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Automotive Emission Control

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Abstract

Emission control systems required by the federal government to reduce exhaust, crankcase, and fuel system emissions a.re resulting in engines that have a. totally new set of fundamental characteristics. This paper is intended to examine the various emission control systems and attempt to gain insight into their effect on engine performance, economy, service and trouble shooting techniques that will make servicing these engines more effective.

Automotive Emission Control

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INTRODUCTION

AIR POLLUTION AND THE AUTOMOBILE

When hazy skies began to be noticed in the late 1940's over Los Angeles, no one was sure of the cause. In 1952, it was ascertained that the automobile was one of the major contributors to smog. It was found that engine exhaust emissions react with sunlight and other agents to form the irritating photo chemical smog.[1]

Background Information

The complete smog-forming process is still not entirely understood, but it is recognized that the automobile's contribution is the emission of hydrocarbons and oxides of nitrogen. In addition to these, it is estimated that the automobile produces 55% of the carbon monoxide in the air.[2] However, carbon monoxide levels in the atmosphere remain constant. Also, the automobile emits small solid matter which consists primarily of lead from the gasoline (see Figure 1 for sources of automobile emissions). The average car in the United States, with no emission control devices, would take in about 64,500 pounds of air-fuel mixture and release about 2,300 pounds of pollutants (refer to Table 1 for further date and source).

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1. John P. Kushnerick (ed.), "Smog Control and the Service Dealer," Motor Age, Vol. 89, No. 7, July, 1970, p. 65.

2. Ibid.

SOURCES OF POLLUTANTS FROM
AN AUTOMOBILE WITHOUT
EMISSION CONTROLS

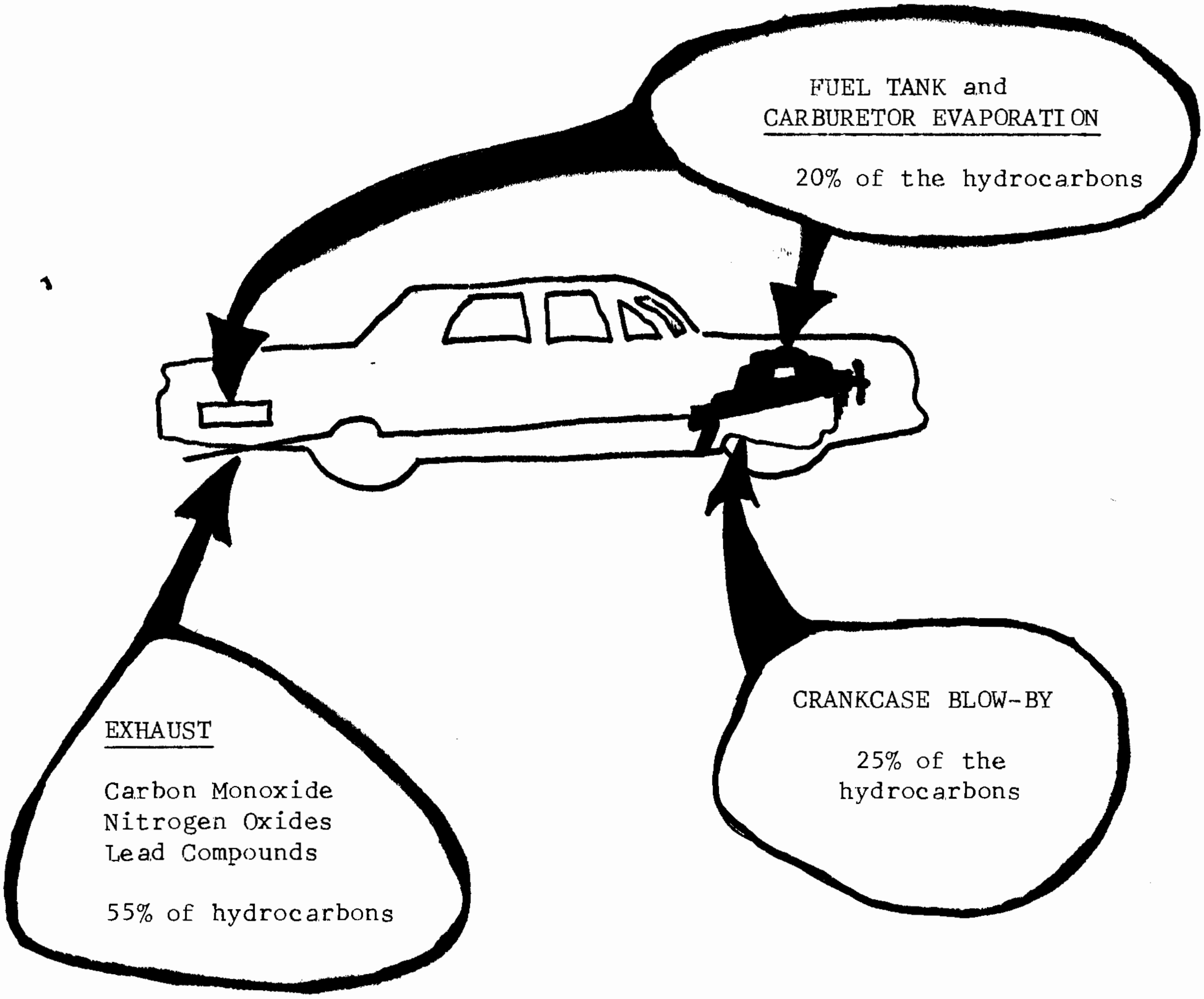

Figure 1

Sources of Pollutants[3]

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3. W. Robert Epperly, "Control of Automotive Emissions--Past Present and Future," (an unpublished report presented to the Montana Petroleum Association, Billings, Montana, September 25, 1970), p. 19.

Table 1

Pollution Emissions

EACH YEAR AN AVERAGE UNCONTROLLED CAR IN THE UNITED STATES	LBS.
TAKES IN:	
Fuel	4,500
Air	60,000
	64,500
EMITS POLLUTANTS:	
Carbon Monoxide	1,700
Hydrocarbons	500
Nitrogen Oxides	90
Particulates	10
	2,300

Source:

W. Robert Epperly, "Control of Automotive Emissions--Past, Present and Future," (unpublished report presented to the Montana Petroleum Association, September 25, 1970, Billings, Montana), p.18.

In the U.S. the automobile released an estimated 86 million tons of pollutants in 1966.[4]

As a result of information like the preceding, the state and federal governments began to pass legislation aimed at requiring auto manufacturers to produce engines that would cut down on pollution emissions. The first emission control system, the PCV (Positive Crankcase Ventilation), was introduced in 1961 in California, becoming nationwide in 1963.[5] From relatively simple PCV in 1961, very sophisticated systems have been introduced that control, in addition to crankcase emissions, exhaust, fuel tank, and carburetor emissions.

To meet the federal and state requirements presented in Table 2, the automobile manufacturers have used two major categories of control systems other than the PCV: 1.) the A.I.R. Package (Air Injector Reactor: General Motors and American Motors), and Thermactor (Ford), which both have air injection into the exhaust manifold, and 2.) C.A.P. (Cleaner Air Package; Chrysler), C.C.S. (Controlled Combustion System; General Motors), and IMCO (IMproved COmbustion; Ford), which use engine modification to control exhaust emissions.[6]

These sophisticated emission control systems have had a considerable effect on the operation and maintenance of the internal combustion gasoline engine. The general scope of this report is to examine the various emission control systems, their operation, and their service.

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4. Ibid, p. 17.

5. Kushnerick, loc. cit.

6. Autolite Ford, "Controlling Pollution," Shop Tips, Vol. 9, No. 6, February, 1971, p. 10.

Table 2

United States Automotive Exhaust Levels
Past, Present and Anticipated Future
(Grams/Miles)

Model Year:					%		
California	1960*	1966	1970	1971	reduc-	1975	1980
United States	1960	1968	1970	1971	tion	1975	1980
Hydrocarbons							
exhaust	11	3.3	2.2	2.2	80	0.6	0.24
evaporation	2.5	---	0.4**	0.4	84	over	over
crankcase	3.4	0	0.	0	100	all	all
Carbon Monoxide	80	35	23	23	71	11.5	4.7
Nitrogen Oxides	5	---	6	4**	20**	0.95	0.4
Particulates	0.3	---	0.3	---		0.1	0.03

* Uncontrolled Car   ** California only

Sources:

W. Robert Epperly, "Control of Automotive Emissions--Past, Present and Future," (Unpublished report presented to the Montana Petroleum Association, September 25, 1970, Billings, Montana), p.p. 22, 24.

Statement of the Problem

Emission control systems required by the federal government to reduce exhaust, crankcase, and fuel system emissions are resulting in engines that have a totally new set of fundamental characteristics. This paper is intended to examine the various emission control systems and attempt to gain insight into their effect on engine performance, economy, service and trouble shooting techniques that will make servicing these engines more effective.

Purposes of the Study

1. To improve understanding of emission control systems and their operation and service,

2. To assemble information on this topic for use in a high school automotives course.

Methods of Approach

1. Review of current literature on the subject,

2. Review and compilation of materials obtained from related industries,

3. Review of data pertaining to performance of emission control systems, and

4. Interviews of automobile dealerships and service managers.

Chapter 2

CRANKCASE EMISSION CONTROL SYSTEMS

As stated in the introduction, pollution comes from several different sources. This chapter will discuss the various parts, operation, and systems servicing of PCV systems. The various figures shown as part of this chapter will illustrate the locations of these parts as they are being discussed.

Crankcase Emissions

During the combustion process in a gas engine, gases seep past the piston rings into the crankcase. These gases are the result of burned and unburned fuel and oil in the combustion chamber. The seepage (blow by) past the rings is the result of: (see Figure 2)

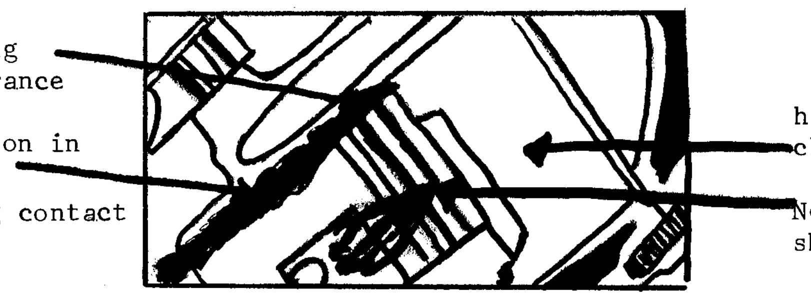

Figure 2

Engine Blow-by[7]

7. AC Spark Plug Division, General Motors Corp, "Crankcase and Exhaust Emission Systems," Service Manual, SM-17, January, 1969, p. 1.

1. High combustion chamber pressures.

2. Necessary working clearance of piston rings in their grooves.

3. Normal ring shifting that sometimes lines up clearance gaps of two rings or more.

4. Reduction in ring sealing contact area with change in direction of piston travel.

If this blow-by is not removed from the crankcase, it condenses in the crankcase to form sludge and oil dilution.

Water condensing in the crankcase will combine with other elements to form acidic compounds which attack bearings, cylinder walls, and other engine surfaces. Blow-by gases tend to deteriorate lubricating oil and reduce the ability to protect moving parts. Unburned fuel and its additives react with oil in the crankcase to form sludge and varnish deposits which can plug oil passages and hasten engine wear.

One system of venting these harmful substances from the crankcase was almost universally used by auto makers from the early 1920's until the advent of the PCV in 1961. It consisted of a "breather cap" to allow fresh air intake and a "road down draft tube" to draw off this airflow, and with it the crankcase fumes. The system served very successfully for many years, but was always beset with two problems: 1.) it was not absolutely effective because at speeds under 20 mph, it would not develop enough flow to vent completely, and 2.) it contributed to air pollution by venting crankcase fumes directly into the atmosphere.[8] (See figure 3).

