizing the valve in unit, allowing propane to flow and the throttle butterfly opening in carburetor.

To adjust idle, the idle stop adjusting screw is used to open butterfly and the propane valve is adjusted to achieve proper idle speed. By adjusting both, you will have a smooth idle at any desired speed. On a conventional carburetor, the idle circuit is included in the carburetor and adjusting the idle stop screw, opening or closing the butterfly, the carburetor will automatically allow more fuel to enter to maintain the proper air fuel mixture. With the VCD System, the propane flow and the butterfly work independently so the butterfly opening is compensated by the propane flow on the valve in the device.

Propane flow (accel side) is adjusted to obtain a smooth transition to the power circuit from cruising mode by opening and closing accel valve. The micro switch on the accel side will also allow fine adjustment to when the valve starts to open by the vacuum situation. (note format, page 3 last para.).

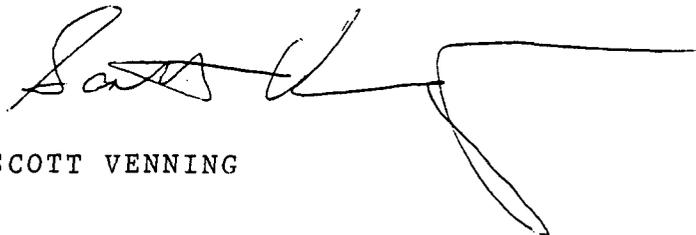
- B. This system is safe to work with and is to be regarded to as you would working with a gasoline only system. All fittings and hoses must be checked for leaks. The pressure must be maintained at  $1\frac{1}{2}$  - 2 lbs. The propane tank, as in our installation, is under pressure but is being used in many vehicles safely and effectively today.
- C. Having a modified (will be on exchange basis or produced with modifications for original equipment). The system can be installed by trained personnel in approx.  $1\frac{1}{2}$  hours with allowing for adjusting and check out time.
8. Section 4B - Operation. Starting is no problem and is like starting with a conventional carburetor. The accelerator pump is still used and will allow plenty of fuel as the accelerator is pumped for starting.
- A. Propane will flow at 5lbs. oil pressure. Switches are available with adjustable settings if any problem would arrive in the future or with a particular installation.
- B. The accelerator pump will allow fuel for starting and when you are out of the idle position the engine will run normally on gasoline. As the throttle is released, after a few seconds, oil pressure will be up and then will allow propane to flow for idling.

- C. The propane flow seems to be constant through all temperatures. In severe cold the oil pressure comes up slower but the engine will run above idle at any time (with or without oil pressure) allowing the extra few seconds to get oil pressure needed in severe cold.
- D. We have not experienced any cold starting problems.
- E. This system has been tested in Chicago over a 2 year period. Temperatures experienced and had success in starting and complete operation.  
90 - 95 degrees, 40 - 80, 10 - 30 degrees.
9. Section 4C Safety. I am not sure as to exactly what standards met. This system is simpler to operate than only propane conversions and all propane flowing after the tank regulator is under 2 lbs. The carburetor modifications leave the carburetor no less safe or dependable than in its conventional form.
10. Section 5-B - Regulated Emissions and Fuel Economy. The testing we have accomplished have been mostly city driving or a combination of city and highway. To be sure of accuracy, we would install a special 5 gallon tank in the vehicle that is designed to use all fuel at any angle the vehicle is driving at and would carry 2 propane tanks.

To start a test, we would measure a desired amount of gasoline and then fill the tank with it and record the amount and mileage. The propane tank would be weighed on a large scale breaking the measurements down to grams and recorded also. At this point we would start the test. Driving would continue until the vehicle would run out of gasoline. The mileage was recorded and the propane tank was switched with the other then we would return to the shop. The propane tank was weighed and we would review our figures.

If there are any questions that I have not satisfactorily answered, please contact me and I will resolve them immediately.

