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FEDERAL LOW-EMISSION VEHICLE PROCUREMENT ACT

GOVERNMENT

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JOINT HEARINGS

BEFORE THE

SUBCOMMITTEE ON ENERGY, NATURAL
RESOURCES, AND THE ENVIRONMENT

OF THE

COMMITTEE ON COMMERCE

AND THE

SUBCOMMITTEE ON AIR AND WATER POLLUTION

OF THE

COMMITTEE ON PUBLIC WORKS

UNITED STATES SENATE

NINETY-FIRST CONGRESS

SECOND SESSION

ON

S. 3072

TO STIMULATE THE DEVELOPMENT, PRODUCTION, AND
DISTRIBUTION IN INTERSTATE COMMERCE OF LOW-
EMISSION MOTOR VEHICLES IN ORDER TO PROVIDE THE
PUBLIC INCREASED PROTECTION AGAINST THE HAZARDS
OF VEHICULAR EXHAUST EMISSION, AND FOR OTHER
PURPOSES

JANUARY 27, 28, AND 29, 1970

Serial No. 91-51

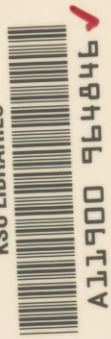
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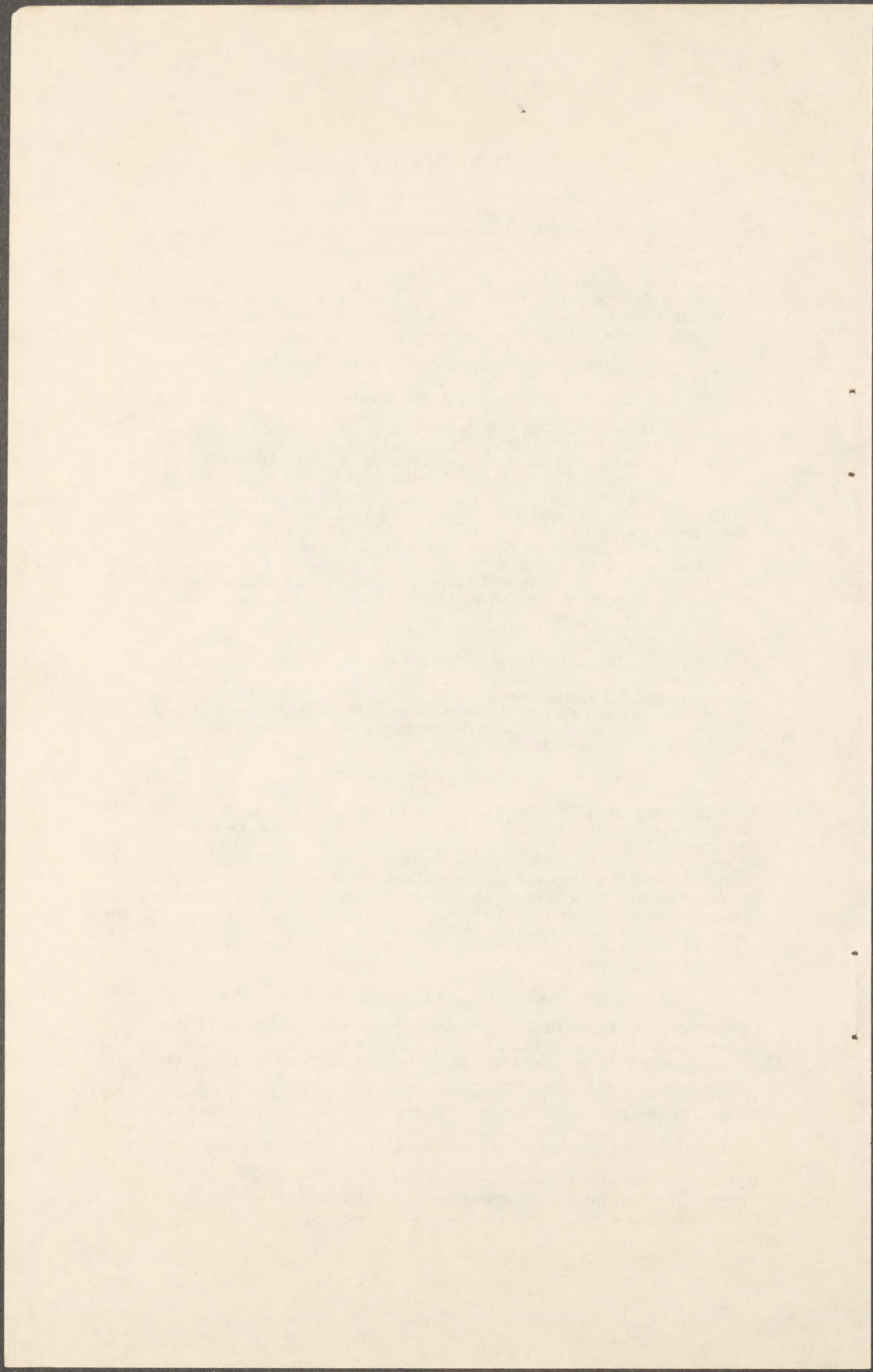
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FEDERAL LOW-EMISSION VEHICLE PROCUREMENT ACT

TUESDAY, JANUARY 27, 1970

COMMITTEE ON COMMERCE,

SUBCOMMITTEE ON ENERGY, NATURAL RESOURCES,
AND THE ENVIRONMENT;

COMMITTEE ON PUBLIC WORKS,
SUBCOMMITTEE ON AIR AND WATER POLLUTION,
Washington, D.C.

The subcommittees met at 10:15 a.m. in room 5110, New Senate Office Building, Washington, D.C., Hon. Warren G. Magnuson, (chairman of the Commerce Committee); Hon. Philip A. Hart (chairman of the Subcommittee on Energy, Natural Resources, and the Environment); and Hon. Edmund S. Muskie (chairman of the Subcommittee on Air and Water Pollution) cochairing.