8. AC Spark Plug Division, General Motors, AC News, 9970, p. 2

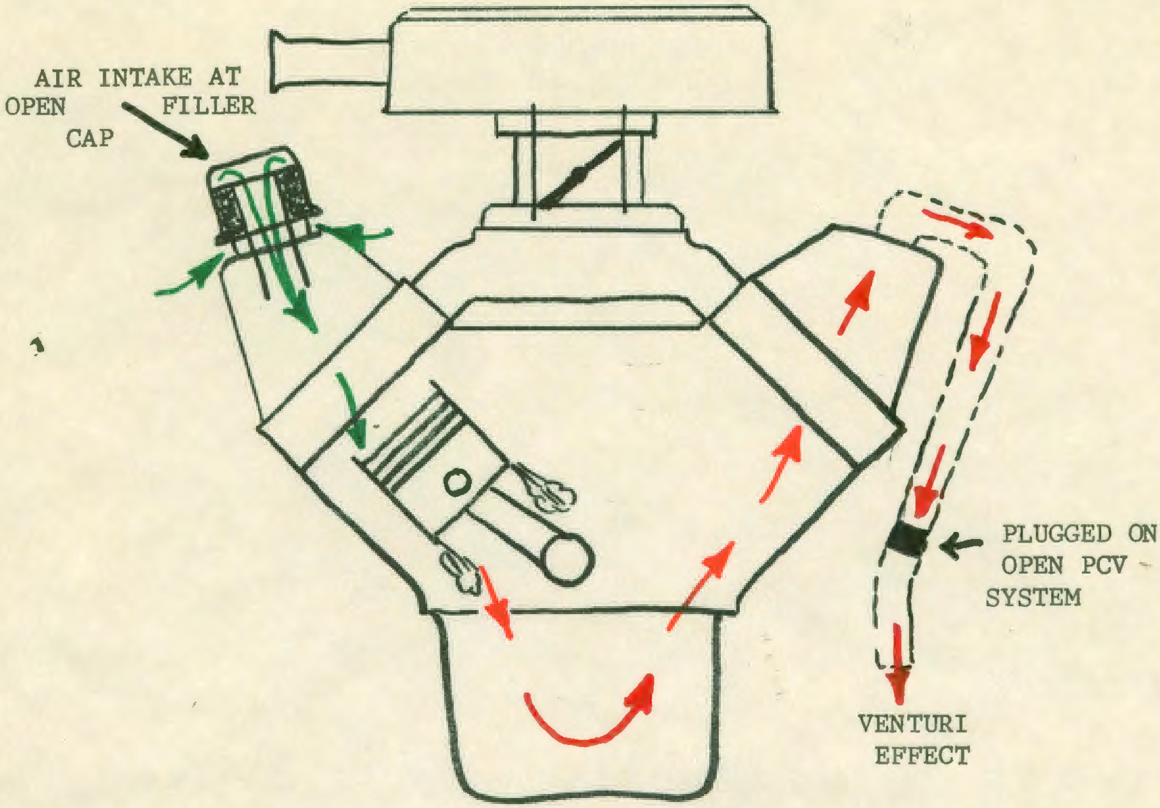

Figure 3

Road Down Draft Tube[9]

9. Autolite Ford, op. cit., p. 5.

Both of these problems were solved successfully by the PCV system which vents the crankcase fumes at all speeds directly into the intake manifold, recycling them to the combustion chambers for further burning as shown in Figure 4.

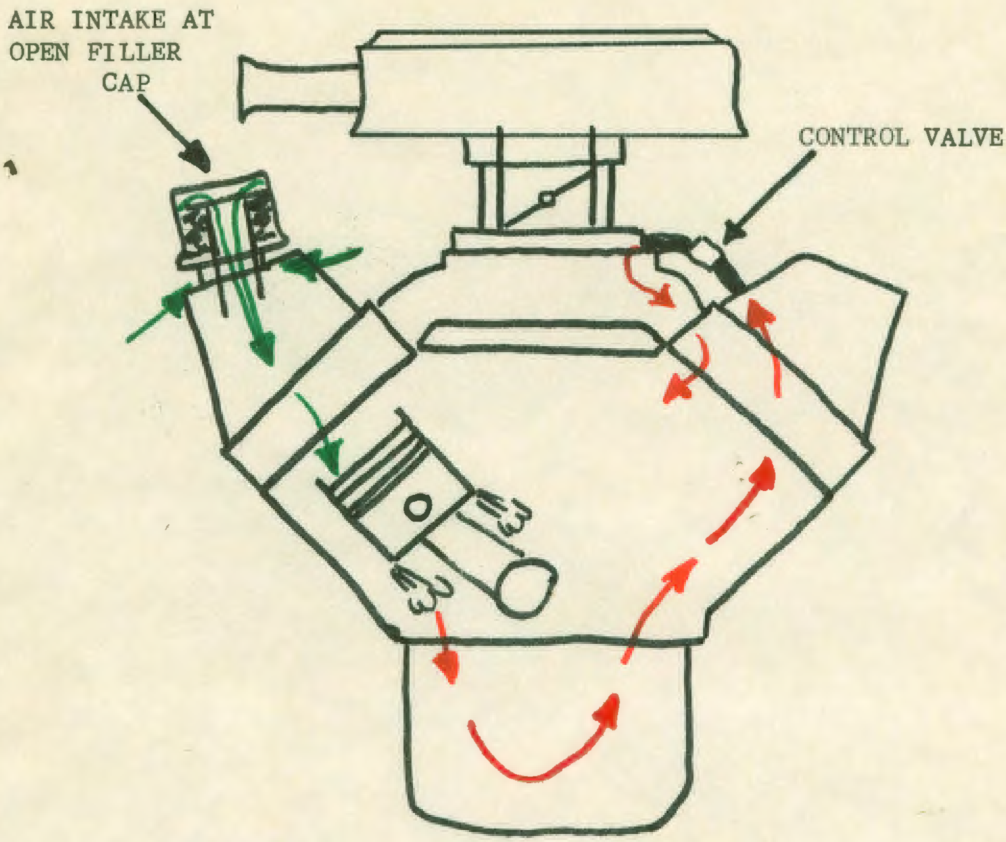

Figure 4

The PCV System[10]

10. Ibid, p. 5-6.

Positive Crankcase Ventilation (PCV)

In 1961 in California and in 1963 in the nation, a new system, the positive crankcase ventilation (PCV) system was introduced on all U.S. built cars. However, this system had been used on military and commercial vehicles long before this to combat sludge problems. The State of California has since required the use of PCV on most models.[11]

The PCV system has evolved through four major revisions. This has resulted in four types of systems that may be found on American automobiles:[12]

Type 1 - Valve controlled by intake manifold vacuum (open)

Type 2 - Valve controlled by crankcase vacuum.

Type 3 - Tube to air cleaner device

Type 4 - Combination Systems (closed)

Each of these types of crankcase emission systems has been used by the various car manufacturers at one time or another. The latest requirement is that all engines use the closed crankcase ventilation system (Type 4). According to the above classification, this would be the combination system.

Type 1--Valve Controlled by Intake Manifold Vacuum (Open) The Type 1 system conducts the blow-by to the intake manifold by way of a variable orifice valve, the opening of which is controlled by intake manifold vacuum (refer to Figure 5).

11. AC Spark Plug Division, General Motors Corp. "Crankcase and Exhaust Emission Systems," op. cit., p. 2.

12. Autolite Ford, op. cit., p. 6.

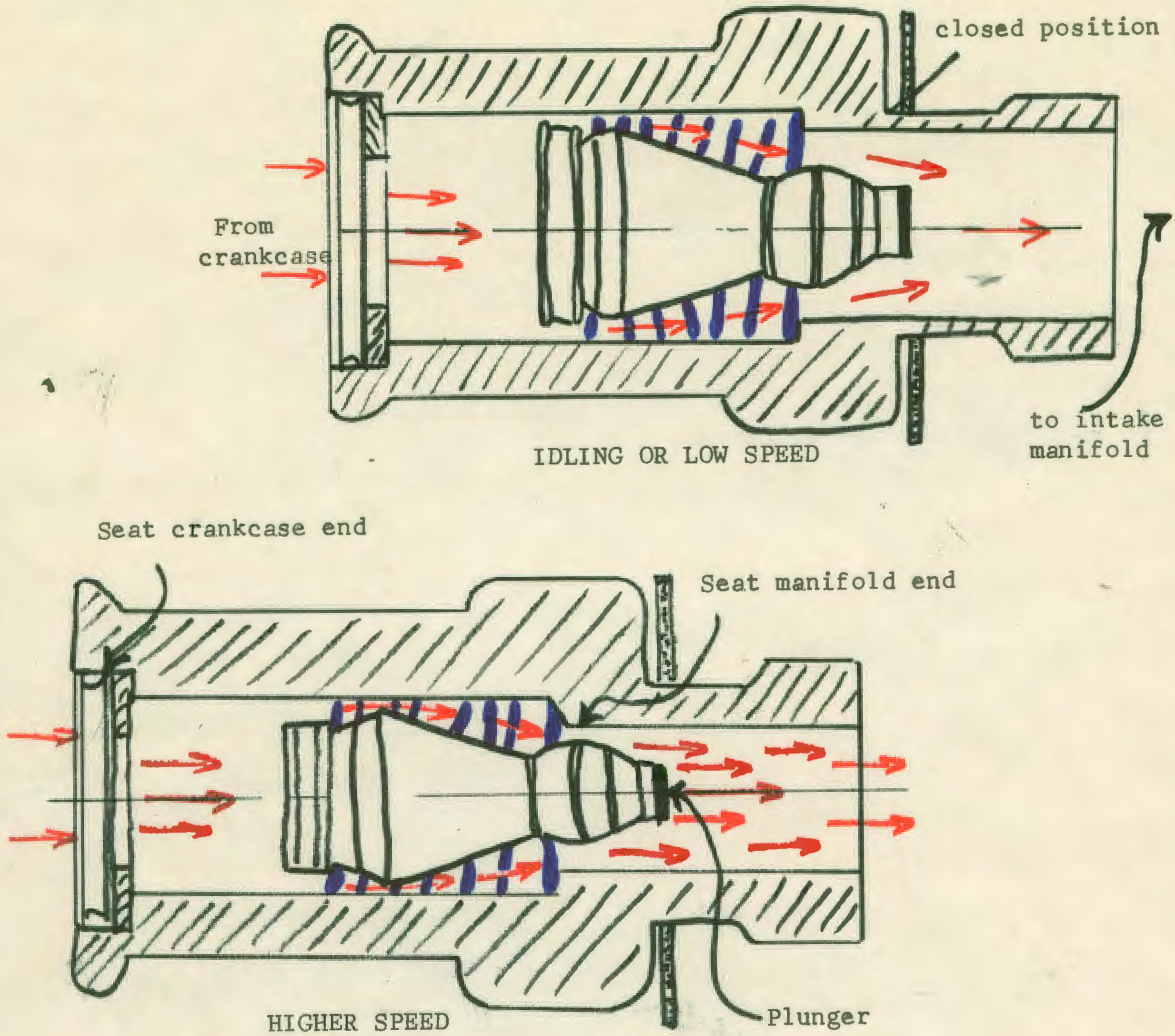

Figure 5

Type 1 System[13]

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13. Ibid.

The ventilating air entering the system flows down past the push rods into the lower portion of the crankcase where it mixes with the blow-by. Under crankcase pressure and manifold vacuum, the fumes are recirculated to the intake manifold entering either through the carburetor or below the carburetor (usually at the spacer plate). In most systems, the air flow must be regulated to meet changing operating conditions. This regulation, or metering, is essential when crankcase fumes enter below the carburetor since they will affect the air-fuel mixture ratio. Metering of these fumes is accomplished by the use of a PCV valve.

PCV systems do not rely on vehicle speed, as did the road draft tube system. Instead, they make use of the engine vacuum and crankcase pressure that exist whenever the engine is running. This assures a continuous, positive flow of ventilation through the crankcase at all engine speeds.

Since the vacuum supply for the PCV system is from the intake manifold, the flow through this system into the manifold must be controlled in such a manner that it varies in proportion to the regular air-fuel ratio being drawn into the intake manifold.

The PCV valve varies the amount of flow through the system according to the various modes of operation (i.e., idle, cruise, acceleration, etc.). The valve itself consists of a coil spring, valve, and a two-piece outer body which is crimped together. The valve dimensions, spring, and internal dimensions are such to produce the desired air flow requirements (refer to figure 5.).

During the periods of deceleration and idle, manifold vacuum is high. The high vacuum overcomes the force of the valve spring, and the valve bottoms in the manifold end of the valve housing. This does not completely stop the flow, but it does restrict the flow of crankcase vapors to the intake manifold (refer back to Figure 5--PCV Valve Operation).

Figure 6 shows the West Coast Control Valve used on some PCV systems.

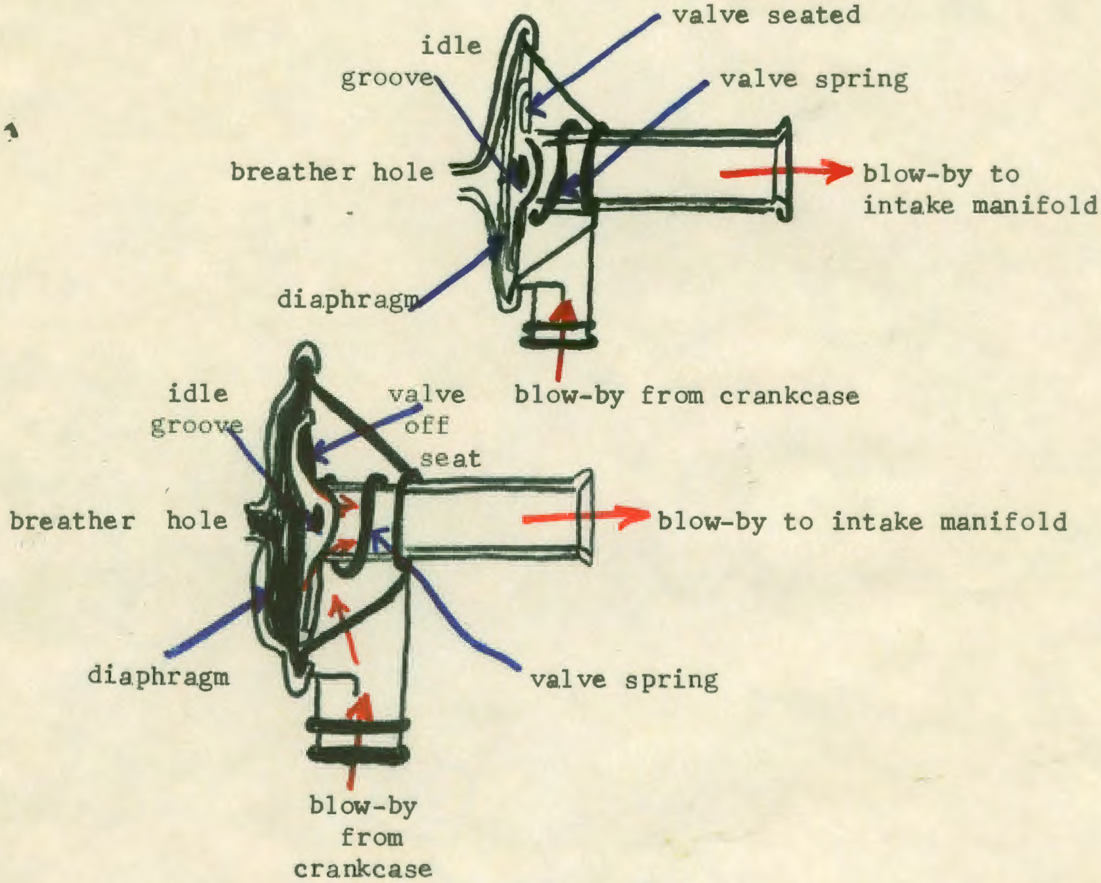

Figure 6

PCV Valve Operation[14]
West Coast Control
Valve

14. Ibid.

When the engine is accelerated or operated at constant speed, intake manifold vacuum is less than at idle or during deceleration. The spring force is stronger than vacuum pull during this mode, so the valve is forced toward the crankcase end of the valve housing. With the valve in this position, more crankcase vapors flow into the intake manifold.

