

State of California
AIR RESOURCES BOARD

EXECUTIVE ORDER D-75
Relating to Exemptions under Section 27156
of the Vehicle Code

CAGLE CORPORATION
"CAGLE AUTOMATIC FUEL CONTROL" DEVICE

Pursuant to the authority vested in the Air Resources Board by Section 27156 of the Vehicle Code; and

Pursuant to the authority vested in the undersigned by Section 39515 of the Health and Safety Code and Executive Order G-30A;

IT IS ORDERED AND RESOLVED: That the installation of the "Cagle Automatic Fuel Control" device manufactured by Cagle Corporation, 400 Yellowstone Ave., Pocatello, Idaho 83201 has been found to not reduce the effectiveness of required motor vehicle pollution control devices and, therefore, is exempt from the prohibitions of Section 27156 of the Vehicle Code for 1977 and older model year vehicles using conventional carburetors except those equipped with a fuel pump with a recirculation system.

This Executive Order is valid provided that installation instructions for this device will not recommend tuning the vehicle to specifications different from those listed by the vehicle manufacturer.

Changes made to the design or operating conditions of the device, as exempted by the Air Resources Board, that adversely affect the performance of a vehicle's pollution control system shall invalidate this Executive Order.

Marketing of this device using an identification other than that shown in this Executive Order or marketing of this device for an application other than those listed in this Executive Order shall be prohibited unless prior approval is obtained from the Air Resources Board.

This Executive Order does not constitute any opinion as to the effect that the use of this device may have on any warranty either expressed or implied by the vehicle manufacturer.

THIS EXECUTIVE ORDER DOES NOT CONSTITUTE A CERTIFICATION, ACCREDITATION, APPROVAL, OR ANY OTHER TYPE OF ENDORSEMENT BY THE AIR RESOURCES BOARD OF ANY CLAIMS OF THE APPLICANT CONCERNING ANTI-POLLUTION BENEFITS OR ANY ALLEGED BENEFITS OF THE "CAGLE AUTOMATIC FUEL CONTROL" DEVICE.

No claim of any kind, such as "Approved by Air Resources Board" may be made with respect to the action taken herein in any advertising or other oral or written communication.

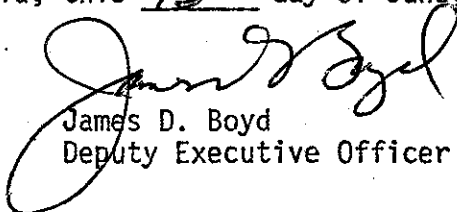
Section 17500 of the Business and Professions Code makes untrue or misleading advertising unlawful, and Section 17534 makes violation punishable as a misdemeanor.

Section 43644 of the Health and Safety Code provides as follows:

"43644. (a) No person shall install, sell, offer for sale, or advertise, or, except in an application to the state board for certification of a device, represent, any device as a motor vehicle pollution control device for use on any used motor vehicle unless that device has been certified by the state board. No person shall sell, offer for sale, advertise, or represent any motor vehicle pollution control device as a certified device which, in fact, is not a certified device. Any violation of this subdivision is a misdemeanor."

Any apparent violation of the conditions of this Executive Order will be submitted to the Attorney General of California for such action as he deems advisable.

Executed at Sacramento, California, this 13th day of June, 1977.


James D. Boyd
Deputy Executive Officer

State of California
AIR RESOURCES BOARD

May 27, 1976

Staff Report

Evaluation of Cagle Corporation
"Cagle Automatic Fuel Control" Device
for Compliance with the Requirements
of Section 27156 of the Vehicle Code

I. INTRODUCTION

Cagle Corporation, 400 Yellowstone Avenue, Pocatello, Idaho 83201, a wholly owned subsidiary of Kilbourne Investment Company, has submitted an application dated November 22, 1977 (Exhibit A) requesting an exemption from the prohibitions of Section 27156 of the California Vehicle Code for its "Cagle Automatic Fuel Control" device for installation on 1977 and older model year vehicles using conventional carburetors.

The applicant submitted as part of its application technical information regarding its device and back-to-back CVS-75 emission tests on two vehicles showing that the installation of the device would not have any adverse effects on the vehicle's exhaust emission control system.

The applicant subsequently submitted parts specifications and a production sample of the device for possible confirmatory testing¹.

¹Kilbourne Investment Corporation letter to ARB, dated January 13, 1977.

