The Motor Vehicle and Clean Air

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INTRODUCTION

Back in the late fifties, highway engineers and motor vehicle manufacturers faced a mutual challenge—meeting the public clamor for a first-class system of private transportation. All the talk then was very pro-highway, pro-automobile, and pro-highway transportation. And the challenge was met—Americans now have the most efficient highway transportation system in the world—one that moves people, goods, and vehicles effectively and economically.

Ecologists Attack Motor Vehicles and Highways

Today, the tide has changed. In fact, it has completely turned, as you know only too well. The automobile and highway transportation are being attacked on all fronts. Newspapers, radio, TV, magazines are all publicly condemning the motor vehicle and the road it rides on. Although the outcry takes on many forms, most of the attacks are launched under the environmental banner. The automobile is condemned as a polluter of the environment, and highways are looked upon as despoilers of the countryside.

Engineers Look to Improve Motor Vehicles and Highways

But despite these criticisms, Americans still want the convenience of an efficient highway transportation system. Private transportation, and the mobility it provides, have become a way of life in this country, and will remain a necessity for years to come. So, the mutual challenge facing us today is the continued development and improvement of this system—including highways and the vehicles to ride on them—while at the same time eliminating any adverse impact either may have on the environment.

Development of Emission Control Devices

Just as you, in the highway engineering field, are committed to designing and building highways that are compatible with the environment, we in the automotive business are determined to remove the

motor vehicle as a source of air pollution. A great deal of progress has been made along both lines in recent years.

In the automobile industry, new vehicles which have emission control devices for crankcase, exhaust, and evaporative systems, emit 80 percent less hydrocarbons and 65 percent less carbon monoxide—two major ingredients of air pollution—than models on the road ten years ago which did not have pollution control equipment. These statistics, incidentally, are based on current U. S. government test procedures.

Today, four out of every five cars in use have one or more devices to control emissions. For example, all cars manufactured since the start of the 1963 model year have had controls to limit emissions that were formerly released from the crankcase. Exhaust controls were introduced nationwide on 1968 models, and 1971 cars have a third control system to limit evaporative losses from the fuel tank and carburetor. In addition, controls for oxides of nitrogen were introduced on many 1970 models—a full year ahead of any legal requirement—and most 1971 engines are designed to run on low lead or lead free fuel.

[Editor's Note—At this point in his talk, MacCleery presented a 12-minute movie entitled, *Your Car and Clean Air*. The movie script, reprinted below, has been only slightly edited for these proceedings.]

Your Car and Clean Air (12-Minute Movie)

HISTORICAL DEVELOPMENT OF AUTOS AND INTERNAL COMBUSTION ENGINES

Once upon a time—and in historical years it wasn't very long ago—to own an automobile was an uncommon luxury. Not any more! People now call it a common necessity, being the favorite product of American industry. America built it, and it helped build America. For most people it's the comfortable, private way to get where the action is: to the job, to the market, to the fun.

Our population grew and prospered, and the automobile, compared to other things, became an important factor in the family budget—more people, and far more cars. We made wider roads with better traffic patterns. We built safer cars and expressways for safer and quicker travel. And, through the years, car makers have reached ahead to seek solutions to the problems created by the growing population of people and cars.

Why Use Internal Combustion Engines?

Most experts agree that the internal combustion engine is a contributor to the photochemical smog that sometimes covers our cities. Why then do we use internal combustion engines?

There were electric cars in the early 1900's, but they lacked power and range. There were steam cars, too. But boilers and burners were complicated and particularly prone to getting out of order. And, too, keeping close company with a boiler full of live steam made a lot of people nervous. In contrast, the internal combustion engine was compact, convenient and dependable. So, it became the most popular power source for our automobiles.

But it's also true that car makers have continued to experiment with and re-evaluate not only electricity and steam but other power sources as well. Whatever share the internal combustion engine has in polluting the air, it is unwelcome.

SMOG THEORIES AND AUTO EMISSIONS

Los Angeles was the first American city severely afflicted with smog. A rapidly expanding population—of people and industry and cars as well—was contributing pollutants to an area where there is very low wind velocity and very bright sunlight.

Theory of Photochemical Reaction

As the condition worsened, theories about its cause became more and more abundant; most of them had little basis in fact. But in the early 1950's Professor Haagen-Smit, of the California Institute of Technology, presented an explanation of the phenomenon in his theory of photochemical reaction in which he said photochemical smog occurs when unburned hydrocarbons, the products of incomplete combustion from many sources, reacted photochemically with nitrogen oxides in the presence of sunlight. His theory pointed to emissions from automobiles, for the first time, as one source of the photochemical smog problem. It launched the industry's first big research project on vehicle emissions, in Los Angeles and in Detroit laboratories, studying the theory and planning the research programs that were to follow.

Development of Tools and Techniques to Study Emissions

Instruments and techniques for this new kind of research did not exist, so the first emphasis was upon developing these sensitive tools and methods.