In the event of a backfire, the valve plunger is forced back and seated against the inlet of the valve body. This prevents the backfire from traveling through the valve and connecting hose into the crankcase. If the backfire was allowed to enter the crankcase, it could ignite the volatile crankcase blow-by gases.

It should be noted that additional air is permitted to enter the intake manifold when positive crankcase ventilation is used. However, the carburetor used with this system is calibrated to compensate for the air, plus blow-by gas that enters the intake manifold from the crankcase. The valve illustrated in this discussion is referred to as a "constant action" valve. The slight wobbling action of the plunger tends to be self cleaning. Early model "orifice" type valves which metered through a drilled hole in the plunger had an inherent tendency to clog at the plunger bleed hole and, as a result of this, have been discontinued. Operation theory of both valves is the same.[15]

A large majority of the crankcase devices installed in American-made cars from 1961 through 1963 were of the Type 1 variety. The system includes a hose between the crankcase and the regulator valve and another hose between the valve and a fitting at the base of the carburetor.

15. AC Spark Plug Division, General Motors Corp., "Crankcase and Exhaust Emission Systems," op. cit., p. 3-4.

When the engine is not running, or if it should backfire, the valve remains in the off position. Under idle conditions, the manifold vacuum is high and the valve is still closed; a small orifice through the center of the valve handles the flow requirements. As the manifold vacuum approaches 12-15 inches of mercury, the valve begins to open; thus, increasing the flow capacity of the valve. The amount of blow-by tends to increase proportionately as manifold vacuum decreases, until, at high speeds, with low manifold vacuum, the valve, or more specifically, the plunger portion of the valve, opens and permits maximum flow. The Type 1 system was factory-installed in 1961 through 1963 with individual components instead of conversion kits available for these model year cars.[16] The overall effectiveness of the Type 1 system in controlling crankcase emissions under various operating conditions is detailed in chart form in Table 3.

There is one additional type of valve unlike the plunger type that is referred to as the dual action valve. It was used on several years production of Oldsmobile.[17] It functions as follows:

At low rpm operation, unburned hydrocarbons are drawn into the intake manifold via valve opening connecting tube, and orifice at the carburetor base plate. At high engine rpm, a slight vacuum occurs at one point, a slight blow-by pressure occurs at the underside of the check valve. This combination of vacuum and pressure raises the check valve off seat, allowing the additional blow-by to flow into the air cleaner. At this time, both the fixed orifice and the check valve are in operation.

16. Autolite Ford, op. cit., p. p. 7-8.

17. AC Spark Plug Division, General Motors Corp., "Crankcase and Emission Systems," op. cit., p. 4.

Table 3

Type 1 System Effectiveness

Conditions Affecting Emission Control	Position Throttle	Available Vacuum	Compression Pressure	Amount of blow-by from engine	Position of PVC valve	Path of blow-by	Approx. % effectiveness
Engine off[a]	closed	none	none	none	open	none	
Low Speed (idle)	closed	none[b]	low[c]	low	closed[d]	all through valve	100
Low speed (load)[e]	wide open	low	high	high	fully open	half through valve and half to atmosphere	50
High Speed	partly open	medium	medium	medium	partly open	3/4 through valve and 1/4 to atmosphere	75

a. In case of backfire, during cranking, the vacuum in the intake manifold will cause the PCV valve plunger to move toward the crankcase; thus, sealing the passage to the crankcase and preventing a possible explosion.

b. Blow-by is at a minimum when manifold vacuum is high at idle.

c. Blow-by is at a maximum when compression is high.

d. PCV valve is on minimum (closed) flow position when manifold vacuum is high.

e. For low speed, open throttle position, as well as various throttle plate positions and load combinations, the main concern of emission control is at idle and during deceleration conditions.

Source:
Autolite Ford, op. cit., p. 7.

Some Ford products also used this type of valve, and it is used as a conversion kit for used cars.[18]

Type 2--Valve Controlled By Crankcase Vacuum This system conducts emission from the crankcase system through the rocker arm cover to the intake manifold. The valve in the system is controlled by crankcase vacuum (see Figure 7).

The crankcase vacuum device was originally produced and continues to be used as a conversion kit for used cars. This system depends greatly on an airtight crankcase. No air leaks can be tolerated from the rocker arm covers or galley pans (the road draft tube must be removed or plugged when converting a used car) inasmuch as this would upset the ability of the valve to control the flow of blow-by.

The control valve meters crankcase vapors to the manifold through a variable orifice valve. The orifice is controlled by crankcase vacuum. Ventilating air is admitted to the crankcase through a restricted opening in the breather cap. The valve varies its opening to remove all of the blow-by which is now diluted with ventilating air. The flow rate adjusts to the blow-by rate of the engine and handles the requirements of most vehicles.

Type 3--Tube-to-air cleaner devices This system uses a tube type conductor between the crankcase and the carburetor air cleaner. (In some installations the air cleaner is connected to the oil filler cap.) Flow is induced into the tube by pressure drop created as engine air rushes through the air cleaner (see Figure 8).

18. Autolite Ford, op. cit., p. 8.

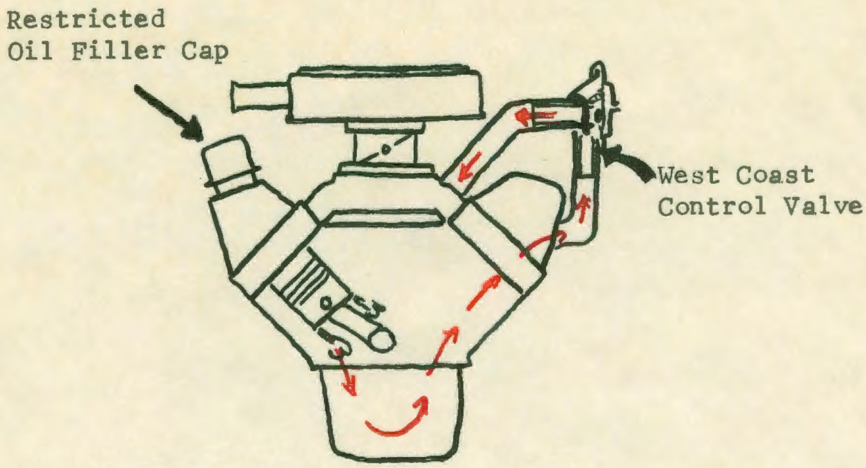

Figure 7

PCV Type 2 [19]

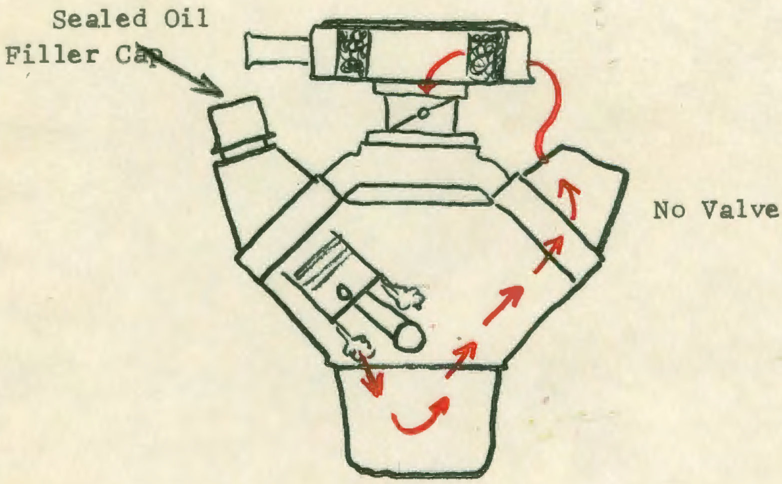

Figure 8

PCV Type Three [20]

19. Ibid.

20. Ibid.

Foreign vehicle manufacturers have made use of the Type 3 system merely to provide an escape path for the blow-by; no provision is made to introduce ventilating air to the crankcase. Thus, this system is also known as a "sealed" system.[21]

The Type 3 system was abandoned by American manufacturers because it carried over the condensation which developes in the crankcase of a cold engine. The moisture was either deposited on the air filter element or dropped into the carburetor. In cold climate, this could result in carburetor icing.[22]

One of the basic characteristics of this type of system is that it tends to enrich the fuel-air mixture. Since blow-by is mostly unburned fuel-air mixtures, the addition of the blow-by flow to the upstream side of the carburetor causes, in effect, a second charge of combustibles to blend with the carbureted mixture as it flows through the carburetor. On new cars, carburetor calibrations compensated for the secondary fuel charge. The opposite effect is encountered when the blow-by is added to the downstream side of the carburetor, as is the case with Type 1 and Type 2 systems. On these systems, ventilating air induced through the crankcase into the intake manifold tends to create a lean fuel-air mixture.

<u>Type 4--Combination Systems</u> The combination or closed crankcase system is used on all current Ford-built engines as

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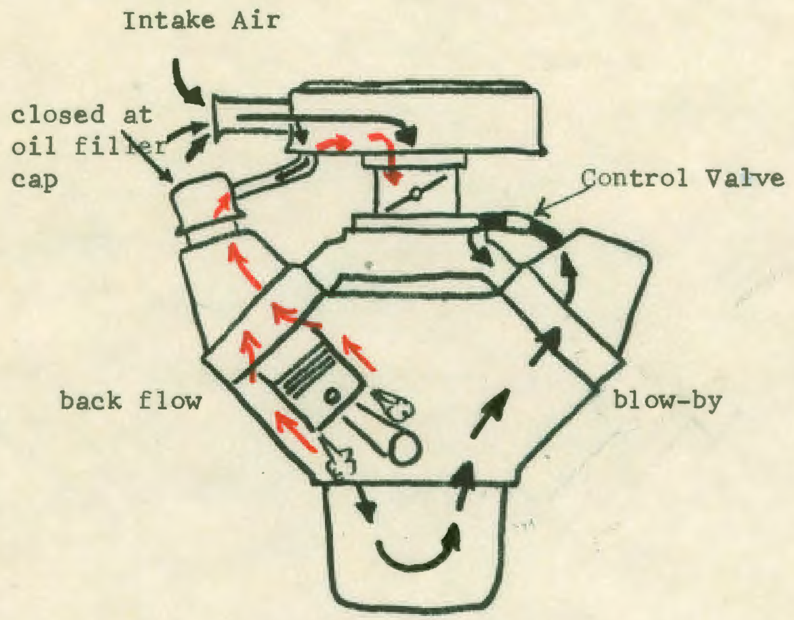
21. Ibid.

22. Ibid.

well as on most other American-made vehicles. (Refer to Figure 9.) This system is similar in many respects to the open (Type 1) system used earlier. Instead of getting fresh air through the oil filler cap as with the open system, the closed system obtains fresh air through the carburetor air cleaner. A tube routes the air to the oil filler cap which is sealed from outside air. The fresh air circulates through the crankcase and picks up blow-by as well as condensation vapors and crankcase fumes.[23]



Reverse Installation of
Control Valve can Cause
Explosion in Event of
Backfire

Figure 9

Type 4[24]
Closed or Combination Emission
Crankcase System

23. Ibid.

24. Ibid, p. 9.

The PCV control valve then meters this mixture into the intake manifold where it combines with air-fuel mixture and is burned in the combustion chamber. Possible smog-inducing hydrocarbons emitted by the exhaust system are thus virtually eliminated. The advantages and effectiveness of the Type 4 system are detailed in chart form in Table 4.