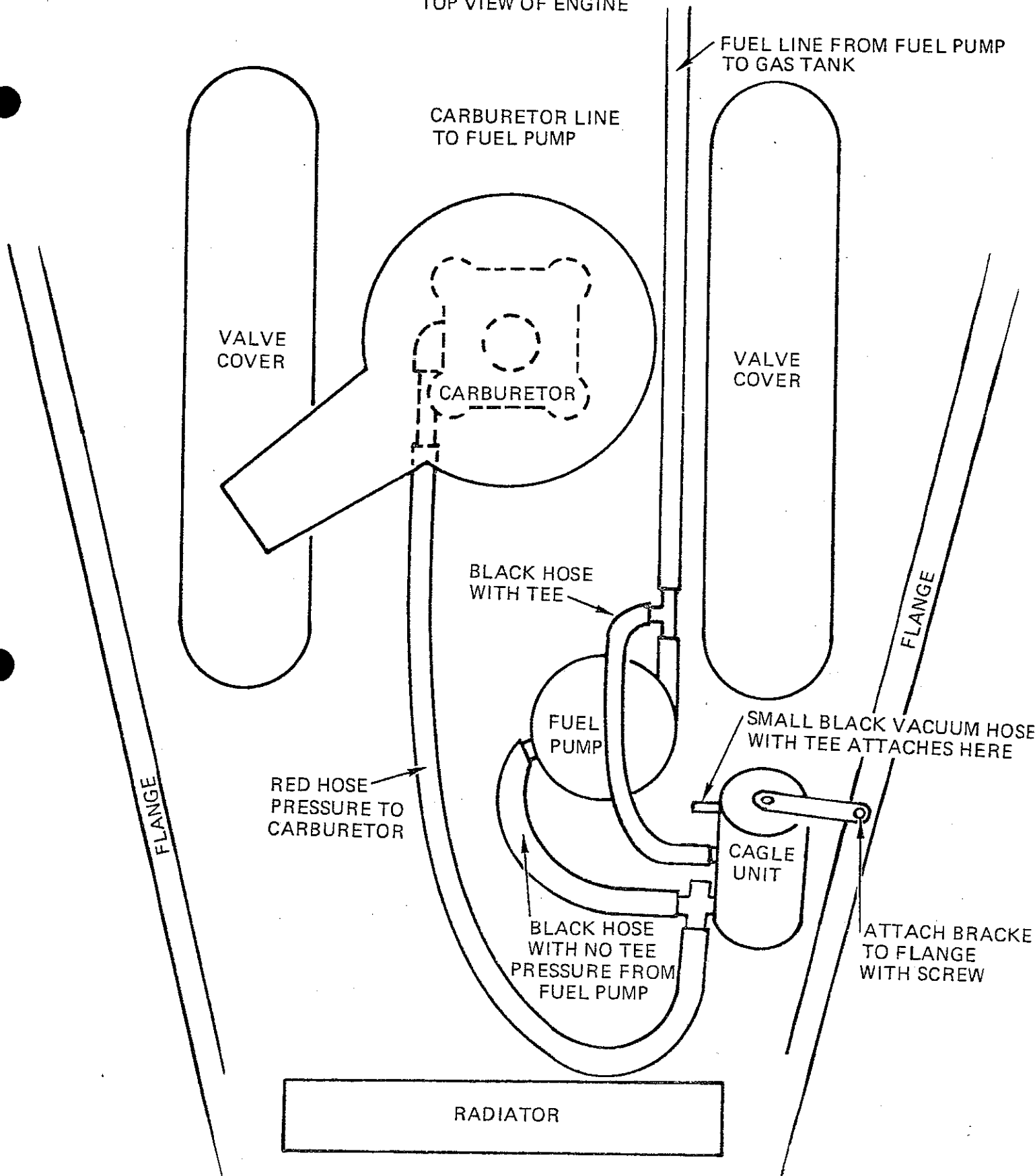
II. SYSTEM DESCRIPTION

The "Cagle Automatic Fuel Control Unit" is an aftermarket add-on device which controls the fuel pressure to the carburetor by means of recirculation of the fuel to by-pass the fuel pump. The device is a mechanically operated unit installed between the fuel pump and carburetor. The purpose of the device is to reduce the fuel pressure at the inlet of the carburetor during high manifold vacuum conditions such as idle and deceleration when the fuel demand is low. The kit consists of the Cagle device, hoses, and mounting accessories. Fig. 1 shows how it is installed in the fuel system. The Cagle device is made of aluminum body with brass fittings. It has a piston modulating valve, spring loaded closed and actuated by means of manifold vacuum. Fig. 2 shows the cut-away view of the Cagle device in the engine idling operating position. At this manifold condition the piston is unseated from port A and allows the gasoline to recirculate back to the fuel pump inlet. This fuel free flow condition typically causes the fuel pressure at the carburetor inlet to drop from 5 to 6 psi to 2 psi.