Present: Senators Magnuson, Hart, Cannon, Moss, Cotton, Baker, Muskie, and Dole.

OPENING STATEMENT BY THE CHAIRMAN, SENATOR WARREN G. MAGNUSON

The CHAIRMAN. The committee will come to order.

As cochairman of this meeting, I have a statement I would like to make on this matter, and then I am sure maybe the Senator from Maine would also like to make a statement.

First of all, I want to thank Senator Hart for inviting me to sit with this Subcommittee on Energy and Natural Resources and Environment, which is beginning hearings on a bill which I introduced, S. 3072, the Federal Low-Emission Vehicle Procurement Act.

As chairman of the Commerce Committee I would like to welcome, too, on behalf of the full committee and your subcommittee, the Air and Water Pollution Subcommittee of the Public Works Committee and its distinguished chairman, the Senator from Maine, Mr. Muskie.

Now, the Nation, of course, is under the siege of some pretty strange enemies, enemies who would infiltrate the very air we breath.

This country has never before known such enemies. They may not be seen or heard, but they are assaulting the lungs of all people, especially infants, asthmatics, and the aged. They go by less emotional names than tyrants. They are called hydrocarbons, carbon monoxide, sulfur and nitrogen oxides, and other chemical names, but they are enemies of our own creation; and no missile or antimissile will pro-

Staff member assigned to this hearing: S. Lynn Sutcliffe.

tect us from these things unless we take some action and try and stop this invasion.

We could stop it by bringing industry and transportation in this country to a standstill. But as chairman of the Senate Commerce Committee—a committee dedicated to the advancement of commerce and transportation—we, of course, could not consistently support this battle plan. Nor do I support, nor I am sure the committee supports, a course of action which fails to recognize the seriousness of the threats to our environment.

So, strong steps must be taken and taken as soon as possible.

Government and industry must disarm these assailants by creating technology that will allow industry and commerce to flourish without producing this evil or at least minimizing it to its lowest possible denominator.

The Senate Commerce Committee, and particularly the Energy, Natural Resources, and the Environment Subcommittee, will continue to lead the fight against these evil things of our own creation by trying to search and stimulate these new technologies. The committee is going to welcome assistance from all quarters.

This bears repeating—everybody in this room knows this—the automobile is the worst polluter in this country. Only by changing the technology of land-propelled vehicles can we begin to win the major war against pollution of the air.

The Senate Commerce Committee and the Air and Water Pollution Subcommittees of the Committee on Public Works headed by the Senator from Maine began to map out a plan for this battle that must be waged as early as May of 1967. At that time the committees held joint hearings to consider what alternative propulsion technologies were available, technologies that did not produce dangerous pollutants.

The initial hearings concentrated on alternative cars, electric cars, and things of that kind.

In May of 1968 the committee continued their search for smogless or low-emission vehicles and explored the steam engine technology.

In March of 1969 the Senate Commerce Committee published a report on "The Search for a Low-Emission Vehicle" and recommended that the Government use its purchasing power to generate development of technologies that were low or nonpolluting.

So, the bill before the committee embodies that recommendation. It creates a legislatively guaranteed market for smogless vehicles so that consumer demand in the free market will reflect, before it's too late for action, the need and desire for smogless vehicles.

As many have said, you have to begin a journey with a single step, and we think this is one of the first steps to bring the search for low-emission vehicles, hopefully, to a successful end.

Another essential step is to provide adequate research and development funds for people working on low-emission vehicles, and this includes the prominent manufacturers of automobiles and others. This will insure that there will be competition in this area and the best possible vehicle might be developed.

This year the Senate insured that this step would be taken by appropriating \$45 million for the development of pollutionless technology.

I hesitate there to determine the fate of that \$45 million. I think that we have had some setback on that, as late as last evening.¹ But I hope this second step is not foreclosed or seriously delayed.

We hope that the President joins us in the search for low-emission vehicles, the search that we have been conducting for a long time.

So, in closing, Senator Hart, let me commend S. 3072 to you and let me thank the Senators who cosponsored this measure in addition to Senators Muskie and Jackson who were on the bill when it was introduced.

There are many Senators who have already asked to cosponsor it, and I suspect there are at least 15 more if we talked to them and explained it. For the record, I would like to submit the names of the 35.

Senator HART. They will be received and the bill and any agency comments will be placed in the record.

(The list of Senators, the bill, and agency comments follow :)

Mr. Magnuson (for himself, Mr. Jackson, Mr. Muskie, Mr. Baker, Mr. Bayh, Mr. Bible, Mr. Boggs, Mr. Brooke, Mr. Byrd of Virginia, Mr. Cannon, Mr. Eagleton, Mr. Fong, Mr. Gravel, Mr. Harris, Mr. Hart, Mr. Inouye, Mr. Kennedy, Mr. McGee, Mr. McIntyre, Mr. Mansfield, Mr. Metcalf, Mr. Mondale, Mr. Moss, Mr. Nelson, Mr. Packwood, Mr. Pell, Mr. Percy, Mr. Randolph, Mr. Scott, Mr. Sparkman, Mr. Spong, Mr. Stevens, Mr. Tydings, Mr. Yarborough, and Mr. Young of Ohio) introduced the following bill; which was read twice and referred to the Committee on Commerce.

[S. 3072, 91st Cong., first sess.]

A BILL To stimulate the development, production, and distribution in interstate commerce of low-emission motor vehicles in order to provide the public increased protection against the hazards of vehicular exhaust emission, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Federal Low-Emission Vehicle Procurement Act of 1969".

DEFINITIONS

SEC. 2. For the purpose of this Act—

- (1) "Board" means the Low-Emission Vehicle Certification Board;
- (2) "Federal Government" includes the legislative, executive, and judicial branches of the Government of the United States, and the government of the District of Columbia;
- (3) "motor vehicle" means any vehicle, self-propelled or drawn by mechanical or electrical power, designed for use on the highways principally for the transportation of passengers except any vehicle designed or used for military field training, combat, or tactical purposes;
- (4) "low-emission vehicle" means any motor vehicle which produces significantly less pollution than the class or model of vehicle for which the Board may certify it as a suitable substitute.