Exhaust Pipe, Crankcase, Fuel Tank and Carburetor Emissions

The first *progress* was actually in devising the equipment that would provide a more complete look at the problem. Automobile engineers zeroed in first of all, quite naturally, on the exhaust pipe.

As the test equipment grew more sophisticated, so did the knowledge of what was actually going on, and there were some surprises. Exhaust emissions were only part of the problem.

Emissions from the crankcase, fuel tank, and carburetor, were also pollution factors. In fact, the tail pipe was found to account for only 60 percent of the total hydrocarbon emissions. Fully 20 percent were emitted from the crankcase, and the remaining 20 percent came from the evaporation of fuel from the gasoline tank and carburetor.

RESEARCH STUDIES AND RESULTS

Crankcase Studies and Development of PCV Valve

The first success of the new research was the development of a means to eliminate crankcase emissions. These were the unburned hydrocarbons that were blown past the piston rings into the crankcase. To do away with this source of pollution, the engineers designed a positive crankcase ventilation system to return unburned gases to the intake for burning.

A key factor in this device is the PCV valve which controls the flow of gases from the crankcase to the carburetor intake, and ventilates the crankcase with filtered air. The efficiency of the system depends upon this valve and the system has eliminated 20 percent of all the hydrocarbon emissions.

Carburetor Studies and Carburetor Redesigns

Other pollutants, besides hydrocarbons, are carbon monoxide and nitrogen oxides; hydrocarbons and carbon monoxide being the first targets. The basic elements in these emissions are nitrogen, oxygen, hydrogen, and carbon. These elements make up air and gasoline which, after carburetion, become the ingredients for combustion. How they are mixed, distributed and burned determines the carbon monoxide and hydrocarbon emission levels.

Engineers studied all aspects of the combustion process to determine how they could reduce the hydrocarbons and carbon monoxide that an engine emits into the atmosphere.

The ratio of air and gasoline in the carburetor is a critical factor in eliminating carbon monoxide.

The ratio of the carburetor mix is also important in order to control hydrocarbons. So carburetors have undergone elaborate and sophisticated changes in recent years. But the designing, testing and refining of new carburetors are by no means the end of the job.

Sophisticated Carburetor Test Equipment

The same laboratories that redesigned the carburetors also assisted in the design of the sophisticated test equipment that could monitor within strict limits the flow characteristics on every single carburetor. Computerized and complex, the test equipment verifies that a carburetor meets its specifications and will deliver to the engine an air-fuel mixture which, when burned, will be kind to the atmosphere.

Air-Fuel Mix Distribution and Redesign of Manifolds and Valves

From the carburetor, the research and engineering moved along the route of the air-fuel mixture to its distribution into the cylinders of the engine for burning. Manifolds and valves were redesigned.

Combustion Studies and Redesigns

Today's car with the modern internal combustion engine has about 15,000 parts, yet its reliability is extremely high. Every engine change and improvement is guided by three standards—performance, durability and reasonable economy. Combustion itself was a paramount target for all research.

Combustion Chambers Studies With High Speed Cameras

It involves many variables, and extending our knowledge of it required some new equipment such as high-speed cameras that could peek inside the combustion chambers of an operating engine and slow down the action so that engineers could study it.

Many Basic Design Changes for Better Combustion

What was seen led to many changes in the engine design. A few of these were the location of valves and their timing; the design of spark plugs; the shape of combustion chambers, the design of pistons, and the timing of the ignition.

Air Injection at Exhaust Valves

In addition to reducing emissions by changing the *basic* design of the engine, some manufacturers have developed a system of air injection. The method amounts to this: air is injected at each exhaust valve opening; the additional air continuing the oxidation of the hydrocarbons in the exhaust manifold so that fewer are emitted into the atmosphere.

Carburetor and Fuel Tank Emissions Controlled

The final source of hydrocarbons is the evaporation from the carburetor and fuel tank. These emissions are controlled on all 1971 model cars.

PAST RESEARCH COSTS AND RESULTS IMPRESSIVE

The progress in reducing unwanted emissions has not come easily. It has been gained with scores of studies and more than five million man-hours in research and development, all aimed at removing the automobile as a significant source of pollution. The results are impressive.

In 1970 model cars in California, with all controls, hydrocarbons are down 80 percent, carbon monoxide about 65 percent. This will be nationwide for 1971. (These figures are based upon present test procedures which are effective through the 1971 model year.) The job is still not complete, and the research and development by the individual manufacturers have been accelerated.

RESEARCH CONTINUES AND INCREASES

Engineers are continuing research to expand their understanding of the part played by motor vehicles in air pollution.

Emission Data and Federal and State Standards

New in-plant audit equipment is at work gathering emission data. These data compare representative domestic production cars with the certification standards set by the federal and state governments.

The data come from cars picked at random from the assembly line and put through emission tests similar to those established for federal standards. They cover the complete driving cycle. A car starts cold, idles, then accelerates to 30 miles an hour. For a time it *cruises* at 30 miles an hour, decelerates and cruises at 15 miles an hour. Then the driver accelerates to 50 miles an hour and finally brings it back to idle. During all aspects of the tests, the emission levels are recorded and compared with current government standards.