III. SYSTEM EVALUATION

The staff reviewed the technical information submitted by the applicant and conducted appropriate laboratory tests to evaluate the device. Emission data submitted by the applicant and ARB laboratory test results were analyzed to determine if the device has any adverse effects on the vehicle's exhaust emission control system.

TOP VIEW OF ENGINE



Manufactured by:
CAGLE CORP
400 Yellowstone Ave.
Pocatello, Idaho 83201

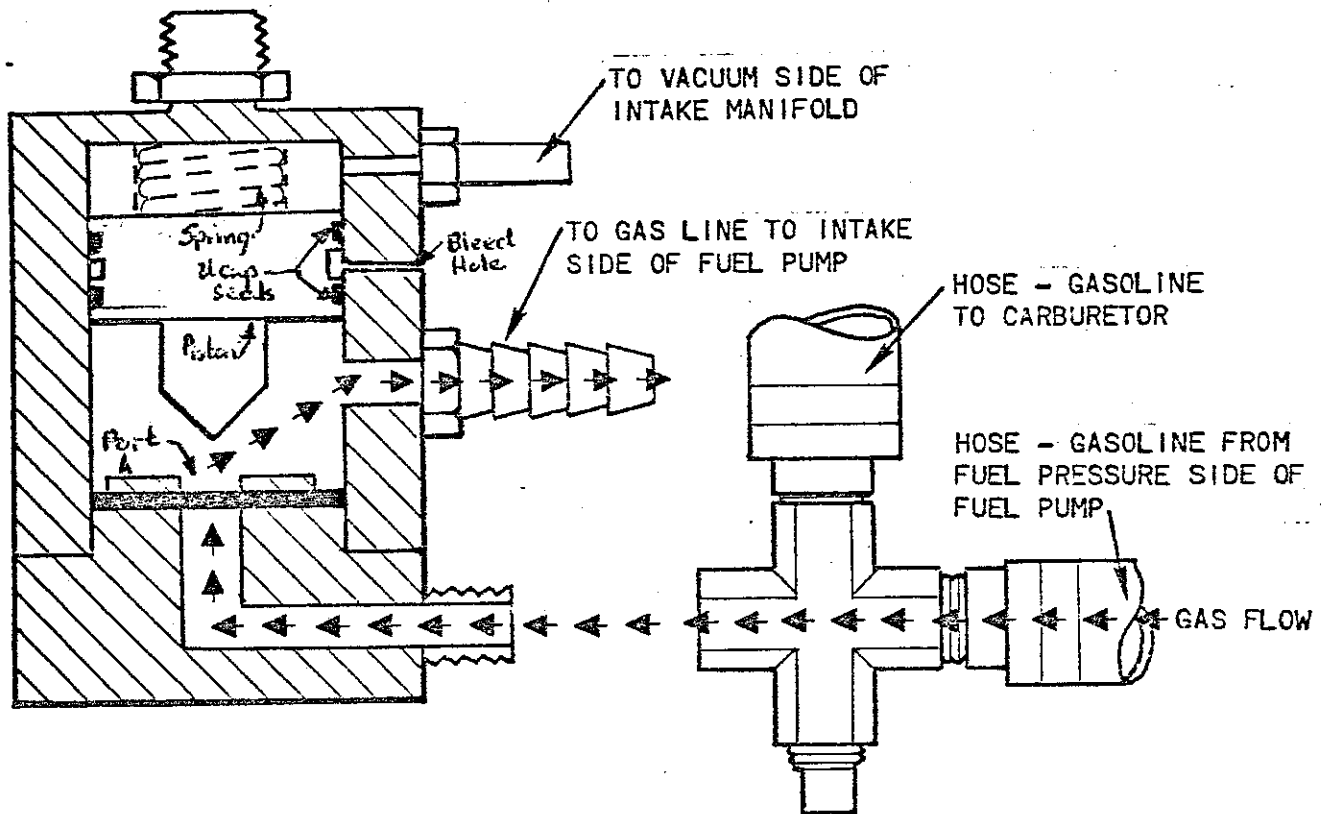


CAGLE DISTRIBUTORS Inc.
2633 East 28th St., Suite 622
Long Beach, California 90806
213-426-6163

Fig. 1 Cagle Automatic Fuel Control installed in the fuel system

Fig. 2 - CAGLE AUTOMATIC FUEL PRESSURE CONTROL UNIT

(VIEW DURING ENGINE IDLING
OR LOW ENGINE SPEED)



CUTAWAY VIEW WITH PISTON IN OPEN POSITION DURING OPERATION OF UNIT.