Sincerely,



SCOTT VENNING

SV:d



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

ANN ARBOR, MICHIGAN 48105

67  
ATTACHMENT G

OFFICE OF  
AIR, NOISE AND RADIATION

December 15, 1982

Mr. Scott J. Venning  
617 S. Busse Road  
Mount Prospect, IL 60056

Dear Mr. Venning:

We received your letter of November 29. I am writing to confirm our understanding of the information supplied and claims made for the device and to discuss an appropriate plan for testing.

We are still unsure whether the model tested was a VCD or a V-3 but the test data are to apply to both. The claims for the efficiency of the device are based on these test data and are representative of the typical benefits achieved. You claim the device will:

1. Reduce the cost of fuel and the use of energy by 30% while idling,
2. Reduce the cost of fuel and the use of energy by between 14 and 23% in normal vehicle operation, and
3. Achieve these savings without a loss of power.

We also understand that the vehicle operates only on gasoline while cruising.

It appears that you are now ready to undertake testing at an independent laboratory. I have enclosed a copy of the basic test plan for 511 evaluations and a description of the test cycles. Since it is clear the device will affect emissions and fuel economy, the testing should include the complete Federal Test Procedure. However, either cold start or hot start testing would be acceptable to us. Test Plan A (no parameter adjustments required and no mileage accumulation required) is appropriate for your device. You may use the Test Sequence Code that you feel is most appropriate. Two vehicles will need to be tested.

By January 22, please let us know the test sequence you select, the laboratory you have selected, and the scheduled dates for your testing. Also, we are still awaiting your formal reply to our letter of November 29. The information requested in that letter is needed for our evaluation of your device. If you have any questions or require further information, please contact me at (313) 668-4299.

Sincerely,

*Merrill W. Korth*  
Merrill W. Korth  
Device Evaluation Coordinator  
Test and Evaluation Branch

Enclosure

cc: VCD File

"VCD" file

VCD FUEL SYSTEMS

617 S. BUSSE ROAD • MT. PROSPECT, IL 60056 • (312) 593-2184

ATTACHMENT H

February 22, 1983

Merrill W. Korth  
EPA  
Motor Vehicle Emission Laboratory  
2565 Plymouth Road  
Ann Arbor, Mi 48105

Dear Mr. Korth;

As per our phone conversation 2/22/83 I have sent you an estimate from EG&G Automotive Research, Inc.

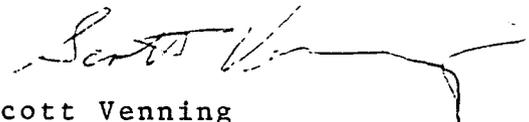
I have also contacted Olson Engineering, and have been promised an estimate to be sent out by 2/24/83. One problem has come up at Olson Engineering, that until now I was not aware of. Jim Buxton at Olson seems to think that 1980 GM 229 V6 is not available in California. Could you please answer this question for me.

Olson Engineering is sending me a three part estimate:

- 1) VCD locates car with 229 V6
- 2) Olson Engineering locates 229 V6 vehicle out of state.
- 3) Use Buick 231 V6 (not acceptable for test)

I am also contacting a few other labs that may be more convenient. I will keep you posted on my progress and will forward the Olson Engineering estimate.

Sincerely,



Scott Venning

February 28, 1983

Merrill W. Korth  
EPA  
Motor Vehicle Emission Laboratory  
2565 Plymouth Road  
Ann Arbor, Mi. 48105

Dear Mr. Korth;

Enclosed is an estimate from Olson Engineering Inc. Would you please review this and let me know if this estimate meets your requirements.

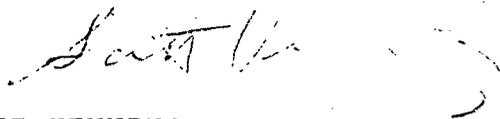
I have also contacted the following and waiting for a reply.