The Effect on Engine Performance and Economy

In no case should the PCV system be removed in search of some small measure of increased engine performance. The PCV-equipped engine will not adequately vent its crankcase without the system installed, and this will quickly lead to a dirtier engine which experiences increased wear rates. The removal of the system will also seriously alter air flow in the intake manifold and upset the air-fuel ratio. At idle, approximately one-quarter of the intake air flow in a modern engine flows through the PCV system. If this is cut off, either by a plugged valve or a disconnected system, engine performance will suffer. Along with rough idling and a tendency to stall, the engine will show reduced gasoline mileage until the PCV system is restored to proper working order.

Engineers explain that in any reciprocating engine of conventional design, a certain quantity of raw fuel and combustion products will bypass the piston rings and enter the crankcase during normal operation. This material must be removed or the engine will be subjected to several damaging conditions.[25]

25. AC Spark Plug Division, General Motors, op. cit., AC News, p. 2.

Table 4

ADVANTAGES OF A TYPE-4 CONTROL SYSTEM

Conditions Affecting Emission Control	Position Throttle	Available Vacuum	Compression Pressure	Amount of Blow-by from engine	Position of PCV Valve	Path of Blow-by	Approx % effect.
Engine Off[a]	closed	none	none	none	open	none	
Low Speed (idle)	closed	high[b]	low[c]	low	closed[d]	all through valve	100
Low Speed (load)[e]	wide open	low	high	high	fully open	1/2 through valve and 1/2 to air cleaner	100
High Speed	partlyopen	medium	medium	medium	partly open	1/4 to air cleaner and 3/4 through valve	100

a. In case of backfire, during cranking, the vacuum in the intake manifold will cause the PCV valve plunger to move toward the crankcase; thus, sealing the passage to the crankcase and preventing a possible explosion.

b. Blow-by is at a minimum when manifold vacuum is high at idle.

c. Blow-by is at a maximum when compression is high.

d. PCV Valve is on minimum (closed) flow position when manifold vacuum is high.

e. For low speed, open throttle position, as well as various throttle plate positions and load combinations, the main concern of emission control is at idle and during deceleration conditions.

Source:

Autolite Ford, op. cit., p. 9.

Servicing Crankcase Emission Control Systems

Although the PCV systems sound rather complicated, the service techniques used on them are relatively simple. The biggest single problem with the system is a gradual build up of sludge over a period of time that causes clogging of the various parts. This condition necessitates either cleaning or replacement of the affected parts.

The system should be tested at regular intervals as recommended by the manufacturer. AC, for example, recommends testing the system every four months or 6,000 miles, whichever occurs first and/or during engine tune up.[26]

Recommendations vary, but the PCV system of most cars should be checked and the valve serviced or replaced at least every 12 months or 12,000 miles.[27] More frequent maintenance is often necessary if:

1. The vehicle is mainly used for short trips, and the oil doesn't get hot enough to fully rid itself of volatile contaminates. Deposits have a greater tendency to build up internally, including in the valve and vent plumbing.

2. If there is a great deal of stop and go driving and excessive idling, more frequent PCV service and oil filter changes are necessary. Here, again, more than an average amount of impurities can collect internally.

3. If the engine is worn to the point that it is consuming oil at a higher than normal rate, PCV service intervals must be shortened. In this case, rings permit excessive blow-by. Far more contaminants get into the crankcase. Only if the engine is overhauled will it be possible to return to the longer recommended PCV maintenence intervals.[28]

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26. AC Spark Plug Division, General Motors, "Crankcase and Exhaust Emission Systems," op. cit., p. 5.

27. Tony Grey, "PCV: Understand The System to Sell the Service," <u>Motor Age</u>, Vol. 89, No. 4, April, 1970, p. 57.

28. Ibid, p. 57-58.

Numerous signs and symptoms of PCV system failure exist. They are: engine stalling, rough idling, overheating, oil-soaked distributor points, oil seeping from rocker cover, oil blowing out rear main oil seal, burned spark plugs, burned valves, oil dilution and contamination, sludge in the crankcase and valve chambers, oil burning because of back pressure in the crankcase, engine bearing failure, and scuffed pistons.[29]

Checking the system can be accomplished in several ways: 1. PCV tests, 2. a vacuum gage, or 3. a tachometer.

The PCV Tester By using a PCV tester, a service technician can quickly determine if the system is operating properly. The procedure for this is as follows:

1. Inspect the hoses, filler cap, oil dipstick and seal to make sure they are sealing properly.

2. Remove the oil filler cap and start the engine.

3. With the engine running at idle speed, place a PCV tester over the oil fill hole or tube.

4. If testing with the Autolite (EV-44) tester, observe the position of the yellow ball--green (good) indicates that the PCV system is functioning properly. Red (repair) indicates that the PCV system needs to be serviced.

5. Install new PCV vlave, clean hoses, and retest.[30]

Vacuum Gage When using a vacuum gage to test crankcase vacuum, an adaptation is put into the oil fill hole, the engine started, and the gage checked to determine the presence of vacuum in the crankcase. If vacuum is present, the system is all right; if not the technician must determine the cause.

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29. "How to Maintain Crankcase Ventilation," Motor Service, December, 1970, p. 35.

30. Autolite Ford, "Controlling Pollution, Part II," Shop Tips, Vol. 9, No. 7, March, 1971, p. 5.

<u>Tachometer</u> When using a tachometer to test the PCV, procede as follows: Connect a tachometer to the engine, then pinch the PCV hose leading to the intake manifold. If engine speed drops 50 or 60 rpm, the system is operating properly. If no change in speed is apparent, air flow through the system is restricted (plugged valve, clogged vacuum port, etc.). If speed drops more than 60 rpm, the valve is stuck open.

Valve operation can be checked by alternately pinching and releasing the PCV hose to the intake manifold. If the valve is operable, it will make a clicking sound as it opens and closes.

If tests indicate that the system is not operating properly, disconnect the hose at the intake manifold. A strong suction should be felt at the fitting; if not, clean the port and retest.[31]

Summary

This chapter has pointed out that there are four basic types of PCV systems to eliminate crankcase emissions:

Type 1 - Valve controlled by intake manifold vacuum (open)

Type 2 - Valve controlled by crankcase vacuum

Type 3 - Tube to air cleaner device

Type 4 - Combination Systems (closed)

Prior to the use of PCV, a road draft tube ventilated the crankcase blow-by fumes into the atmosphere causing air pollution. The PCV draws these fumes back into the engine to be burned. The PCV system has proved to be a boon to the engine, allowing a cleaner engine interior, better performance and economy, plus, by utilizing a closed system, virtually eliminating all crankcase emissions.

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31. "How to Maintain Crankcase Ventilation," op. cit., p. 34.

Servicing PCV systems is quite simple and can be accomplished by three methods: 1. PCV testers, 2, vacuum gages, or 3. tachometers.

Some common symptoms of PCV failure are: engine stalling, rough idling, overheating, oil-soaked distributor points, oil seeping from rocker cover, oil blowing out rear main oil seal, burned spark plugs, burned valves, oil dilution and contamination, sludge in crankcase, engine bearing failure, and scuffed pistons.

The use of PCV has eliminated crankcase emissions and 25% of the hydrocarbon emissions. Chapter three will discuss the source of approximately 55% of the hydrocarbon emissions, the exhaust system.

Chapter 3

EXHAUST EMISSION CONTROL SYSTEMS

Excessive exhaust emissions are due primarily to incomplete combustion in the combustion chamber. The automobile manufacturers use different means to control these emissions and likewise use different general terms to identify their systems.

There are basically two types of engine exhaust emission control systems in use throughout the automotive industry. By type, they are:

1. The Air Injection System
2. Engine Modification System

Table 5 shows the systems used by the various auto manufacturers.

Air Injection Systems

The air injection system usually consists of the following major components:[32]

1. belt-drive air supply pump,
2. air by-pass valve,
3. check valve,
4. internal or external air manifolds (combustion pipe),
5. air supply tubes on external air manifolds only.

In operation, compressed air from the pump is distributed through the air manifold to the pipe extension or each exhaust valve jet. The injection of air at this point causes those unburned fuel and oil par-

32. Autolite Ford, "Controlling Pollution," op. cit., p. 11.

Table 5

Engine Exhaust Emission Identification Chart

Vehicle Manufacturer	Air Injection System	Engine Modification Type System
Ford Motor Co.	Thermactor	IMCO IMproved COmbustion
American Motors	A.G. Air Guard	Engine Mod.
Chrysler Corp.	not used	C.A.P. Cleaner Air Package or C.A.S. Cleaner Air System
General Motors	A.I.R. Air Injector Reactor	C.C.S. Controlled Combustion System

Source:

Autolite Ford, "Controlling Pollution," Shop Tips, Vol. 9., No. 4, February, 1971, p. 10.

ticles and other by-products of combustion to burn here rather than pass out to the atmosphere through the exhaust pipe. The check valve prevents exhaust gases from entering the pump should pump or drive belt failure occur.[33] Figure 10 shows a typical air injection system.

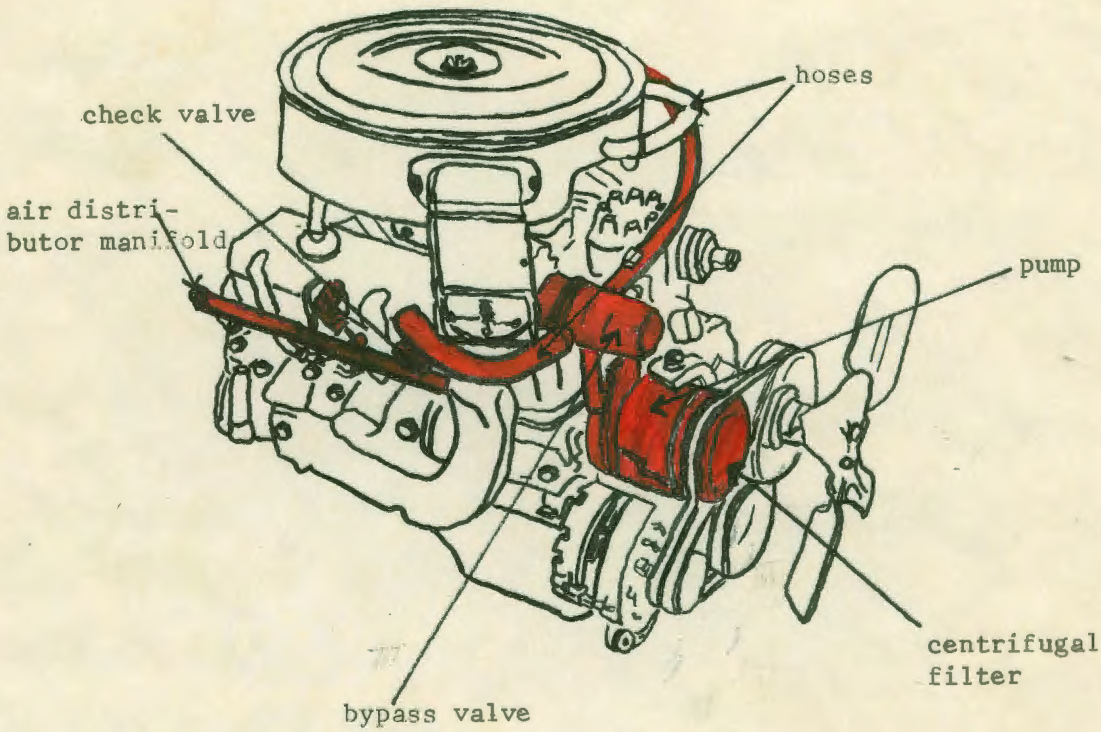

Figure 10

Air Injection System[34]

33. AC Spark Plug Division, General Motors, "Crankcase and Exhaust Emission Systems," op. cit., p. 6.

34. Autolite Ford, "Controlling Pollution," op. cit., p. 11.

During deceleration, the fuel-air ratio is very rich in the area of the exhaust valve. If the air pump system was allowed to operate under this condition, backfiring conditions would result as soon as the fresh air from the pump mixed with the overly rich vapor. A vacuum-operated diverter valve (by-pass valve) prevents this by dumping air pump output into the atmosphere during the deceleration period. Some installations, however, divert the air pump output directly back to the air pump itself.[35]

Engine Modification Systems

To reduce exhaust emissions in most new cars today, engine modifications are used to achieve more complete combustion of the fuel while maintaining satisfactory performance of the car. These modifications apply to practically every part of the engine. The most important ones enable a car to run on fuel and air mixtures that contain considerably more air than theoretically necessary for complete combustion, and thus result in less unburned gasoline and carbon monoxide. The intake system modifications include preheating the air entering the carburetor to get better mixing, opening the automatic choke faster to get more air in quicker, and improving the accuracy with which the carburetor meters the fuel-air mixture to the cylinder.

Within the engine, the surface area of the combustion chamber has been reduced to cut down quenching of the flame at cool walls. Compression ratio has also been reduced to lessen hydrocarbon emission. Valve

35. AC Spark Plug Division, General Motors, "Crankcase and Exhaust Emission Systems," op. cit., p. 5,6.

timing, idle speed, spark timing, and so on have been adjusted to approach optimum combustion[36] (refer to Figure 11 - Engine Modification System).