ARROWS (←) SHOW FLOW OF EXCESS GASOLINE BEING RECYCLED THROUGH FUEL PUMP

TEE FITTING FOR BOTTOM OPENING IN UNIT (ROTATED 90° FORWARD)

Technical Analysis

The reduction of fuel pressure to the carburetor inlet due to the installation of the Cagle device will result in leaner air/fuel mixtures. This phenomenon can be explained as follows²:

1. The carburetor float valve operates as a variable orifice where the flow rate (\dot{m}) is described by

$$\dot{m} = C_d A \sqrt{2g \rho \Delta p} = K_z \sqrt{2g \rho P_2}$$

C_d = discharge coefficient

ρ = fuel density

A = orifice area

Δp = pressure differential ($P_2 - P_{\text{bowl}}$)

g = gravitational constant

P_2 = carburetor inlet pressure

$K_z = C_d A$ is a function of the float level, z , where Z is the liquid height above a reference.

2. Reducing the carburetor inlet pressure (P_2) requires a higher K_z to maintain the demand flow rate (\dot{m}) into the bowl. This requires a slightly lower float level and fuel level in the bowl (Δz).
3. The lower fuel level increases the head that must be overcome in the main and idle circuits and therefore reduces the fuel flow for any throttle (air flow) setting; this fuel reduction is more significant at low engine speeds where Δp across the venturi is small ($\Delta p \approx \Delta z$). The result is a leaner fuel/air mixture.
4. Increasing the carburetor inlet pressure reverses the above process and raises the float and fuel level. This results in enrichment.

²"Filt -0- Reg." V.C. - Section 27156 Evaluation, May 25, 1976.

The device is intended to operate at high manifold vacuum conditions (low engine speed or deceleration) when the vehicle is usually operating at a richer fuel/air mixture . The carburetor generally operates rich at these conditions due to closed throttle conditions and high fuel pressure. Vaporization and distribution in the intake manifold under idle conditions are relatively inefficient. Therefore, rich mixtures are necessary to cover up these deficiencies and insure sufficient fuel to all cylinders for a smooth idle.

Since the use of the device changes the flow calibration of the carburetor it is necessary to conduct appropriate emission tests to determine if these changes are significant to cause an increase in emissions.

The Cagle device incorporates two U-cup seals to separate the vacuum chamber from the gasoline. Failure of these U-cup seals could lead to gasoline leaking to atmosphere causing an evaporative emission increase and safety hazard or to the intake manifold causing an increase in exhaust emissions. Fig. 3 is the section view of the Cagle device showing possible leakage points. A review of the seal specifications and durability tests data submitted by the applicant showed that the U-cup has adequate sealing capability.

Since the device employs recirculation to reduce fuel pressures two potential problems are apparent. Recirculation could reduce the capacity of fuel pump and the reduction of fuel pressure could

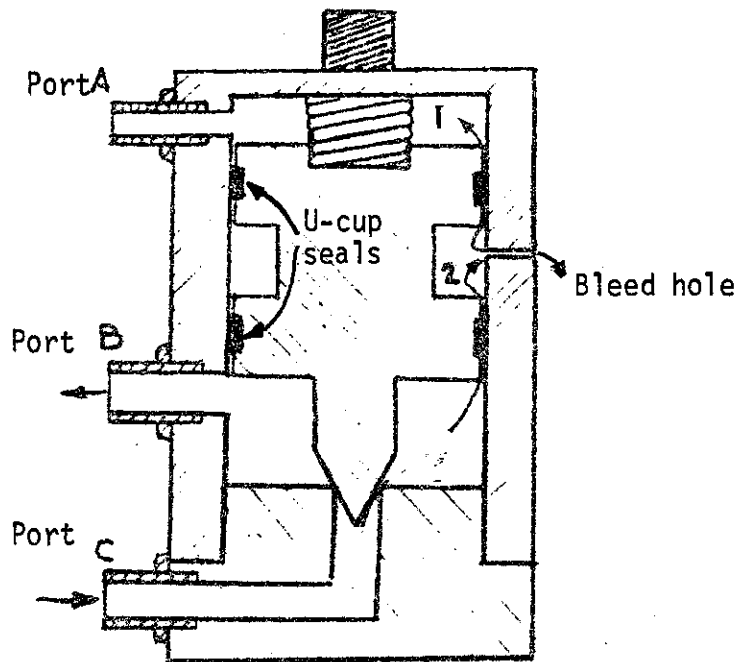


Fig. 3 Section view of the Cagle showing possible leakage points.