LOW-EMISSION VEHICLE CERTIFICATION BOARD

SEC. 3. (a) There is established a Low-Emission Vehicle Certification Board to be composed of the Secretary of Transportation or his designee, the Secretary of Health, Education, and Welfare or his designee, the Director of the National Highway Safety Bureau in the Department of Transportation, the Administrator of the General Services Administration, and one member appointed by the President. The Secretary of Transportation or his designee shall be the Chairman of the Board.

¹ On Monday, Jan. 26, 1970, President Nixon vetoed the Labor-HEW appropriation bill. In the bill which was finally signed by the President, the \$45 million was retained.

(b) Any member of the Board not employed by the United States may receive compensation at the rate of \$125 for each day such member is engaged upon work of the Board. Each member of the Board shall be reimbursed for travel expenses, including per diem in lieu of subsistence as authorized by law (5 U.S.C. 5703) for persons in the Government service employed intermittently.

(c) (1) The chairman, with the concurrence of the members of the Board, may employ and fix the compensation of such additional personnel as may be necessary to carry out the functions of the Board, but no individual so appointed shall receive compensation in excess of the rate authorized for GS-18 by section 5332 of title 5, United States Code.

(2) The Chairman may fix the time and place of such meetings as may be required.

(3) The Board is granted all other powers necessary for meeting its responsibilities under this Act.

CERTIFICATION

SEC. 4. (a) The Secretary of Health, Education, and Welfare shall determine which models or classes of motor vehicles qualify as low-emission vehicles in accordance with the provisions of this Act.

(b) The Board shall certify any class or model of motor vehicles—

(1) for which a certification application has been filed in accordance with subsection (d) of this section;

(2) which is a low-emission vehicle as determined by the Secretary of Health, Education, and Welfare; and

(3) which it determines is suitable for use as a substitute for a class or model of vehicle presently in use by agencies of the United States.

The Board shall specify with particularity the class or model of vehicles for which the class or model of vehicles described in the application is a suitable substitute. In making the determination under this subsection the Board shall consider the following criteria:

- (1) the safety of the vehicle;
- (2) its performance characteristics;
- (3) its reliability potential;
- (4) its serviceability; and
- (5) its fuel availability.

(c) Certification under this section shall be effective for a period of two years from the date of issuance.

(d) (1) Any party seeking to have a class or model of vehicles certified under this Act shall file a certification application in accordance with rules established by the Board and published in the Federal Register.

(2) The Board shall publish any notice of each application received in the Federal Register.

(3) The Board shall determine whether or not the vehicle for which application has been properly made is a low-emission vehicle in accordance with procedures established by it and published in the Federal Register.

(4) The Board shall conduct whatever investigation necessary, including actual inspection of the vehicle at a place designated by the Board in the certification application rules established under this section.

(5) The Board shall receive and evaluate written comments and documents from interested parties in support of, or in opposition to, certification of the class or model of vehicle under consideration.

(6) Within ninety days after the receipt of a properly filed certification application, the Board shall reach a decision by majority vote as to whether such class or model of vehicle is a low-emission vehicle and is a suitable substitute for any class or classes of vehicles presently being purchased by the Federal Government for use by its agencies.

(7) The Board shall publish in the Federal Register, within ninety days after the receipt of a properly filed certification application, a report of its decision on such application which sets forth with particularity the reasons for granting or denying certification, together with dissenting views.

PROCUREMENT OF LOW-EMISSION VEHICLES

SEC. 5. Certified low-emission vehicles shall be acquired by purchase by the Federal Government for use by the Federal Government in lieu of other vehicles

if the General Services Administrator determines that such certified vehicles have procurement and maintenance costs which are no more than 125 per centum of the procurement and maintenance costs of the class or model of motor vehicles for which they are certified substitutes.

WAIVER

SEC. 6. For the purposes of this Act any statutory price limitations shall be waived, and the procuring agency shall be required to purchase available certified low-emission vehicles which are eligible for purchase before purchasing any other vehicles for which the low-emission vehicle is a certified substitute.

APPROPRIATIONS AUTHORIZED

SEC. 7. There are authorized to be appropriated such sums as may be necessary to carry out the provisions of this Act.

EFFECTIVE DATE

SEC. 8. This Act shall take effect immediately upon signing by the President and the Board shall promulgate the procedures required to implement this Act within ninety days thereafter.

COMPTROLLER GENERAL OF THE UNITED STATES,
Washington, D.C., November 10, 1969.

HON. WARREN C. MAGNUSON,
*Chairman, Committee on Commerce,
U.S. Senate,
Washington, D.C.*

DEAR MR. CHAIRMAN: By letter dated October 29, 1969, you requested our report on S. 3072, 91st Congress.

The primary purpose of this measure is to stimulate the development, production, and distribution of low-emission motor vehicles in order to provide the public increased protection against the hazards of vehicular exhaust emission. We view this measure as primarily a matter of policy and as we have no special information that would assist the Committee in its consideration of the merits of S. 3072, we offer no recommendations concerning the action to be taken on the merits of the measure. Assuming favorable action is to be taken however, the following comments are offered for the consideration of the Committee.

Section 5 of S. 3072 would encourage the use of approved low-emission motor vehicles by the Federal Government. Specifically, section 5 would require the Administrator of the General Service—after appropriate tests and certification—to substitute low-emission vehicles for other vehicles upon a determination that procurement and maintenance costs of low-emission vehicles do not exceed 125 per centum of the procurement and maintenance costs of the vehicles for which they are substituted.