General Motors C.C.S.(Controlled Combustion System)

One example of an engine modification system is the General Motors C.C.S. (Controlled Combustion System). The GM C.C.S. consists of the following:

1. hot thermostats--190° - 200° thermostats result in better warm up and more complete combustion of fuel, and
2. revised timing and modified ignition distributors--initial timing is retarded at idle as compared to past years. The centrifugal advance on most distributors starts at a higher rpm. Most vacuum advance units are of the "ported" type. This means that the vacuum unit is connected to a port in the carburetor that is located above the throttle valve. Therefore, there is no vacuum advance at idle.[37]

General Motors describes their dual action vacuum advance, part of the C.C.S. system:

> Some cars use a dual action vacuum control with vacuum connections on the advance side and retard side of the diaphragm. A hose is connected from a port located just above the throttle valve. Another hose is connected from the retard side of the distributor vacuum advance assembly to a port located below the throttle valve. With the engine idling and the throttle valve closed, vacuum from the intake manifold is applied to the retard side of the vacuum advance assembly. This retards the timing approximately 5° - 10°, depending on application, below the initial timing setting. At speeds above idle, the throttle valve changes positions.
>
> Engine vacuum is then exposed to both sides of the distributor advance assembly diaphragm. The calibrated springs positioned on either side of the diaphragm are so calibrated that the vacuum in the advance side pulls the diaphragm into position, thus advancing the spark in the normal manner.

36. Epperly, op. cit., p. 4-5

37. AC Spark Plug Division, General Motors, "Crankcase and Exhaust Emission Systems," op. cit., p. 6.

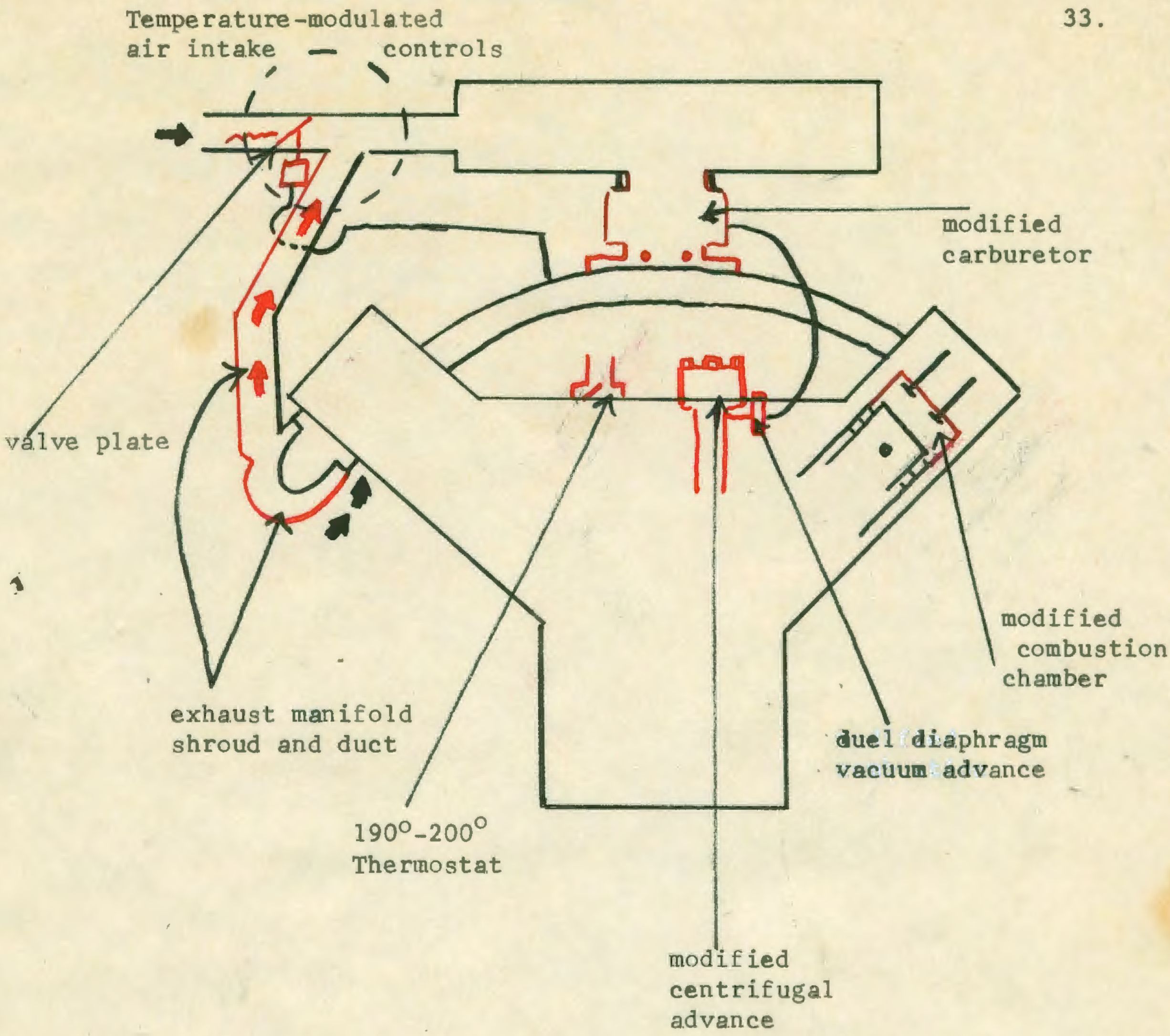

Figure 11

Engine Modifications
System

They also describe the Thermostatic Vacuum Switch, or TVS used with their system:

> Engines with retarded initial timing tend to run better at idle if allowed to idle for lengthy periods of time. Therefore, many engines are equipped with a thermostatic vacuum switch (TVS). When the coolant temperature reaches a specified value, the valve connects direct engine vacuum to the distributor advance which advances the spark timing to speed up the engine. This results in lower combustion chamber temperature and, along with higher fan speed, cools the engine down. After the engine has cooled, the TVS switches the vacuum back to the normal retarded position.
>
> This valve is located in the engine coolant jacket near the front of the engine and normally has three hose connections, although in some instances, it may have either two or five depending upon the design of distributor being used. When five connectors are used, they are labeled as follows: MT-manifold vacuum, CA-carburetor advance, DA-distributor advance, CR-carburetor retard, and DR-distributor retard. The latter two connections were used as early as 1968 and have since been plugged at the TVS adapter connector.

C.C.S. also employs a vacuum advance valve:

> Some models use this valve to provide for better combustion during coasting conditions when the throttle is closed and engine vacuum is high. This valve applies direct engine vacuum to the distributor to advance ignition timing which results in more complete combustion of the fuel charge.

Carburetion for the Controlled Combustion System varies somewhat, also. General Motors comments:

> Most cars use a carburetor designed and calibrated to deliver a leaner fuel-air mixture. Idle speeds are also higher because, as previously mentioned, initial ignition timing is generally retarded as compared to previous years. By comparison, if two equal engines were in operation, with the only difference being that one had retarded timing, a wider throttle plate opening would be required to obtain the same rpm on the engine with the retarded spark. With a wider throttle opening, more air can be drawn into the intake manifold resulting in a leaner fuel-air mixture during idle or off-idle throttle position.
>
> Many carburetors have an idle fuel limiting feature. This is a fixed internal orifice at the base of the idle mixture screw which means that if the screw is turned outward in excess of its designated area of adjustment, fuel-air ratio will not be greatly affected.

GM also employs the "idle stop solenoid" to correct the possibility of dieseling after turning off the ignition because of the higher idle speeds used with emission control systems. This solenoid allows the throttle valve to close beyond the normal idle position when the ignition switch is turned off. General Motors cars equipped with C.C.S. also employ a thermostatically-controlled air cleaner:

> The thermostatically-controlled air cleaner is designed to keep air entering the carburetor at approximately 100° when underhood temperatures are less. By keeping the air at this temperature, carburetor icing can be minimized, engine warm up can be improved and finally the carburetor can be calibrated for leaner fuel-air mixture ratios which will reduce hydrocarbon emission. This system is also referred to as the Auto Thermac.
>
> The Auto Thermac system basically consists of a temperature control sensor, vacuum-operated air control motor, hoses and pipes. Also included is the necessary shrouding (heat stove) around the exhaust manifold which supplies heated air to the carburetor. The sensor is located in the cleaner body in the clean air side of the air filter. In operation, the sensor bleeds varying amounts of air, depending on the temperature, to the vacuum motor which, in turn, through its linkage, provides for four modes of operation:
>
> 1. the static mode: when the engine is not in operation, the control damper assembly will be so placed that the snorkel tube passageway will be open and the hot air pipe will be closed as a result of the absence of vacuum in the diaphragm chamber of the vacuum unit and the effect of the diaphragm spring which pushes the diaphragm and its linkage downward.
>
> 2. hot air delivery mode - at underhood temperatures of less than 85° - when the engine is started, engine vacuum is applied to the vacuum chamber in the motor via the connecting hoses and the sensor. The vacuum overcomes the force of the diaphragm spring and the diaphragm and linkage are pulled upward. In turn, the control damper assembly is positioned to shut off the flow of cold air and permit hot air to enter the air cleaner through the hot air pipe. In case the engine should be heavily accelerated while in the hot air mode, the vacuum level in the system will drop to a very low level which in turn will cause the motor diaphragm spring to push the diaphragm and linkage downward, thus positioning the control damper assembly to permit air to enter the air cleaner through the snorkel tube.
>
> 3. cold air delivery mode - when temperature of air at the sensor is above 128° - the sensor bi-metal spring relaxes and moves downward. This allows the sensor air bleed valve to open. A sufficient amount of air will bleed into the motor vacuum diaphragm chamber, droppings its vacuum level. The

diaphragm spring will force the diaphragm and its linkage downward, placing the control damper assembly so as to open the cold air passage and close the hot air pipe, permitting cold air to enter the air cleaner.

4. regulating mode - at temperatures between 85° and 128° - varying amounts of air are bled into the system, depending on the exact temperature at the sensor unit. This results in a vacuum level and control damper assembly position required to maintain carburetor air temperature at from 85° to 128° when underhood temperatures are below this range.[38]

The General Motors C.C.S. is typical of the engine modification systems and illustrates the operation and service of all systems utilizing engine modification to control exhaust emission.

Service

Service of these exhaust emission systems requires the use of very sophisticated equipment. In addition to an engine analyzer to insure proper tune up settings, an exhaust emission analyzer is necessary to check hydrocarbon and carbon monoxide emission to make certain that the vehicle meets standards set by federal and state governments.

Servicing these systems usually results from one of two possible reasons: engine malfunction or a spot check of emission levels indicates that service is necessary. The engine should also be brought within accepted emission levels during the course of a routine tune up.

Engines that are equipped with air injection, in addition to regular tune up, should have the air pump checked periodically to make certain its output is sufficient. Also, the check valves in the air manifold should be checked to make certain that exhaust cannot leak past them.

The air by-pass valve that allows air pump output to be vented to the atmosphere when deceleration ocurrs should also be checked. Unless it is working properly, the air injection and exhaust systems can be

38. Ibid, pp. 6-10.

ruined because of severe backfire upon deceleration.

Servicing controlled combustion systems is usually simply a matter of routine tune up. However, with these systems, it is vital that the exact manufacturers specifications be adhered to. Close is not good enough.

Also, the complete fuel and ignition system should be checked to make certain that all parts meet specifications. Just one small system defect can affect the entire system adversely. For example, 2^{o} of timing error can be the difference between a car that meets specifications of emission and performs properly and one that seems in need of a complete tune up.

Summary

Exhaust emissions are controlled by two methods:

1. air injection into the exhaust manifold
2. engine modification systems

To reduce exhaust emissions in most new cars today, engine modifications are used to achieve more complete combustion of the fuel while maintaining satisfactory performance of the car. These modifications apply to practically every part of the engine. Figure 12 diagrams the effectiveness of these systems since 1960.

Servicing of vehicles with exhaust emission control systems requires the technician to meet absolutely the manufacturers specifications in order to insure good performance.

This chapter has discussed methods presently in use to meet emission levels set by regulations. Chapter four will deal with the last source of auto emissions, the fuel tank and carburetor and evaporative emission control.