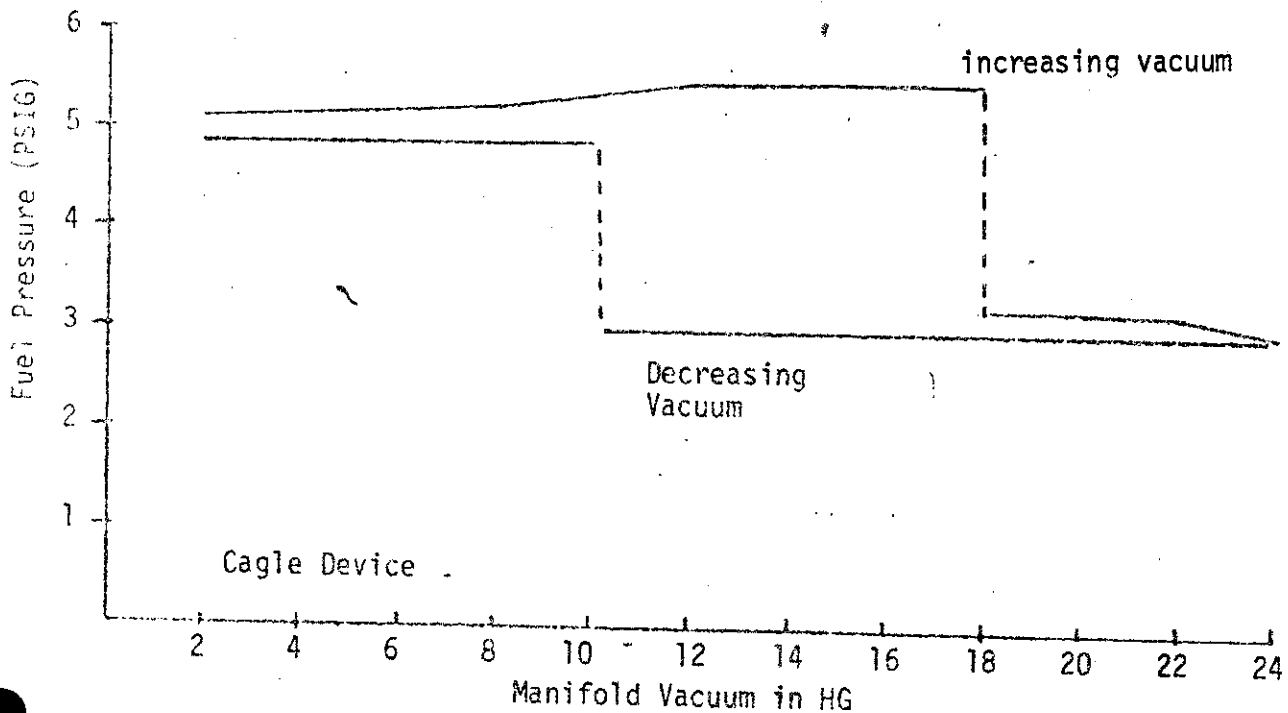


Fig. 4 Calibration curves of the Cagle device from initial test run

increase the tendency of the engine to be "vapor locked" due to the reduction of the pressure in the fuel system. Both conditions reduce the fuel flow and could cause lean misfire, loss in power, or else complete stoppage of the engine. A driveability test could detect the above problems.

ARB Laboratory Tests

The above discussion identifies the area of concern where test evaluation should be performed to detect any adverse affects of the use of the device on the vehicle's exhaust emission control system. The following test program was performed in sequence to determine any leakage problems, device flow calibration, effects on vehicles exhaust emission control system and driveability:

1. Device leakage test with 18 inches Hg vacuum applied at Port C and 5 psig water pressure applied at Port B (Fig. 3).
2. Steady state tests to determine devices flow calibration and emissions using the Ford 302 CID engine dyno.
3. Back to back emission tests on a 1974 V.W. with a 1.6L, engine and automative transmission.
 - a. cold start CVS-75
 - b. 2 hot start CVS-72
4. 200 miles driveability test
5. Device leakage test (same as No. 1).