Ordinarily it would be assumed that the stated 125 per centum figure would be calculated on the basis of vehicles purchased under statutory price limitations now prescribed in the law. However, section 6 of S. 3072 specifically waives statutory price limitations "For the purposes of this Act." This waiver authority could be construed to apply not only to purchases but also to the 125 per centum determination required by section 5. In such case, the calculation under section 5 would be based on vehicles purchased on the open market which of course would be higher than vehicles heretofore purchased by the Government under statutory limitations. As we are not sure such is intended by S. 3072, we feel that clarification of this matter is needed in the bill or its legislative history.

We also question whether the statutory price limitations should be waived in their entirety as provided in section 6. The objective could be accomplished by waiving only the additional procurement costs of low-emission vehicles.

Sincerely yours,

R. F. KELLER,
Assistant Comptroller General of the United States.

NATIONAL SCIENCE FOUNDATION,
Washington, D.C., December 10, 1969.

HON. WARREN C. MAGNUSON,
Chairman, Committee on Commerce,
U.S. Senate,
Washington, D.C.

DEAR MR. CHAIRMAN: This is in reply to your request of October 29, 1969, for the comments of the National Science Foundation on S. 3072, "To stimulate the development, production, and distribution in interstate commerce of low-emission motor vehicles in order to provide the public increased protection against the hazards of vehicular exhaust emission, and for other purposes."

We do not feel that we are in a position to offer comments as to the desirability of enactment of S. 3072. However, we do believe that efforts to diminish the hazards of vehicular exhaust emission are in the public interest and if S. 3072 or a similar bill were to be enacted we would endeavour to cooperate in every appropriate way to help assure adequate scientific research for the effort.

Sincerely yours,

W. D. McELORY, Director.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., January 29, 1970.

HON. WARREN G. MAGNUSON,
Chairman, Committee on Commerce,
U.S. Senate,
Washington, D.C.

DEAR SENATOR MAGNUSON: Thank you for the opportunity to submit our views on S. 3072, a bill "To stimulate the development, production, and distribution in interstate commerce of low-emission motor vehicles in order to provide the public increased protection against the hazards of vehicular exhaust emission, and for other purposes."

The Atomic Energy Commission supports the purposes of this bill.

The Bureau of the Budget has advised that there is no objection to the presentation of this report from the standpoint of the Administration's program.

Cordially,

GLENN T. SEABORG, Chairman.

FEDERAL POWER COMMISSION,
Washington, D. C., January 29, 1970.

HON. WARREN G. MAGNUSON,
Chairman, Committee on Commerce,
U.S. Senate,
Washington, D.C.

DEAR MR. CHAIRMAN: On October 29, 1969, you requested our views concerning S. 3072, the "Federal Low-Emission Vehicle Procurement Act of 1969." The stated purpose of the Act is "To stimulate the development, production, and distribution in interstate commerce of low-emission motor vehicles in order to provide the public increased protection against hazards of vehicular exhaust emission, and for other purposes."

Stated briefly, the bill would authorize a program for procurement by the United States of approved low-emission vehicles for Government use as a means of combating air pollution and encouraging development of low-emission motor vehicles. Furthermore, the bill would establish a Federal interdepartmental board and procedures for certification of the particular types of vehicles that qualify under such program and permit the acquisition of new vehicles if the procurement and maintenance costs do not exceed 125 percent of those of conventional internal-combustion vehicles.

While we fully support the aims and purposes of S. 3072, we take no position on the merits of this particular approach to the problem. We recognize the seriousness of the air pollution situation and are concerned about the respective contributing roles of various sources of air pollution as illustrated by the fol-

lowing table, which has been compiled from National Air Pollution Control Administration sources:

[In percent]

	Carbon monoxide	Nitrogen oxides	Particulate matter	Sulfur oxides
Motor vehicles.....	92	45	5	2
Powerplants.....	1	25	20	53
All other.....	7	30	75	45
Total.....	100	100	100	100

We believe these statistics reveal the need for decisive corrective action. I will, therefore, address myself to the environmental problems of the electric and gas utility industries on January 30, 1970, in my statement before your Subcommittee on Energy, Natural Resources, and the Environment.

As far as the control of vehicle pollution is concerned, government procurement of low-emission vehicles as a stimulus to research and development, is only one possible approach to this complex problem. The determination of which approach to pursue requires specific scientific and technological expertise. The Department of Health, Education, and Welfare, with its responsibilities for air pollution control, is in the best position to evaluate the potential effectiveness of S. 3072. We defer, therefore, to its judgment and experience.

The Bureau of the Budget advises that it has no objection to presentation of this report from the standpoint of the Administration's program.

Sincerely,

JOHN N. NASSIKAS,
Chairman.

STATEMENT OF HON. PHILIP A. HART, U.S. SENATOR FROM MICHIGAN

Senator HART. The hearing this morning is a new phase in the effort of the Energy, Natural Resources, and the Environment Subcommittee to develop sound legislative techniques that will enable Government and industry to root out environmental hazards. The subcommittee is delighted that the Subcommittee on Air and Water Pollution of Public Works, led so effectively by the Senator from Maine, Mr. Muskie, has joined us.

I believe the Energy, Natural Resources, and the Environment Subcommittee of the Senate Commerce Committee can accomplish what you, Mr. Chairman, have asked of it—that we can find ways to eliminate pollution from automobiles, commercial transportation sources, and other interstate commerce activities, without eliminating the activities.

The subcommittee accepts the assignment and will seek to carry out, in cooperation with the strong ally of the Interior Committee and the strong ally of the Air and Water Pollution Subcommittee of Public Works, while recognizing our own primary responsibility for pollution caused by transportation sources and other activities in interstate commerce.

The legislation which the subcommittee considers today, jointly with the Air and Water Pollution Subcommittee, Senator Magnuson's bill, S. 3072, would add an important additional weapon in the arsenal of antipollution weapons. It focuses the purchasing power of the Federal Government on low-pollution technologies.