Automotive Testing Laboratory  
P.O. Box 289  
East Liberty, Ohio 43319 (Myron Gallogly)

Ethyl Corporation  
1600 West Eight Mile Road  
Ferndale MI 48220 (Bill Brown)

I will be out of town 3/7/83 - 3/14/83 and will contact you when I return. I should have a reply from these labs at that time.

Sincerely,



SCOTT VENNING  
VCD FUEL SYSTEMS



## UNITED STATES ENVIRONMENTAL PROTECTION AGENCY ATTACHMENT J

ANN ARBOR, MICHIGAN 48105

March 16, 1983

OFFICE OF  
AIR, NOISE AND RADIATION

Mr. Scott J. Venning  
617 S. Busse Road  
Mount Prospect, IL 60056

Dear Mr. Venning:

We received your letters of February 15 and 28 which requested our comments on the two test plans enclosed. I am writing to confirm our recent telephone conversation and to comment on these letters.

As I explained during our telephone conversation of March 1, the quotation from EG&G indicated that they only intended to perform a total of four LA-4s and four HFETs. However, we require duplicate test sequences, both before and after installation of the device, on a minimum of two vehicles. For a device for which both urban and highway benefits are claimed, the test sequence consists of a cold start FTP plus an HFET (or as a simplified alternative, a hot start LA-4 plus a HFET). Thus eight FTPs and eight HFETs are required. You planned to clarify this quote with EG&G. Please let us know the status of the test plan with this lab.

Your February 28 letter asked for our comments on the test plan from Olson Engineering. It appears adequate and provides the necessary number of tests. You also asked if the 1980 GM 229 CID engine was available in California. I thought it was not. I have checked further and it appears this engine is unavailable in California, at least through 1982.

You also stated that you were requesting quotes from Automotive Testing Laboratories and Ethyl Corporation. Please forward these test plans as soon as possible. Also, try to make your lab selection soon so that the testing can be completed by May 15. As a result of a recent ruling, we will have to start charging applicants for the testing performed by EPA. We are now in the process of implementing this directive but anticipate that those devices well along in the evaluation process will be exempt. In any case, it is in your interest to complete the testing as soon as possible.

By March 31, please let me know the test laboratory you have selected and the scheduled dates of your testing. If you have any questions or require further information, please contact me at (313) 668-4299.

Sincerely,

*Merrill W. Korth*  
Merrill W. Korth  
Device Evaluation Coordinator  
Test and Evaluation Branch

March 18, 1983

Merrill W. Korth  
EPA  
Motor Vehicle Emission Laboratory  
2565 Plymouth Road  
Ann Arbor, Mi. 48105

Dear Mr. Korth;

After looking over all four estimates, inclosed are estimates from Automotive Testing Laboratories, Inc. and Ethyl Corporation, I would like to test with;

Automotive Testing Laboratories Inc.  
P.O. Box 289  
East Liberty, Ohio 43319

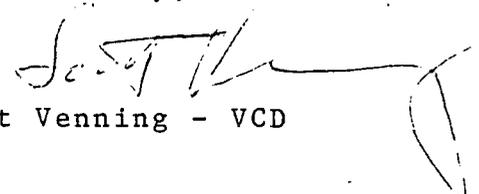
There estimate looks fairly brief, but seems to contain all of the necessary steps. Would you please check over there estimate and please advise me. The price is inline with the others and they are one of the closer labs.

Ethyl Corporations estimate is very confusing on steps:

1. Locate two vehicles - \$1050
- 3., 4. Baseline tests not included.

I am also concerned with the additonal fee possibly required by EPA. We are very far along with our project and are tring to complete it as soon as possible.

Sincerely,

  
Scott Venning - VCD



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

73

ANN ARBOR, MICHIGAN 48105

ATTACHMENT L

April 6, 1983

OFFICE OF  
AIR, NOISE AND RADIATION

Mr. Scott J. Venning  
617 S. Busse Road  
Mount Prospect, IL 60056

Dear Mr. Venning:

We received your letter of March 18 which asked for our comment on the enclosed test plans and your proposed choice of labs.