During the initial emission tests on the engine dyno the lower U-cup seal in the original Cagle unit failed and gasoline squirted out of the bleed hole to the atmosphere (see Figure 3). The test was immediately stopped.

The applicant attributed the cause of the seal failure to poor quality of the supplier⁴ and submitted another device which incorporate U-cup seals manufactured by another supplier, the Parker Seal Company. Technical specifications of the seal were also submitted⁵.

Testing on the device was resumed and the results of the tests were documented in ARB Test Report V7701 dated April 21, 1977.

The following are the summary of the test results:

1. Leakage tests - No observable leak was detected during the initial and final leakage tests.
2. Flow calibration - Test data indicates the device has very erratic performance. Figure 4 is the plot of the calibration curves from initial test run indicating significant variation of pressures between increasing and decreasing vacuum conditions. However, further tests could not duplicate these conditions. When operational, usually during idle, the device reduced the fuel pump pressure from 5.5 psig to 2.5 psig. However, the device would not stay open long enough at steady state condition to stabilize for valid emission measurements.

⁴Kilbourne Investment Corp. letter to ARB dated February 23, 1977.

⁵Ibid 1.

Table I - CVS emission test data from a 1974
 Volkswagen, 1.6L, Automatic Transmission
 with and without the Cagle Automatic Fuel
 Control device. (Performed by ARB Laboratory)

	<u>Cold Start CVS-75</u>			<u>MPG</u>
	<u>Grams per Mile</u>			
	<u>HC</u>	<u>CO</u>	<u>NOx</u>	
Baseline	2.35	24.6	1.67	26.2
Device	2.03	16.9	1.51	29.0
% Change	-13.6%	-31.3%	-9.5%	10.7%

	<u>Hot Start CVS-72*</u>			<u>MPG</u>
	<u>Grams Per Mile</u>			
	<u>HC</u>	<u>CO</u>	<u>NOx</u>	
Baseline	1.95	19.8	1.61	27.8
Device	1.76	15.2	1.56	29.0
% Change	-9.7%	-23%	-3%	4.0%

*Average of two Hot Start CVS-72 Tests.

Table II - Cold Start CVS-75 emission data with and without the Cagle Automatic Fuel Control device submitted by the applicant

		Grams Per Mile		
		<u>HC</u>	<u>CO</u>	<u>NOx</u>
<u>1971 Ford LTD</u> <u>5.75L, V8</u>	Baseline	2.13	20.6	3.86
	Device	1.86	18.6	4.17
	% Change	-12.7	-9.8	8.0

		Grams Per Mile		
		<u>HC</u>	<u>CO</u>	<u>NOx</u>
<u>1972 Pinto Wagon</u> <u>2.0L, 4 Cyl</u>	Baseline	4.52	56.7	2.34
	Device	4.12	54.0	2.41
	% Change	-8.8	-4.8	3.0

3. Emission tests - The emission data are summarized in Table I. The back-to-back test using the official CVS-75 test procedure indicated a reduction of all the three components of exhaust emissions (HC, -13.6%; CO, - 31%; NOx, - 9.5%), and fuel economy improved 10.7%. The average of two Hot start CVS-72 tests also supported these results. During the CVS emission tests a pressure gauge was installed at the fuel inlet of the carburetor and indicated that the device was operating (but erratic) during the test.
4. No driveability problem was detected during the 200 mile test.

Applicant's Test Data

The applicant submitted back-to-back CVS-75 emission tests conducted by Olson Engineering Inc., Huntington Beach, on the following vehicles:

1. 1971 Ford LTD, 5.75L, V8 engine with automatic transmission
2. 1972 Pinto Station Wagon, 2.0L, 4 cyl engine with automatic transmission.

Table II is the summary of the test results. The data shows the average reduction of HC and CO emissions were 10% and 7% respectively and 5% increase in NOx for the two vehicles when the device was installed.

Discussion

The above emission tests indicated that the leaning effect of the device due to lowering of fuel level in the carburetor bowl is not significant to adversely affect the carburetor flow characteristics. When the device was installed on the 1973 VW, the 3 components of exhaust emissions decreased. This can be explained by the leaning effect of the device which allows the carburetor to operate predominantly at more than stoichiometric conditions where all the emissions decrease as the air fuel mixtures becomes leaner. On the 1971 Ford and 1972 Pinto, the carburetors were probably operating at predominantly less than stoichiometric conditions since the leaning effect only lowers the HC and CO emissions, and not NOx (see Fig. 5).