Under the bill, the funds which the Government spends for vehicles it buys, for its own governmental use, are directed to those companies which succeed in developing and producing a virtually smog-free car.

The weapon is innovative, because it doesn't depend on regulatory restraint. Rather, it utilizes economic incentive to stimulate changes that will benefit the environment. It will succeed, if it succeeds, by rewarding the most resourceful and responsible manufacturer.

Make no mistake about it. We are talking about a revolution in engine and automotive design, and a revolution that the auto industry itself is now promising to undertake.

There will be some false starts. There will be plenty of bugs, but the Government, not the consumer, in the initial phase, is going to be the guinea pig. Should the carrot approach fail, this country, in the not too distant future, I expect, would have no alternative but to remove the automobile from our city streets and urban freeways.

There is a magnificent staff report of the Commerce Committee which is a committee print, "The Search for Low-Emission Vehicles," and it makes the very sharp comment that there is no other known alternative to reducing air pollution than to attack it at its source.

Because I represent a State so profoundly involved in the automobile, I hope and believe that the industry itself will seize the opportunity now which the Magnuson bill provides, so that those smogless cars will be available not just to the Government, but to the consumers of this country, not 10 or 15 years from now, but 5 years from now.

In these 3 days of hearings which the subcommittee undertakes, we will hear from very thoughtful leaders, both in industry and in Government, in support, I trust, of the Magnuson bill.

We are just delighted that one who has given such effective leadership for so long, not just to the trouble of air pollution, but the whole business of attempting to prevent our environment from deteriorating, the chairman of the Air and Water Pollution Subcommittee of Public Works, is here to participate with us, not alone in these 3 days, but always, I know. Senator Muskie.

The CHAIRMAN. Before Senator Muskie speaks, I want to suggest there is a firm precedent for this approach to this matter. About 3½ years prior to the passage of the auto safety bill, this committee, working with GSA, finally secured a rulemaking down at GSA that they purchase automobiles that had approximately 16 safety devices on that automobile that were not on the automobile sold to the public. This action preceded the auto safety bill, and other bills. All 16 of those safety devices that the Government was using prior to the passage of the auto safety bill became required safety devices on new automobiles.

So, there is a firm precedent for this, and the Government, of course, is the biggest single buyer in the United States.

I thank you for yielding.

STATEMENT OF HON. EDMUND S. MUSKIE, U.S. SENATOR FROM
MAINE

Senator MUSKIE. Thank you, Senator Magnuson and Senator Hart.

First of all, may I express my appreciation and pleasure at sitting once more with the Committee on Commerce on this important subject of automotive emission and automobiles. I guess between us, Senator Magnuson and Senator Hart, the two committees have jurisdiction over the greatest single source of pollution, the automobile.

In view of your jurisdiction over all elements of transportation, and of our jurisdiction of environmental quality, I think this is a very natural marriage of jurisdiction, as we undertake to pick up this problem from where we last left it in our joint hearings.

I would like to refer to the Clean Air Act of 1965. With that act, the Congress moved to regulate vehicle emissions at the point of manufacture, because, as Senator Hart has said, they could not be controlled effectively at the point of use.

In 1968 the Federal Government set the first standards pursuant to that act. We expect a steady tightening of those standards—on a regular and frequent basis—until an emission-free vehicle comes off the assembly line. That is the goal of the Clean Air Act, and it is not a goal whose achievement we can afford to postpone.

In a sense, I am disappointed that we should have had to introduce the legislation which is the subject of this hearing, because it was our hope that, with the enactment of the 1965 act, we would put in the hands of the Federal Administrators the tools necessary to keep tightening the screw of higher enforcement and higher performance. So if the 1965 act had worked as we hoped it would, this additional incentive would not be necessary.

We understood when we enacted the 1965 act that we might be enacting legislation slightly in advance of the industry's capacity to provide the technology, but we felt it was important to move quickly because of the problem of used cars. At that time there were some 80 million used automobiles on the highways. Control of emission from used cars is an almost impossible task, outside of the control of crankcase emissions, which were brought under control by the 1965 act. There are now, I think, some 100 million used cars on the highways. It is important, therefore, that each new generation of automobiles—that is, each year's product—meet the highest possible standards of controlling emissions of which technology is capable.

If we delay implementing available technology by 5 years, we are delaying imposing higher standards on 30 to 40 million automobiles, and at the present stage of the air pollution problem we cannot afford that kind of delay, especially when we are told the technology is available or under development in the laboratories.

So really, Mr. Chairman, I am a cosponsor of the bill that is pending before us, and I will press with you for its passage. But I would hope that it would be unnecessary as an incentive to develop the technology that we need; that, rather, industry itself would feel the pressure of public concern, the urgency of the problem to develop the technology, not only for those automobiles which the Government purchases, but for all automobiles sold to the American public.

This bill is, I think, most important as a stimulus to research. If we need this additional stimulus, I'm for it. The research stimulus, however, is only one part of the potential effect of this bill. We hope also that it will provide competition in an industry in which we sometimes have real doubts about the existence of competition for the development of low-emission vehicles.

I think it was General Motors which indicated recently that an emission-free vehicle exists in their laboratory. We must move it from their laboratory onto the streets. It ought to be moved under the mandate of the 1965 act, but if that isn't enough, I hope it moves under the incentives of this act.

Before we hear the first testimony this morning, I would like to take this opportunity to express my concern over the approach the administration has been taking to control air pollution from both automobiles and jet aircraft.

A handshake agreement produced a promise from the airlines that we would have smokeless—and I emphasize smokeless—not emission-free—jets by the end of 1972. Now we have learned that the Department does not plan any downward revisions in the 1968 standards for automobiles until 1975, and not again after that until 1980.

We did not write the Clean Air Act to encourage voluntary compliance, or handshake agreements. At the time we passed the 1965 act, the then administration had indicated a willingness to rely upon the voluntary compliance of the automobile companies. This subcommittee was not content with that program. We went to Detroit, held hearings here, and were able to persuade that administration that voluntary compliance wasn't enough to meet this problem, and to accept the legislation which the Congress wrote, and to implement it.