RESULTS OF A DECADE OF RESEARCH

Hydrocarbon Emissions Down 80 Percent

In 1960, a given amount of hydrocarbons was produced by one automobile. With 1971 cars having a full set of controls, it would take five cars to produce the same amount produced by the 1960 car. Translation: an 80 percent reduction in hydrocarbon emissions.

Carbon Monoxide Down 65 Percent

Consider carbon monoxide; it has nothing to do with smog formation, but it is a product of combustion. In 1960, one new automobile produced a certain amount of carbon monoxide; 1971 models with a full set of controls produce about 65 percent less.

Research Organizations and Individuals Must Help

The research, in which motor vehicle makers have been assisted by the American Petroleum Institute and the Department of Health, Education and Welfare, will continue to explore the causes and effects of air pollution. This information will be used to assist in developing future control systems.

But you, the driver, also have a responsibility to maintain the progress that has been achieved. You can do this simply by seeing that your engine is properly tuned. This will help reduce pollution and give your car better mileage, too.

Summary

Reviewing the progress briefly, for 1971 models with full controls, there are 80 percent fewer hydrocarbons; 65 percent less of carbon monoxide.

CONCLUSION

Can the average *citizen* notice the difference? No. That is because emissions from the automobile are generally invisible. The difference, however, actually will take place as more and more vehicles with full pollution controls replace older models. The American motor vehicle manufacturers have made outstanding progress and are committed to removing the automobile as a significant source of air pollution. But this goal can be achieved only if you make sure that your car is properly tuned to manufacturer's specifications. Remember, engine care means cleaner air.

[Editor's Note—End of movie. Following pages cover closing remarks by MacCleery.]

PROGRESS NOT FULLY REALIZED AND APPRECIATED

Despite the strides that have been made in reducing vehicle emissions, some of our critics seem to refuse to concede that any progress has been made in recent years. For example, the federal government released a study some time ago, based on its early monitoring network, which stated that in 1965, motor vehicles were responsible for 61 per-

cent of the annual air pollution tonnage. Last year, the Department of Health, Education, and Welfare issued an updated report indicating that in 1968—the first year that hydrocarbon and carbon monoxide exhaust emission controls were installed on new cars nationwide—the transportation sector was responsible for about 42 percent of the nation's air pollution. But in spite of these later findings, the automobile is still being cited as the villain which causes over 60 percent of our air pollution problems.

Another study which is overlooked by our critics is one that was prepared in June 1970 by two scientists in the Department of Mechanical Engineering at the University of California in Berkeley—Professors Sawyer and Caretto. Working with the federal government data for 1965, which indicated that motor vehicles accounted for 61 percent of the annual air pollution tonnage, Professors Sawyer and Caretto concluded that on an air quality—or relative toxicity—bases, motor vehicles were only responsible for 12 percent of the nation's air pollution. Considering the fact that a greater share of the vehicle population is currently equipped with emission controls than several years ago, it is reasonable to assume that even this 12 percent may be high today.

EMISSIONS PEAK IN 1967—NOW DECLINE

One other fact that must be pointed out is that, according to government reports, automotive emissions of both hydrocarbons and carbon monoxide reached their peaks about 1967, and are now on the decline. Present control systems assure that this decline will continue through the next decade as newer vehicles replace older models in the car population. This would occur even if no new generations of controls were introduced and the vehicle population continued to rise at its estimated rate of growth.

INTENSIVE RESEARCH TO CONTINUE

But the automotive industry certainly does not intend to relax its efforts to eliminate vehicle emissions. Individual companies are continuing to pursue the engineering research needed to achieve this goal, and to support work by independent laboratories, universities, and other research organizations.

One of these programs is being carried out under the direction of the Air Pollution Research Advisory Committee of the Coordinating Research Council. This $13 million, three-year program involves some 38 different atmospheric, medical, and engineering projects which have

been funded jointly by the Automobile Manufacturers Association and the American Petroleum Institute, with the Environmental Protection Agency participating on a selected project basis. In March 1971, the initial findings of many of these projects will be discussed at a three-day symposium in Chicago.

Undoubtedly, the information developed from the APRAC program will prove invaluable in helping the scientific community draft a truer picture of our air resources and determine what must be done to improve the quality of our environment. Hopefully, the results will provide scientists with more information on the effects of specific pollutants on human health and on animal and plant life. Atmospheric chemists will have greater knowledge of the interrelationships of various pollutants and be better equipped to trace their dispersal in the air to discover their ultimate fate in the atmosphere. Fuel specialists and automotive engineers should achieve a more complete understanding of the emission potential of various fuel compositions used with a broad range of automotive power equipment and emission controls.

CONCLUSIONS

In closing, I should like to point out that the automotive industry is firmly committed to the removal of the motor vehicle as a significant source of air pollution as rapidly and as effectively as possible. Cleaner air is also our goal.