Although the device was not subjected to standard cycling tests to determine the seal durability, it is the staff's judgement that the U-cup seals have been subjected to sufficient in-use stress during the ARB emission tests to confirm the sealing capability of the U-cup seals submitted by the applicant. However, because of the safety hazard associated with any seal failure the applicant also submitted a statement asserting that the installation of the device will not result in an unsafe condition to the occupants of the vehicle⁶ in addition to durability test data supplied by the seal supplier.

⁶Cagle Corporation letter to ARB, dated April 22, 1977.

QUALITATIVE RELATIONSHIPS BETWEEN EXHAUST EMISSIONS,
BRAKE HORSEPOWER, AND AIR-FUEL RATIO

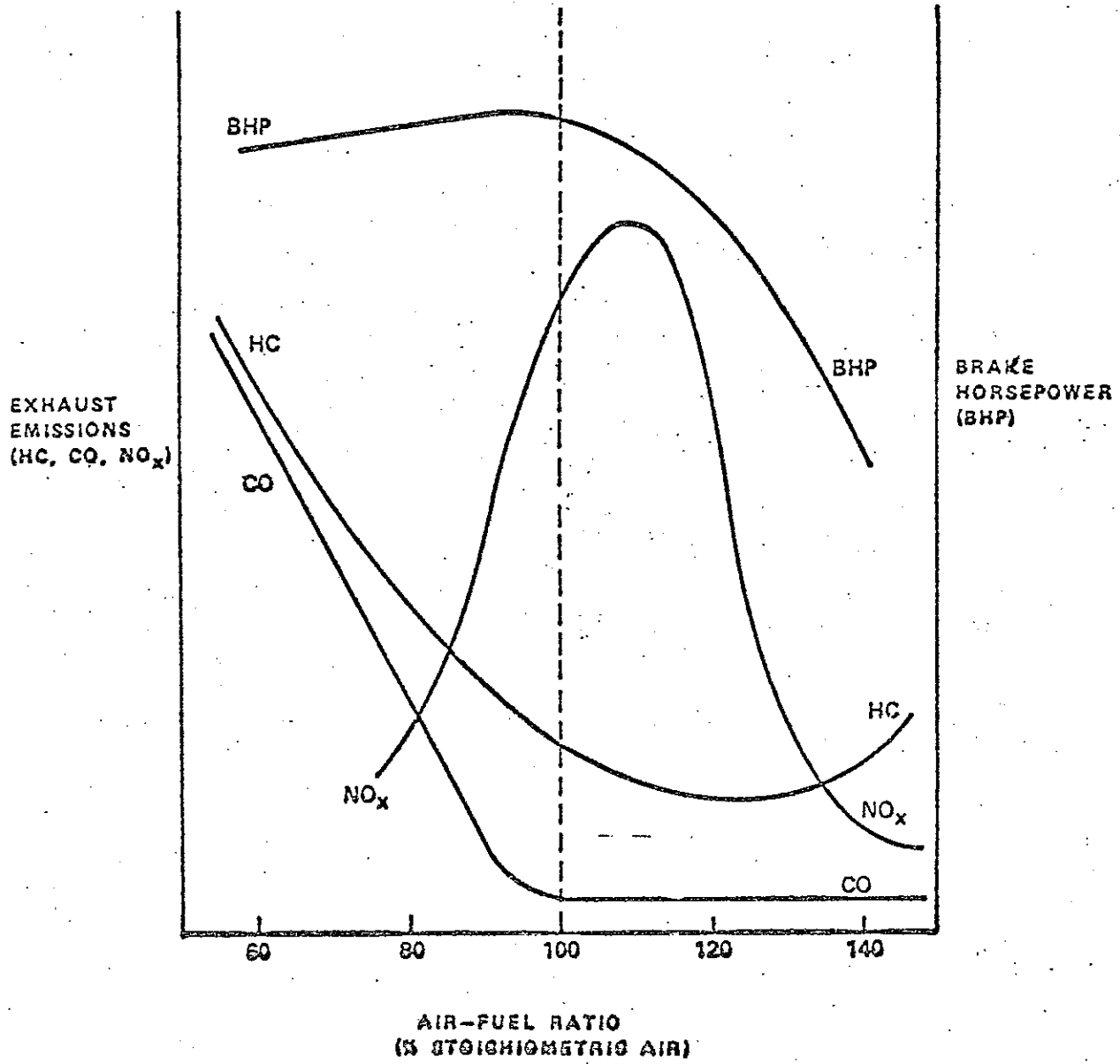


Figure 5

Ref: Auto. Engineering

The 200 mile driveability test on the 1974 VW indicated no detectable deterioration of the vehicle performance. The reduction of the pressure in the fuel system did not cause vapor lock under normal underhood temperatures. In addition since the fuel recirculation occurs only at low fuel demand conditions (low engine speed or deceleration) the reduction in pump flow capacity was not significant to cause any fuel starvation problem.