I hope that this administration will respond to a similar sense of urgency and will endorse public policy enacted by the Congress, to generate the kind of automobiles that we need and thereby truly meet the threat from this country's prime source of air pollution.

Senator HART. Senator Baker?

**STATEMENT OF HON. HOWARD H. BAKER, JR., U.S. SENATOR FROM
TENNESSEE**

Senator BAKER. Mr. Chairman, thank you very much. I believe I may be the only member of this joint hearing who has the privilege of serving on both of the subcommittees concerned.

Since I came to the Senate 3 years ago, I have had the distinct pleasure and privilege of serving on the Senate Public Works Subcommittee on Air and Water Pollution and am now privileged to be the ranking Republican Senator on the Energy, Natural Resources, and the Environment Subcommittee of the Commerce Committee. Therefore I come here wearing two hats today and savor the opportunity to serve in this dual capacity at these joint hearings.

Let me say, to begin with, that I share with Senator Muskie his sense of urgency that we must continue along the dedicated path toward clean air, whether dealing with pollutants from vehicles, stationary sources, or whatever.

I would point out that I was especially pleased to note that the President in his state of the Union message, just a few days ago, went on record, I believe most forcefully and in a very dedicated way, to say that his administration is determined to see that something is done and done now to abate the pollution of the air envelope which sustains us and the waters which surround us.

I believe that this is the first time that any President in the state of the Union message has so committed himself and his administration to such a goal. I look forward in the next few days to having specific implementing messages in these respects delivered to the Congress in the form of recommendations and requested legislation.

I would hope that this legislation on which we are holding hearings now could be dovetailed with the messages that will be delivered by the administration in the days and weeks just ahead in the same field, because the field of air pollution control, the field of the abatement of pollutants from vehicles and from stationary sources, the business of cleaning up the air envelope that surrounds us and the waters on which we thrive, is too vital and too necessary and too urgent now to become anything other than a nonpartisan, bipartisan effort.

I am sure this joint hearing of these two committees will consider it in that vein. I feel sure that the administration will do likewise.

Senator HART. You are right, lungs are without political labels.

I suspect that in the course of these and subsequent hearings there will be noise made that will be regarded by objective observers as partisan, but if in the end we achieve a resolution that is protective of all lungs, so be it. That is what we are trying to do.

Senator CANNON, did you have anything to say?

Senator CANNON. No, I would prefer to wait.

Senator HART. Senator Moss?

Senator MOSS. Just to express my satisfaction that we are proceeding now with this hearing. I served with Senator Muskie on the Air and Water Pollution Subcommittee for a long period of time, and I recall very well the hearings and legislative acts that we had in that subcommittee and yet we still haven't achieved a degree of improvement in the air pollution that is significant.

I am most anxious to try, by this bill, to see if we can't move along toward the objective, because time is indeed short.

Thank you, Mr. Chairman.

Senator HART. Our first witness this morning is Mr. Creed Black, the Assistant Secretary for Legislation of the Department of Health, Education, and Welfare.

Mr. Black, we welcome you. If you would identify your associate?

STATEMENT OF CREED C. BLACK, ASSISTANT SECRETARY FOR LEGISLATION, U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE; ACCOMPANIED BY IRWIN AUERBACH, SPECIAL ASSISTANT FOR LEGISLATIVE AFFAIRS OF THE NATIONAL AIR POLLUTION CONTROL ADMINISTRATION

Mr. BLACK. Mr. Chairman, I am delighted to be here. My associate is Mr. Irwin Auerbach, who is Special Assistant for Legislative Affairs of the National Air Pollution Control Administration.

I am pleased to appear on behalf of the Department of Health, Education, and Welfare. I wish to commend the members of the committee for their longtime interest in this problem and to express our hope that we will be able to work together constructively to help find solutions. I assure all of you that the administration does share the sense of urgency which Senator Muskie and Senator Baker expressed, as indicated by the President's state of the Union address and the fact that he does plan on February 10 to devote another message in great detail to this problem of our environment.

As the Department which is responsible for administering the Clean Air Act, we, of course, have a very vital interest in the subject of these hearings—the search for low-pollution motor vehicles.

There can be no doubt that motor vehicle pollution is a very serious threat to public health and welfare and to the quality of people's lives across this entire Nation. This has been demonstrated and documented a great many times. It is obvious that a high priority must be placed on finding practical solutions to this urgent national problem.

It is a problem that clearly must be attacked simultaneously on many fronts. Attention must be given not only to the motor vehicle engine but also the fuel it uses; not only to the design and construction of motor vehicles but also to the design and location of highways; and not only to ways of moving motor vehicles more efficiently but also to ways of having a transportation system that moves people and goods without damage to the environment. Obviously, such a wide-ranging attack on the problem will require a concerted effort on the part of several Federal departments and agencies, State and local governments, and many groups in the private sector, including motor vehicle manufacturers and fuel producers.

The Federal Government clearly must play a major role in this effort. President Nixon has pledged his administration to do just that. In his state of the Union message, he said: "We shall intensify our research, set increasingly strict standards, and strengthen enforcement procedures—and we shall do it now."

The task of redeeming that pledge is already well underway. Under the provisions of the Clean Air Act, as amended, the Department of Health, Education, and Welfare is conducting a national regulatory program for the control of air pollution from new motor vehicles and is conducting and supporting research and development relating to engines, fuels, emission control devices, and other aspects of motor vehicle pollution control. In part, this research and development effort includes projects conducted for us by other Federal departments and agencies.

The national standards now in effect have reversed the rising trend of hydrocarbon and carbon monoxide emissions from motor vehicles. But unless more stringent standards are imposed, this problem will begin worsening again by the end of this decade. In the very near future, therefore, we will be proposing emission standards more stringent than those already in effect and we will begin making a series of improvements in our procedures for determining whether motor vehicles comply with the standards. Furthermore, in November

1969, Secretary Finch set forth the motor vehicle emission goals that we believe new cars must be capable of reaching no later than 1980. Attainment of these goals will require drastic reductions of motor vehicle emissions.