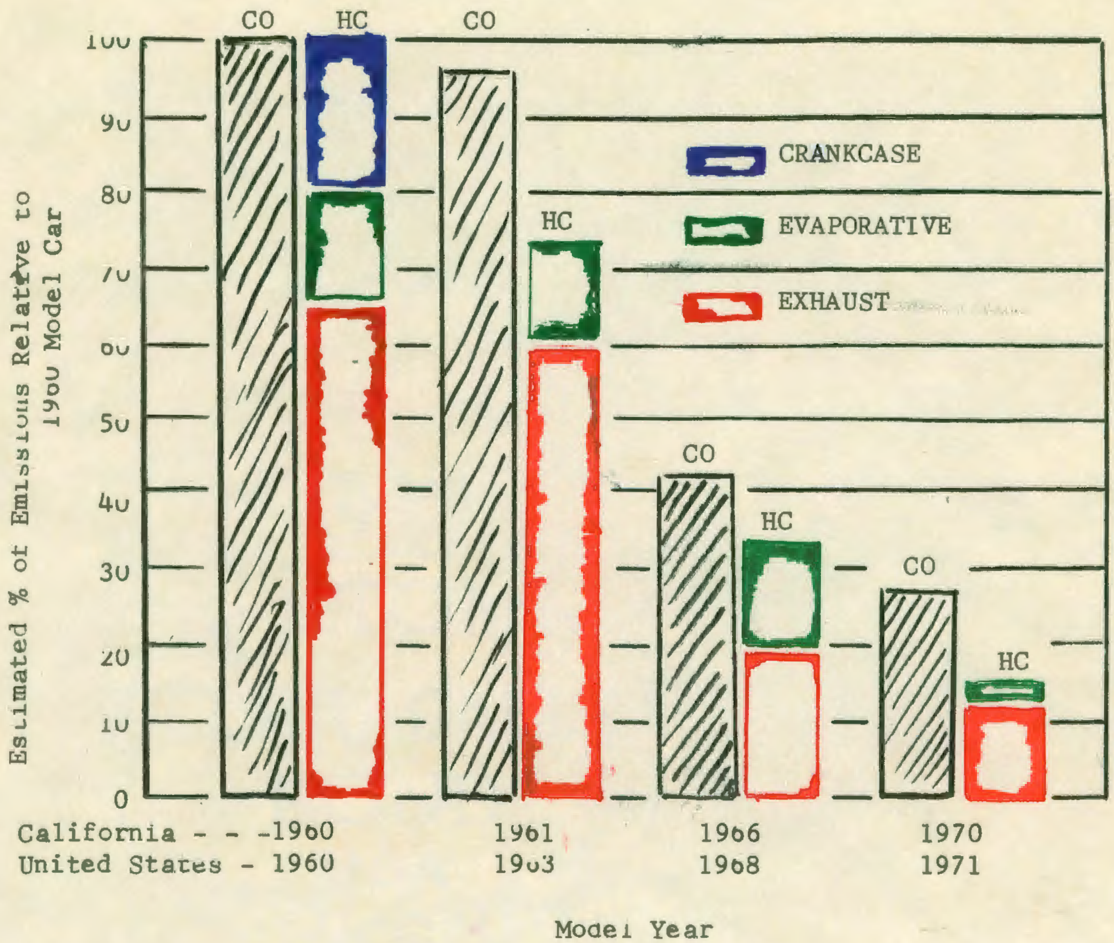

Figure 12

Estimated Reduction of Hydrocarbon and Carbon Monoxide Emissions[39]

39. Epperly, op. cit., p. 23.

Chapter 4

EVAPORATIVE EMISSION CONTROL SYSTEM

To reduce the hydrocarbon emissions from evaporation from the fuel tank and carburetor, companies have developed technology to collect and store evaporating gasoline for later burning in the engine. Esso Research and Engineering Company has demonstrated an evaporative loss control device called "ELCD." This device can virtually eliminate evaporative losses. The heart of the system is a canister of activated charcoal which absorbs the hydrocarbons evaporating from the fuel tank and the carburetor. Under selected engine operating conditions, the hydrocarbons trapped in the canister are released by drawing air through the canister, and are then fed through special lines to the combustion chamber, where they are burned. This system is both dependable and durable. Charcoal absorption systems and other similar devices are being used commercially on 1970 cars in California, and they will be on all 1971 new cars nationwide. These systems have eliminated emissions from the carburetor and the fuel tank.[40]

Figure 13 shows the evaporative emission control system.

Chapter five will discuss several of the more practical and promising systems and a means of meeting future emission standards.

40. Ibid., p.p. 3-4.

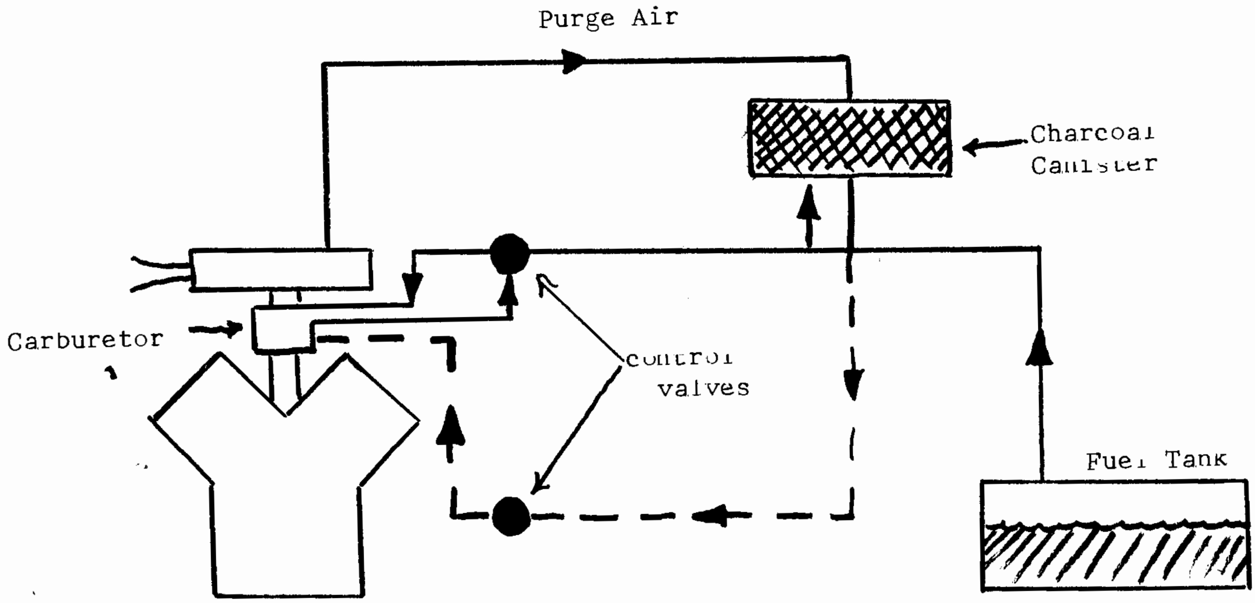

Figure 13

Esso Research Evaporative
Loss Control Device[41]

41. Ibid, p. 20.

Chapter 5

POLLUTION CONTROL FOR THE FUTURE

As stated in previous chapters, crankcase emissions have been virtually eliminated and exhaust and fuel system emissions are steadily falling. However, in order to meet the 1980 federal requirements (see Table 2, Chapter 1), some radical changes in automotive power plants are going to have to take place.

Control systems for auto emissions in the future fall under several categories or combinations of categories:

1. Alternate power plants:
2. a. fuels

   b. catalytic converters

   c. exhaust manifold reactors

   as further modifications of the internal combustion engine.

At the present time, the internal combustion engine appears to be the most practical power plant for American automobiles. With this in mind, step one is to examine the necessary modifications to the internal combustion engine that will allow it to meet federal specifications. (In most cases, these systems have not yet completely satisfied 1980 specifications, but appear to be the most likely to do so.)

The first question that comes to mind when referring to the conventional internal combustion engine is why keep it if something else is available?

T.O. Wagner, research associate for AMCO Research and Development

Laboratory, Whiting, Indiana, says "The internal combustion engine still beats any alternative as a practical power plant for American autos, but the gap may be narrowing. Gasoline engines are still far in the lead because they are reliable, durable, efficient, responsive, compact, light, quiet, and cheap. Also, they have a lower volume of exhaust that must be treated than most other engines. But, unless they are modified for low emissions, they are dirty and modifying them impairs performance, raises costs, or both, and narrows the gap in acceptability between them and alternate power plants."[42]

Research indicates that at the present time, there are three methods of control that have passed performance and economy tests and appear most likely to be used in one form or another: 1. fuels, 2. catalytic converters, and 3. exhaust manifold reactors.

Fuels

Low or unleaded gasoline will be necessary in the future for two reasons: 1. to reduce particulates caused almost solely by tetraethyle lead (TEL), and 2. to allow catalytic exhaust converters to function with economy and longevity.

However, since lead in the gasoline serves two important functions (raising octane rating cheaply and providing valve lubrication), it cannot be simply eliminated. Other methods must be found to do the jobs that lead performs before it can be completely removed from gasoline.

42. James E. McKelvey (ed.), "Alternate Engines May be Closing the Gap," Motor Service, April, 1971, p. 33.

Gasoline that is currently being used has many carefully "refined in" characteristics. Following are some of the characteristics of a good gasoline:

1. It must have controlled volitility (it must not evaporate too quickly or too slowly).

2. It must provide good cold <u>and</u> hot starting.

3. It must burn smoothly to prevent knocking.

4. It must be anti-icing.

5. It must be stable during storage.

6. It must have cleaning properties to remove carburetor deposits.

It is engine knock that we are most concerned with when talking about lead removal. Basically, three things will cause engine knock: 1. improperly adjusted timing, 2. high compression and/or 3. low octane fuels. The dilema lies in that engines perform best on high compression, and this necessitates high octane fuels.

Most regular fuel engines today operate at about a 9-1 compression ratio. Dropping this to 8-1 would result in a decrease of 6% in gas mileage. Premium fuel engines currently run at about 11-1 compression ratio and dropping this to 8-1 would result in a 12% reduction in gas mileage.[43]

Current octane ratings for premium and regular gasoline add the amount of TEL required to bring them to this and are illustrated in Figure 14.

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43. W. Robert Epperly, "Gasoline Composition and Air Pollution," (remarks made at the Public Hearing on Air Pollution of the New Jersey Clean Air Council, Trenton, N.J., April 9, 1970), p. 3.

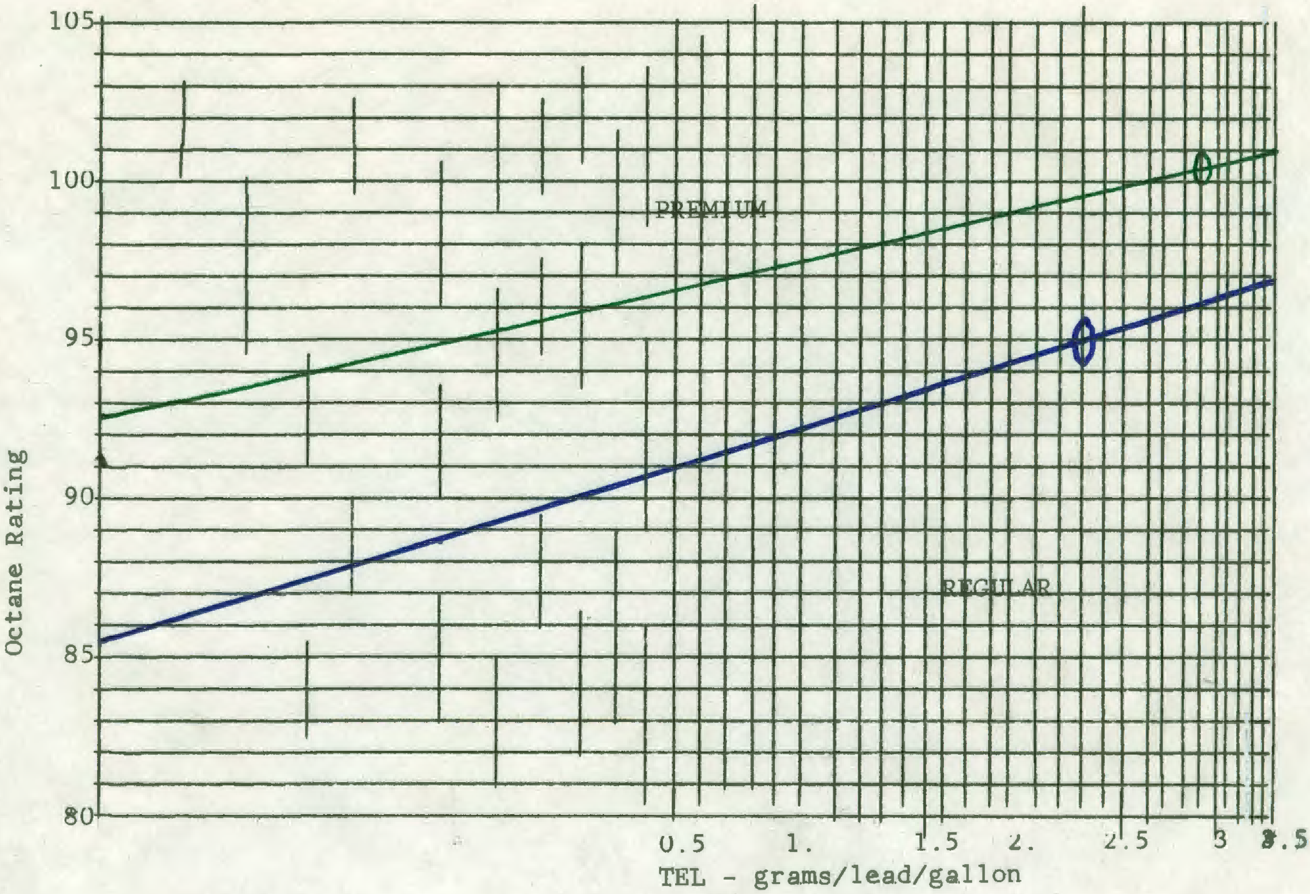


Figure 14

TEL Raises Octane Ratings[44]

44. Ibid., p. 7a.

The octane requirements of automobiles varies greatly with the compression ratio and even autos with similar compression ratios will vary as to their requirements.