Device Limitations

The 1974 VW tested by the ARB, and the 1971 Ford LTD and 1972 Pinto Station Wagon tested by the Olson Engineering have fuel pumps not equipped with OEM recirculation system.

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However, a substantial number of new vehicles are now equipped with fuel pump with a recirculation system without corresponding increase in the pump rated output capacity. Another recirculation system similar to Cagle device added to the OEM recirculation system therefore would worsen the situation and could adversely affect the output capacity of the fuel pump.

IV. MANUFACTURER'S CLAIMS

The applicant stated that he will not advertise any benefit claims on the device⁷.

⁷Ibid 4

ARB staff evaluation of the device indicates the use of the device may slightly improve the fuel economy of the vehicles provided the leaning effect is not excessive to cause engine misfires. Newer vehicles are especially prone to engine misfires since they are usually designed to operate for maximum leanness.

V. CONCLUSIONS AND RECOMMENDATIONS

The ARB staff's evaluation indicated that the "Cagle Automatic Control" device has very erratic performance, and when installed in the vehicle's fuel system leans the fuel/air mixtures. The effect is not however, significant to cause an increase in exhaust emissions. When installed on typical in-use vehicles equipped with fuel pump not employing fuel recirculation, it is the staff's opinion that the device would not have any adverse effects on the vehicle's exhaust emission control system. Therefore, the staff recommends that Cagle Corporation be granted an exemption from the prohibitions of Section 27156 of the California Vehicle Code for its "Cagle Automatic Fuel Control" device for installation on 1977 and older model year vehicles using conventional carburetors except those equipped with a fuel pump with a recirculation system.

KILBOURNE INVESTMENT CORPORATION

400 YELLOWSTONE AVE.
POCATELLO, IDAHO 83201W. GRANT KILBOURNE
PRESIDENTTELEPHONE 208-232-7301
232-1577

November 22, 1976

Vehicle Emission Control Division
Air Resources Board, State of California
9528 Telstar Ave.
El Monte, California 91700

Attention: Mr. G. C. Hass, Chief

Gentlemen:

Cagle Corporation, a Nevada Corporation with principal offices at 400 Yellowstone Avenue, Pocatello, Idaho, is a wholly owned corporation of Kilbourne Investment Company. Cagle Corporation is the manufacturer of a device known as the Cagle Automatic Fuel Control. It proposes to market said device in the State of California through Cagle Distributors, Inc., 2633 East 28th Street, Suite 622, Long Beach, California, 90806. In order to do so, Cagle Corporation hereby applies to the Air Resources Board for a Resolution of Compliance with Section 27156 of the California Vehicle Code. In support of this request, the following information is attached hereto and made a part hereof:

1. Detailed description of the device (Exhibit "A").
2. Purpose of the device is to automatically lower the fuel pressure to the carburetor of gasoline combustion engines with cam driven fuel pumps during periods of operation not requiring the full designed pressure. In doing so, fuel consumption has been found to be lowered without affecting operating efficiencies of the engine and its accessories.
3. Detailed instructions for installation on the vehicle (Exhibit "B").
4. Applicable emission test data taken in accordance with the appropriate Air Resources Board test procedures (Exhibit "C").
5. Makes and models of vehicles and emission control systems for which a Board finding is requested: any gas combustion engine powered vehicle which relies on a cam driven fuel pump to furnish fuel to the carburetor.
6. One complete Cagle Automatic Fuel Control kit is submitted herewith in exactly the same form and manner in which it is proposed that said device be marketed.

Vehicle Emission Control Division

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7. Letter from the manufacturer of "O" rings and "U" cups used in the subject device describing material from which such rings are made. (Exhibit "D")

Inasmuch as this device is now ready to market within the State of California and numerous potential sales are being held in abeyance pending a decision of the Board, action by the Board at its early convenience is respectfully requested.

CAGLE CORPORATION

By W. Grant Kilbourne
President