Whether the needed improvements can be made without introducing new vehicle engine systems or making fuel modifications remains an open question. It is clearly too soon for either Government or industry to relax its research and development activities in this field. The work of the Department of Health, Education, and Welfare will not only be intensified as the President has indicated; it will also be increasingly well coordinated with the related efforts of other Federal departments and agencies.

In addition, we are going to try to stimulate greatly increased efforts on the part of the private sector—not just the automobile manufacturers and fuel producers but also every other group that has a capability of contributing to a solution of the motor vehicle problem. Our intention of getting the private sector to shoulder a bigger share of the burden was announced, as you may recall, in August 1969, following a meeting of the President's Environmental Quality Council, and we have since been examining various plans for action.

A Federal procurement program, such as the one proposed in the bill you have under consideration, certainly is a potentially effective way of providing incentives to the private sector and, therefore, might well be part of our strategy for the seventies in this area. Whether such a program should operate exactly as proposed in the bill will depend on a number of factors, and particularly on what one expects to get from the program and on what other elements are included in the total effort.

I have outlined our plans with regard to motor vehicle pollution control and our views on S. 3072 in very general terms. On February 10, as indicated before, the President will deliver to the Congress a special message on the environment, in which he will spell out our strategy in some detail. Following the presentation of that message, we will be most happy to reappear before this subcommittee for a more detailed discussion of our projected motor vehicle research and control activities and of the provisions of S. 3072.

Mr. Auerbach and I will be glad to answer any questions you might have.

Senator HART. Thank you, Mr. Secretary.

As you say, you outline your plans with regard to motor vehicle pollution control and your view on the Magnuson-Muskie-Jackson bill in very general terms.

What is so magic about February 10? This is a hearing at which we are attempting in the Congress to move legislation. Why aren't you able to tell us your views now?

Mr. BLACK. Because, Senator Hart, as I indicated, the President is planning to deliver his message on the environment on that day. We look at this as one part of a larger package. We would like to put the whole thing before Congress at once.

We have already testified on extension of the Clean Air Act. We will have specific proposals coming up on that in the form of a bill, either with or immediately after the President's message. We will have other detailed comments on particular legislation of this kind at the same time.

Senator HART. Do you know the position now on this bill that we have opened hearings on?

Mr. BLACK. I don't think we are ready to state our position in detail.

Senator HART. I understand you are not ready to state it, but do you know it?

Mr. BLACK. I think that final decision is one that would have to be made by the President.

Senator HART. Maybe I am suffering, as some of us have, from the lash of a President who has lectured Congress for its slowness. Now we are in the business of trying to move to get a low-emission vehicle on the road. That is the business of the Congress, that is the business of the country today.

The fact that a general message which will include comment on this area is coming up in several weeks is not going to be very helpful to this committee unless we want to resume hearings later, and if we resume hearings later, we will probably get a lecture that we were slow. That is the reason if my frustration shows itself, I ask you if you can't tell us now.

Mr. BLACK. On this measure you will not get such a lecture from the President or anyone else.

Senator HART. Let me lecture you. We are here to do business on this bill, and if he is ready to make a speech on Friday, you know what his position is on Tuesday on this bill.

Senator CANNON. That is a week from Friday.

Mr. BLACK. February 10. This is January 27. The message is set for February 10.

Senator HART. Let us see what the Department can tell us about what it has done up to now on this bill.

You say you have conducted and supported research and development relating to engines, fuels, emission control devices, and other aspects of motor vehicle pollution control.

What did the Department spend last year on pollution control research?

Mr. BLACK. Vehicle pollution control research?

Senator HART. General pollution control research, inclusive of vehicles.

Mr. BLACK. The expenditures on motor vehicles were around \$4½ million.

Senator HART. Out of a total of how much expenditure for pollution control?

Mr. BLACK. Approximately a hundred million—\$80 million, I am sorry. Approximately \$80 million.

Senator HART. Four over eighty?

Mr. BLACK. Yes, sir.

Senator HART. One-twentieth?

Mr. BLACK. The \$4½ million was only for research. Another \$2½ or \$3 million was for enforcement of the standards under the Clean Air Act.

Senator HART. How much of that four was for the low-emission innovative propulsion system development?

Mr. BLACK. Mr. Auerbach can give us that figure.

Senator HART. Break it between the low emission and trying to cure the present internal combustion.

Mr. AUERBACH. The amount spent on research relating directly to what we call unconventional vehicles in fiscal 1969 was about half a million dollars.

Senator HART. Half a million out of \$80 million.

Mr. AUERBACH. Yes, sir.

Senator HART. Do you agree that the automobile is the principal factor in air pollution?

Mr. BLACK. Yes; we agree. The President said that in his message.

Senator HART. The arithmetic related to my question explains why I asked the question.

Mr. BLACK. There are other figures that should be introduced here as part of the arithmetic.

It has been possible up until now in the state of the present technology to make very dramatic reductions in emission. Since the act went into effect in 1968—the reductions in hydrocarbon by 1971 standards will be almost 77 percent from the prestandard level. The reduction in carbon monoxide will be 74 percent.

So in that period there has been, as I say, a very dramatic reduction. The curve is going down, and we expect to continue to go down, as we indicated, through this decade of the seventies. Unless we intensify research—as the President says we intend to—by 1980 we expect it to go up again.

Senator HART. I am sure others of us in the Senate, and Senator Muskie, will certainly ask you to give us the figure for the oxides of nitrogen in the period you cited. As I understand it, this is the real hangup in terms of the cure to the internal combustion engine if we are going to get rid of air pollution.

What did the Department request this year for research and development of low-emission technology?