Figure 15 is a plot of the octane ratings required to satisfy different percentages of cars at various compression ratios. One hundred octane premium fuel will satisfy 99% of the automobiles and 94 octane will satisfy 66 2/3% of them.

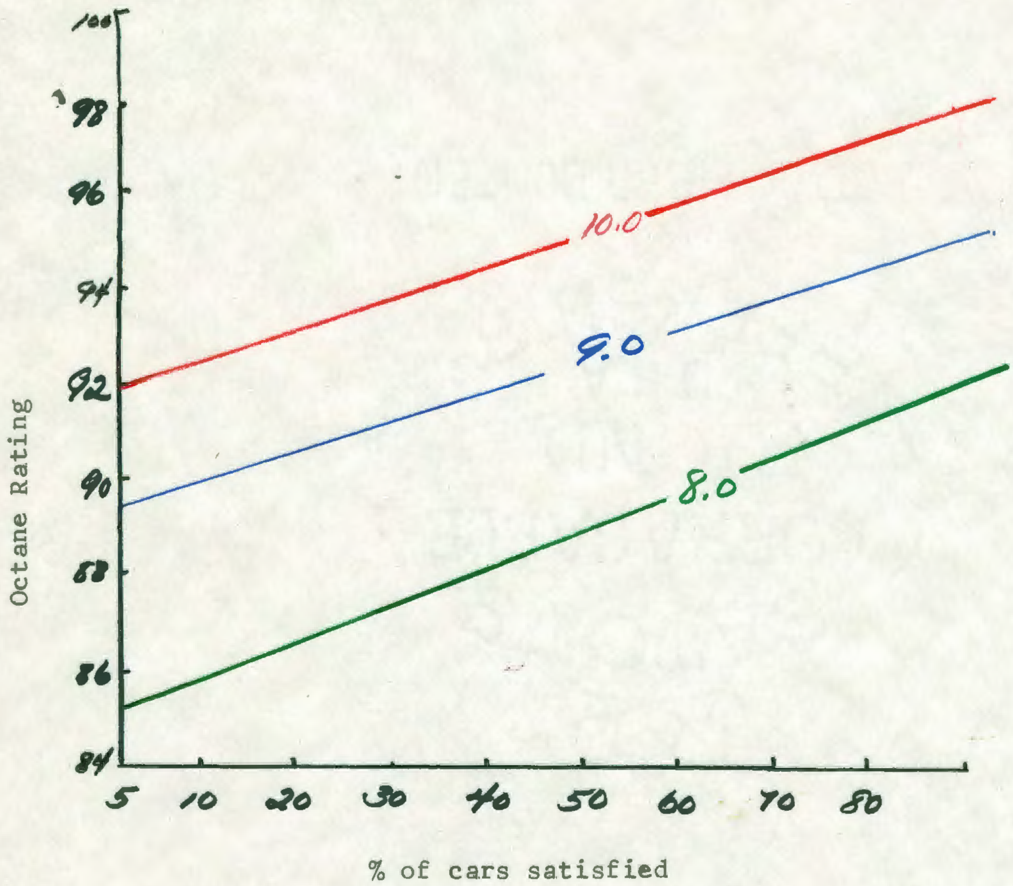


Figure 15

Octane Requirements[44]

44. Ibid., p. 8b.

As shown earlier, basic premium gasoline starts out at 93 octane and regular at 86 octane. Before addition of TEL, these octanes are in a range to satisfy 55% and 4% of the cars respectively.[46]

The basic hydrocarbon groups that are used in gasoline are linear and branched paraffins, aromatics, and olefins. Linear paraffins have very poor octane ratings; olefinic hydrocarbons, fair; with highly branched paraffins and aromatics having good ratings. Figure 16 shows the molecular structures of these various hydrocarbons.

The main difficulty, therefore, in removing TEL from gasoline is that we must increase the number of aromatics and branched paraffins in the gasoline. As yet, no one has found a cheap way to tear molecules apart and rearrange them into the designed configureation.[47]

Processes to carry out such rearrangements have been developed and are in use today, but none of these is inherently cheap. However, gasoline companies are constantly working to lower the cost of this process.

Gasoline companies are working to overcome the cost problems; automotive companies are working to solve exhaust valve problems; both so that we may derive the benefits of using first low lead, then lead-free gasoline. These benefits are the elimination of particulates by elimination of TEL and the allowance of the use of catalytic converters that will drop the exhaust emission to an accepted level.

The Catalyst System

The catalyst system, illustrated in figure 17, uses one catalyst to

46. Ibid, p. 9.

47. Ibid.

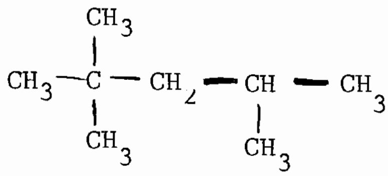
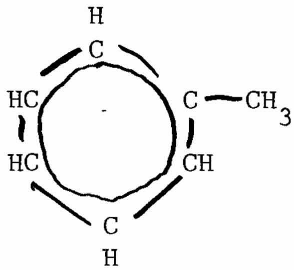
Hydrocarbon Type	Example	Octane Rating
Linear Paraffin	$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$	Poor
Branched Paraffin		Good
Aromatic		Good
Olefin	$CH_3 - CH = CH - CH(CH_3) - CH_3$	Fair

Figure 16

HYDROCARBON MOLECULAR STRUCTURE[48]

48. Ibid., p. 26.

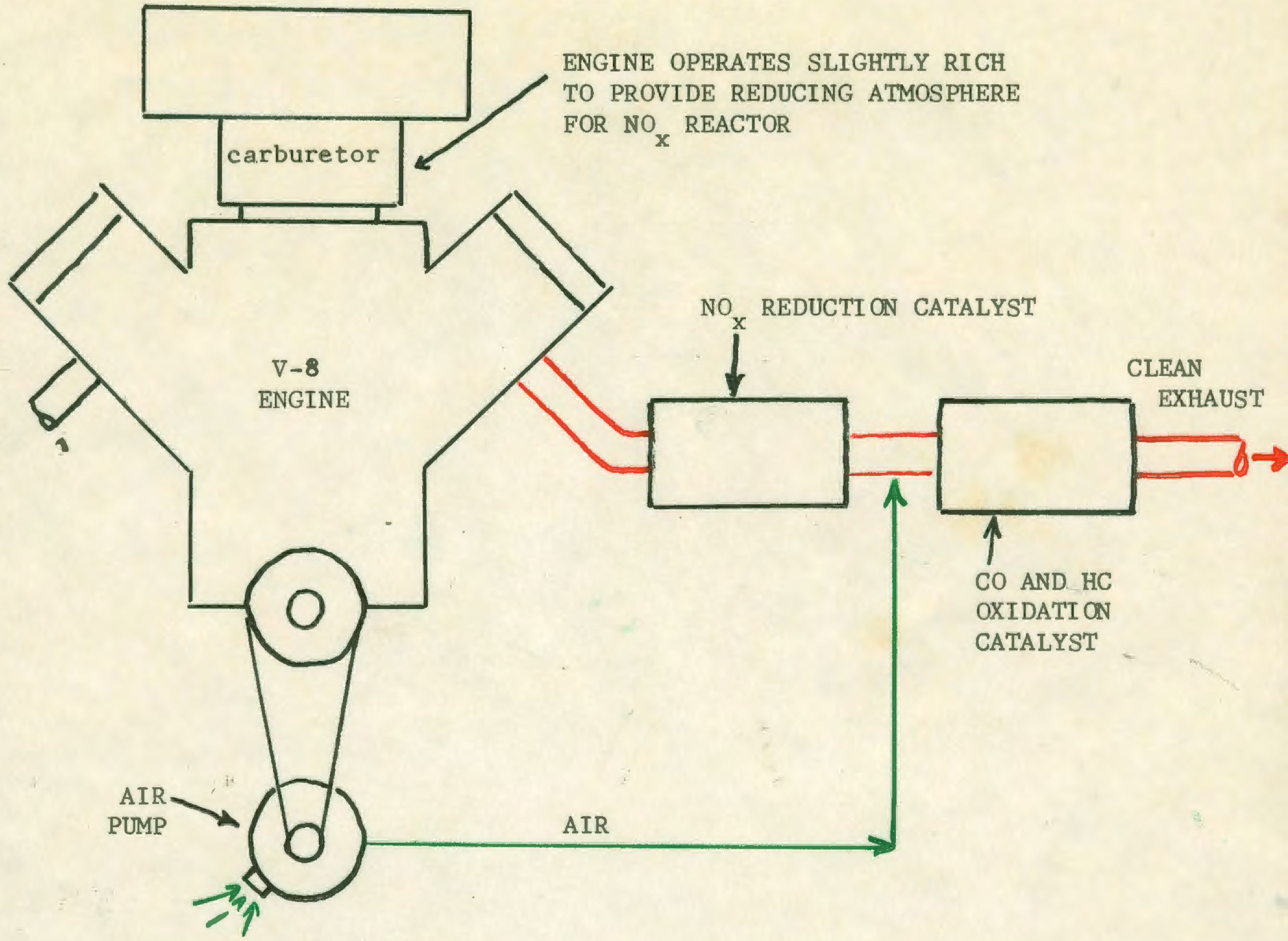


Figure 17

Dual-Catalyst System[49]

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49. Epperly, "Control of Automotive Emissions..." op. cit., p. 28.

Table 6

"Dual-Catalyst" Experimental Car

	Grams per Mile		
	CO	HC	NO_x
Exhaust Emissions			
4000 lb. vehicle	6.9	0.45	0.35
2000 lb. vehicle	3.9	0.25	0.2
1975 Targets	11.0	0.50	0.9
1980 Targets	4.7	0.25	0.4

- fuel economy debit 3%
- requires clear fuel

Source:

W. Robert Epperly, "Control of Automotive Emissions--Past, Present, and Future," (an unpublished report presented to the Montana Petroleum Association, Billings, Montana), Esso Research and Engineering Company Linden, New Jersey, September 25, 1970, p. 37.

reduce nitrogen oxides and another to reduce hydrocarbon and carbon monoxide levels.

Thermal Reactor System

Another system, the termal reactor system, figure 18, is used to reduce emission and has been tested successfully.

Combination System

Another possible alternative has been developed in a kind of combination of systems by Ford. Ford's smog-free engine is not a new engine concept, but a carefully-worked-out combination of systems that have been applied to an existing production engine. The systems that make the engine smog-free are:

1. fuel injection, for uniform air-fuel mixture in all cylinders.
2. metering of air and fuel for air-fuel ratios of 18-1 or leaner.
3. stratified-charge combustion, for complete burning of the mixture.
4. exhaust gas recirculation, to combat emissions of oxides of nitrogen (which increase when hydrocarbon and carbon monoxide elements are most efficiently burned).

The stratified-charge engine produces a 25 percent power increase, plus a ten per cent improvement in economy.[50]

Alternate Power Plants

Some authorities feel that alternate power plants will have to replace the internal combustion engine in order for emission control to be

50. Jim Dunne, "Ford's New Smog-Free Engine," Popular Science, May 10, 1970, p.p. 55-56.

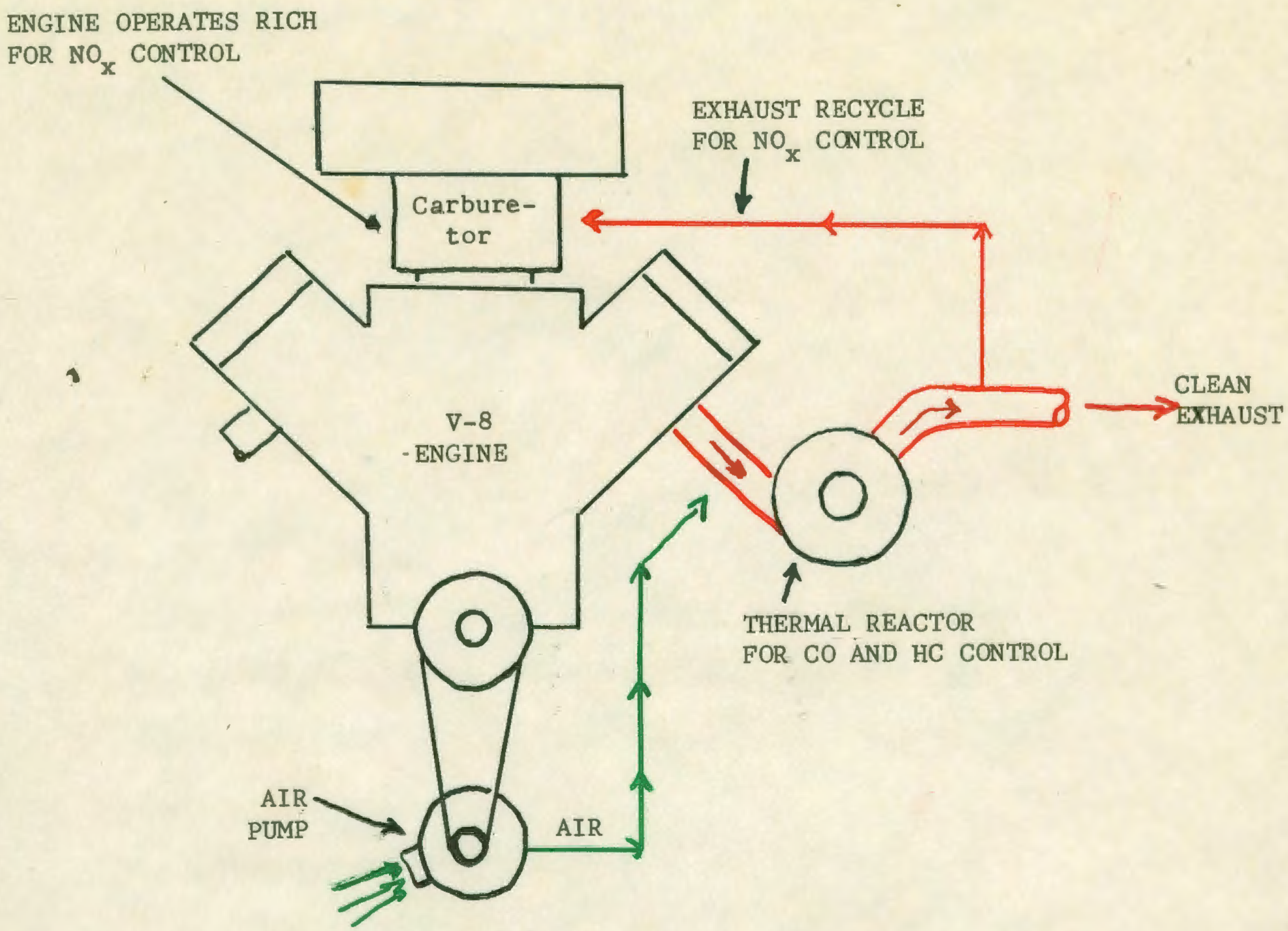

Figure 18

Thermal Systems[51]

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51. Epperly, "Control of Automotive Emissions..." op. cit., p. 26.