Both ATL and Ethyl indicated that they would perform test plan/sequence A-1. This plan/sequence includes duplicate baseline and device tests using both a hot LA-4 and a HFET. Ethyl's proposal should provide the required testing on both vehicles. The ATL quote states "... running two (2) back to back baseline tests and two (2) back to back tests with your system installed." would be clearer if it continued with "... on each of the two test vehicles". You should check with ATL to ensure that their quote is for duplicate baseline and device tests on each of two vehicles. Also, ATL's proposal does not indicate that installation is included although this can be inferred from the narrative description of the sequence.

I can understand your concern about the possibility of being charged for subsequent EPA testing. As I previously stated, we anticipate those devices well along in the evaluation process will be exempt from these charges. However, in making any economic decisions you should consider the possibility of having to pay for testing at the EPA laboratory. In any case, it is in your interest to complete the testing as soon as possible.

By April 20, please let me know the scheduled dates of your testing and the test lab (presently ATL). If you have any questions or require further information, please contact me at (313) 668-4299.

Sincerely,

*Merrill W. Korth*

Merrill W. Korth  
Device Evaluation Coordinator  
Test and Evaluation Branch



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

ANN ARBOR, MICHIGAN 48105

74  
ATTACHMENT M

July 11, 1983

OFFICE OF  
AIR, NOISE AND RADIATION

Mr. Scott J. Venning  
617 S. Busse Road  
Mount Prospect, IL 60056

Dear Mr. Venning:

This letter is to inform you of our intended course of action with respect to our evaluation of the "VCD" device.

As you know, we need test data which support the claims for the device. Based on our previous conversations and correspondence, we anticipated that the testing of the device would have been completed by now. However, it is now apparent that you are still in the process of developing your device and are presently unable to perform the necessary testing.

Because of the need to complete the evaluation in a timely manner, we are preparing our evaluation using the information currently available. We will consider the results of any further testing if we receive the data before the evaluation process is complete.

A notice in the Federal Register will summarize our findings and announce the availability of the final report. You will be sent a draft of both the report and the notice prior to their release. Ultimately, VCD will be added to our list as a device which has been evaluated. This list is distributed to interested parties upon request.

If you should decide to have the device evaluated in the future, a new application will be required. I will be glad to work with you at that time. If you have any questions regarding our course of action, please contact me at (313) 668-4299.

Sincerely,

*Merrill W. Korth*  
Merrill W. Korth  
Device Evaluation Coordinator  
Test and Evaluation Branch

mailed July 25  
Received July 28

July 7, 1983

Merrill W. Korth  
EPA  
Motor Vehicle Emission Laboratory  
2565 Plymouth Road  
Ann Arbor, Mi 48105

Dear Mr. Korth;

Inclosed is the report from ATL. In the first test we had a stalling problem at off idle acceleration which we did not experience in normal driving. We felt that the additional load from the dyno might have made this problem apparent.

The vehicle #3387 stalled six times during the city portion of the testing. We would experience a stall after a complete stop and would hit a lean spot at off idle acceleration.

The results of vehicle #3387 in the city portion were as follows:

CT 19.054  
CS 18.428 Baseline  
  
CT 21.070  
CS 23.985 Device

At this point we felt the stalling problem had to be corrected or the testing would be useless. On the second vehicle #6362 we tried to richen the propane at idle to cover up the lean spot, but after running the vehicle we realised after two stalls the additional propane was not helping and the driver started accelerating harder to get by the lean spot. On the second test we used way to much propane at idle and realised when the testing started that it would not be favorable, because even if the gas mileage was high it was using to much propane. The results of vehicle #6362 in the city portion were as follows;

CT 20.055  
CS 19.265 Baseline  
  
CT 23.835  
CS 28.646 Device

I feel that we can work out the off idle stall and also still use less propane than in the first tests. WE are working on the project and are intending to go back to ATL for further testing.

Sincerely,