Table 7

"Thermal" Experimental Car

	Grams Per Mile		
	CO	HC	NO_x
Exhaust Emissions			
4000 lb. vehicle	7.0	0.25	0.6
2000 lb. vehicle	3.9	0.14	0.3
1975 Targets	11.0	0.50	0.9
1980 Targets	4.7	0.25	0.4

- Fuel Economy Debit 18%
- Operates with leaded fuel
- Will require clear fuel to meet particulate targets

Source:

W. Robert Epperly, "Control of Automotive Emissions--Past, Present, and Future," (an unpublished report presented to the Montana Petroleum Association, Billings, Montana), Esso Research and Engineering Company, Linden, New Jersey, September 25, 1970, p. 35.

successful. Several have been suggested and tested by various companies. Among these are the Stirling Engine, the Wankle rotary gasoline engine, the diesel engine, the gas turbine, a hydrid engine-battery system, and the steam engine.

T.O. Wagner, previously quoted research associate for Amoco in Indiana, evaluated these various proposed alternative power plants at a recent meeting of scientists from American Oil and affiliated companies. He presented the following conclusions:

1. The Stirling Engine: rated as the cleanest of all the practical power plants and about as efficient as the diesel. Although it provides highest emission control and is quiet and efficient, it is bulky, complicated, and expensive. The engine itself works as an external combustion device, using a sealed working medium (hydrogen), two heat exchangers, a displacerpiston, and a working piston. The displacer piston moves the medium between heat exhangers to alternately heat and cool it, and the resulting pressure changes activate the power plant.

2. The Wankel Rotary Gasoline Engine: compact, light, cheap, and quiet with unproved durability; dirtier than internal combustion engines, but allows for more "tinkering" to clean them up without performance damage; also allows more room to install devices such as catalytic units because of small size. Most competitive of all.

3. Diesel engines: rated as very clean and extremely durable, so durable that they keep right on running without maintenance which causes smoky, smelly, dirty emissions eventually without proper service; low on hydrocarbon and carbon monoxide emission, but nitrogen oxide emissions are a problem with no immediately foreseeable solution; the diesel is also noisy and expensive and hard to start in cold weather.

4. Gas turbines: expensive and sluggish; inefficient at low power output as standard for passenger cars; also noisy. Advantage: vibration fee.

5. Hydrid engine-electrical systems: (an electric car with a battery charger carried on board which overcomes the major drawback of electric cars--limited battery capacity), impractical for full-size cars because of necessary weight and expense. Quiet, rates well on emissions; bulky, heavy, complicated, and expensive.

6. Steam or "vapor cycle" cars: quiet with low emission, but bulky, complication, inefficient, expensive, slow to start, unreliable.

Wagner concludes that "for a variety of reasons---technical, political and economic, and sociological---I think that for a while, at least the next decade, legal emissions limits will be tough, but they will be met with conventional engines. There just aren't any acceptable alternatives that give lower emissions; and a legislator who makes the public walk isn't going to get re-elected."[52]

Summary

Future exhaust emission controls will come from one or a combination of the following:

1. low lead or no lead fuels

2. revising the internal combustion engine by catalytic converters or exhaust manifold reactors or some further engine modifications which might include fuel injection, leaner fuel-air mixtures, stratified-charge combustion or exhaust gas recirculation.

52. James E. McKelvey, op. cit., p.p. 33, 86.

Some alternative power plants such as the Stirling Engine, the diesel, the Wankle, steam engines, engine battery combinations, and gas turbines are being tested, but currently fall short of the internal combustion engine for general practicality.

SUMMARY

RECOMMENDATIONS AND CONCLUSIONS

Smog was first noticed over Los Angeles in the late 1940's In 1952, the automobile was named as a major contributor to the problem of photo chemical smog. It was ultimately discovered that the automobile's contributions came from: crankcase blow-by, 25%; exhaust, 55%; and fuel tank and carburetor emissions, 20%.

The PCV was introduced in California in 1961, becoming nationwide in 1963. PCV has evolved through four major types of systems (Positive Crankcase Ventilation):

Type 1 - valve controlled by intake manifold vacuum (open)

Type 2 - valve controlled by crankcase vacuum

Type 3 - tube to air cleaner device

Type 4 - combination system (closed)

The end result is that PCV has virtually eliminated, through the type 4 system, the crankcase blow-by as a source of auto emissions. In addition, the PCV has helped engine economy, performance, and longevity to a certain degree.

Another source of automotive emission is the engine exhaust. This is an area that researchers are still working at to completely control. At present (1971), exhaust emissions are down approximately 50%. Exhaust emission is not as easily controlled as crankcase emissions, but the ultimate goal is 100% control in this area also. The systems presently in use for exhaust emission control are the A.I.R. system and the engine modification system. The air injection system consists primarily of an air pump and an air manifold in conjunction with the exhaust manifold. By injecting air to the exhaust manifold, the exhaust gas hydrocarbons keep on burning. This reduced hydrocarbon emissions into the atmosphere.

The engine modification system goes at the source of the problem, the fuel ignition and compression areas of the engine. It:

1. provides leaner fuel-air ratios
2. alters timing to provide more complete combustions
3. alters combustion chamber design to reduce surface area,

thus reducing unburned hydrocarbons to the exhaust.

All auto manufacturers are currently using this system on their new cars.

The evaporative emission control system is designed to prevent emission from the carburetor and fuel tank. By holding gasoline vapors for re-burning at a later time, this system eliminates evaporative emission from the automobile.

Future emission control systems to meet 1975-1980 specifications will probably be refinements of existing systems as soon as hardware problems can be worked out. Unleaded or low lead gasoline will play a large part in hydrocarbon and particulate emission control. By 1975, the TEL should be removed from gasolines. As a result, low cost methods are going to have to be found for replacing the two major functions of TEL: 1. raising octane ratings, and 2. lubricating exhaust valves.

The more distant future may see such things as alternative power plants replacing the internal combustion engine in cars. Some possibilities already being investigated are the Stirling Engine, the gas turbine, the diesel, the Wankel, steam engines, and combination battery engines.

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GLOSSARY

Advance — to move forward, such as ignition timing

A.I.R. — An air injection system of exhaust emission control (Air Injection Reactor) A product identification name of General Motors Corp.

Air Cleaner — a device mounted on the carburetor through which air must pass on its way into the carburetor air horn. It filters out dirt and and dust particles and also silences the intake noise.

Air Guard — an air injection type exhaust emission system. A product identification name of American Motors Corp.

Air injection — a system whereby pressurized air is transmitted to each exhaust port of the engine. The fresh charge of air mixes with hot exhaust gases and promotes more complete burning of hydrocarbons and carbon monoxide.

Air Pump — an engine belt-driven air pump, incorporating a rotor and three vanes. The vanes rotate freely about an off-center pivot pin, and follow the circular shaped pump bore. A basic component of all air injection type exhaust emission systems

Blow-by — the name given to the high pressure gases that escape past the engine piston rings into the crankcase during both compression and power strokes.

Bypass valve — a valve to control the air supply from the air pump. Normally closed, but opens on engine deceleration to divert air from cylinder head ports to the atmosphere.

C.A.P. (Clean Air Package) An engine modification type exhaust emission system which relies on precision carburetion, breathing and ignition to burn fuel more efficiently. A product identification name adopted by Chrysler Corp.

C.C.S. (Controlled Combustion System) an engine modification type exhaust emission system similar to C.A.P. offered by Chrysler. A product identification name adopted by General Motors Corp.

Check Valve — a one-way valve to prevent exhaust gas backflow into the air pump and air bypass valve in event of pump failure.

Closed System — related to a crankcase emission system which obtains fresh air through the carburetor air cleaner and routes it through a tube to the oil filler cap.

Deceleration Valve — or Distributor Vacuum Advance Control Valve a device used in conjunction with the dual diaphragm vacuum advance unit to advance timing under deceleration conditions

Diverter Valve — (refer to bypass valve) this provides same function as bypass valve. A product name of General Motors.

Duct and Valve Assembly — an assembly incorporated in air cleaner to regulate the temperature of carburetor intake air.

Emission — the act of emitting or releasing from an engine products of incomplete combustion--principally hydrocarbon and carbon monoxide.

Exhaust Gas Analyzer — an instrument for determining air-fuel mixture ratio of the carburetor.

Hydrocarbon — any compound composed of carbon and hydrogen, such as petroleum products. Excessive amounts in the atmosphere are considered undesirable contaminants and a major contributor to air pollution.

IMCO — an improved combustion type engine exhaust emission system. A product identification name of Ford Marketing Corp. Similar to engine exhaust emission systems used on G.M., Chrysler, and American Motors vehicles. (IMproved COmbustion).

Manifold — a tube or pipe for conveying liquids or gases. On injector emission control-eqipped engines, an air manifold is utilized in addition to the engine intake and exhaust manifolds.

Manifold Control Valve — a thermostatically operated valve in the exhaust manifold for varying heat to intake manifold with engine temperature.

Modification — an alteration. To change from original, such as engine modifications--design change, component change, etc.

Open System — descriptive term for crankcase emission control system which draws air through the oil fill opening.

PCV — Positive Crankcase Ventilation emissions systems or Regulator crankcase emission control valve. A valve which controls crankcase vapors which are discharged into the engine intake system and pass through the engine cylinders rather than being discharged into the air.

Pollution	to soil, stain or corrupt by contact. To render unfit for a specified use. (Contaminate level presently specified as less than 275 parts per million of hydrocarbon and less than 1.5% carbon monoxide by volume. Further reduction is planned in vehicle emission levels by federal legislation.)
Ratio	the expression of the proportional mixture of two substances usually expressed as a numerical relationship such as 2:1 or 10:1, etc...in emission systems, concern is with air-fuel ratios.
Relief valve	a pressure limiting valve located in the exhaust chamber of the air supply pump. Its function is to relieve part of the exhaust air flow if the pressure exceeds a pre-determined value.
Retard	usually associated with spark timing mechanisms of the engine. Opposite of spark advance. To delay the introduction of the spark into the combustion chamber.
Road Draft Tube	the traditional method of scavenging the engine crankcase of fumes and pressure. A means by which the engine crankcase was ventilated. Prior to the introduction of crankcase emission control systems, a tube, vented at the crankcase and suspended a few inches above the ground. Depends on venturi action to create a partial vacuum as the vehicle moves. Very ineffective below 20 mph.
Smog	a derivative of two words--smoke and fog; caused by a chemical reaction between hydrocarbons and air in the presence of oxides of nitrogen and sunlight.
Test Gauge Adapter	an adaptor used in conjection with a fuel pump tester to check the air supply pump.
Thermactor	an air injection type of exhaust emission control system. A product identification name of Ford. Currently used with engines coupled with standard transmissions or high performance engines.
Thermostat	a valve which depends on heat to control temperature by opening or closing a damper. In emission systems, to control hot or cold carburetor inlet air.
Vacuum	a term used to describe a pressure that is less than atmospheric pressure; hence, a partial vacuum. A perfect vacuum has not yet been created, as this would necessitate a complete lack of pressure. Used for control purposes throughout the automotive industry.
vacuum advance	advances ignition timing with relation to engine load conditions. This is achieved by using engine vacuum.

Vacuum Control Temperature Sensing Valve — a valve that connects manifold vacuum to the distributor advance mechanism under hot idle conditions.

Ventilation — the process by which fresh air is caused to circulate so as to replace impure air. Principle utilized in crankcase emission systems.