Mr. BLACK. I think our total budget for this year in the appropriations bill will be in the field here of approximately \$5½ million.

Senator HART. As against your request of how much? That is the budget figure.

Mr. BLACK. I am sorry, Senator, I couldn't give you that.

Senator HART. Did you ask for substantially more?

Mr. BLACK. Ask the Congress for more?

Senator HART. No; did you recommend, viewing the needs as you see them in the Department, a figure substantially more than the Budget Bureau approved?

Mr. BLACK. I am sorry, I couldn't give you that figure. Perhaps Mr. Auerbach could.

Mr. AUERBACH. Are you speaking, Senator, relating only to motor vehicle research and development, because if so, that is not a separate line item.

Senator HART. You couldn't tell us how much you intended, or thought necessary, for research and development of low-emission technology?

Mr. AUERBACH. Yes; we think about a million dollars in our original estimate was for low-emission vehicles, and, as a matter of fact, the Budget Bureau has asked us to spend more than that.

Senator HART. Good.

Will you?

Mr. AUERBACH. Yes; if we get the money.

Senator HART. \$1 million would be twice as much as you spent in this past year, as I understand your testimony?

Mr. AUERBACH. That's right.

Senator HART. While you can't tell us today your views specifically on this bill, can you tell us what programs you plan for 1970 in the field of research and development on low-emission vehicles?

Mr. BLACK. We had planned, as the President indicated in his message, to intensify research generally. We are trying to work more closely with other agencies.

Let me say the first thing we plan to do in the seventies, as we indicated in our statement, is to try to strengthen our procedures, so that these standards we have will actually be applying to the automobiles that are being driven. As you know, our present method is to test prototype models. We have some evidence coming in, particularly on the basis of some studies conducted in California, that prototype models are one thing and cars that are coming off the assembly lines being driven on the highways are something else.

So, our first step in the 1970's is going to be to try to strengthen our testing procedures so that we will have more cars conforming to these standards that are set.

So, if we didn't do anything but stand by the present standards, assuming this is successful, and we have reason to believe it would be, we would expect to see a continued decline in this curve of emissions.

The second thing we are proposing to do, as we indicated, is to further tighten our standards. We have already announced the standards for the 1971 model. We will soon be announcing still more stringent standards for the future.

As for specific research programs that we intend to conduct in the next year or so, again I would like to have Mr. Auerbach give you some reading on those.

Mr. AUERBACH. In addition to work on control of emissions from the internal combustion engine, we have begun, as I have indicated, work on unconventional engines. We are currently supporting development of designs for Rankine-cycle engines, and we are going to be doing similar work with respect to turbine engines and other so-called unconventional systems.

We are doing work on the relationships between changes in fuel composition and emission controls, and we also are looking at alternate fuels, such as liquid natural gas and things of that nature.

In addition, we are doing a great deal of necessary supportive research, such as looking into the photochemical process, the process by which smog is formed, to get additional information that can be used in planning control strategy.

Mr. BLACK. I might make one additional point here, Senator Hart.

We are trying, as I indicated in my statement, to stimulate as much research in the private sector as we possibly can. Certainly we concede that the Federal Government has the lead role in this, but we think that a good part of our role must be to stimulate private industry.

The automobile industry, as indicated in some of the opening comments, is one of the giants in our economy, and it has a tradition of spending substantial amounts on research. Certainly it has a vital stake in the outcome of the research in trying to solve this problem.

This is one of the reasons we have announced long-range goals for emission standards rather than sticking to the year-by-year goals which are based strictly on what technology at the moment is capable of doing. We are setting some targets for the automobile industry to reach, and we expect them to invest substantially of their own funds in the research, so that the total research effort can certainly not be measured by the Federal Government's role.

Here, again, I point out HEW fulfills only one part of that. You are going to be hearing later, I know, from Mr. Kunzig. The GSA has a very interesting research project going.

There are other results in the Federal Government that you will be hearing about later in the hearings.

Senator HART. I apologize for having to leave after having been so harsh at the outset, but the Committee on the Judiciary is considering the nomination of Judge Carswell, and I have been called to attend.

Senator Cannon, I hope, will be able to continue to be here.

Senator CANNON. Yes.

Mr. Black, you stated here in your opening statement that attention must be given not only to motor vehicle engines but also to the fuel that they use—not only to the design and construction of motor vehicles but also to the design and location of highways.

Are you suggesting that we are going to have to relocate the highway system of this country to get rid of the emission problem?

Mr. BLACK. What I am suggesting, Senator Cannon, is the same thing I think President Nixon tried to suggest in his state of the Union address and what Secretary Finch suggested in the comments he made on television Sunday, that the problem we are dealing with here is a total environmental problem.

One of the problems we think we face is too often in the past it has been attacked only by bits and pieces, little compartments.

We are trying to look at the whole thing as a package, which again is why we want to delay our final comments on any one small piece of that package until the President can present his message on the whole thing.

Senator CANNON. I just don't find that consistent with the President's statement where he says, "We shall intensify our research, setting increasingly strict standards and strengthening enforcement procedures, and we shall do it now." And yet you are suggesting to solve this whole problem we have got to wait for a redesign and relocation of our highways. We haven't completed the Interstate Highway System yet.

The action was started in 1958. This is 1970. That is 12 years, and it is going to be another 2 years before we complete it. That is 14 years. So, I am kind of shocked to even have an implication that we are going to redesign and relocate highways to get at the root of this problem.

It seems to me when a Nation can establish the goal of putting a man on the moon and do it as we did here in the Congress 10 years ago and accomplish that in 10 years, certainly we ought to be able to set a target of less than a 10-year period to correct the pollution-emission problem.

You are suggesting in your statement that by 1980 we will have some added standards and perhaps something to shoot for. You say, "In November 1969 Secretary Finch set forth the motor vehicle emission goals that we believe new cars must be capable of reaching no later than 1980."

If his Department can't solve that problem in less than that time, I would suggest maybe we ought to turn it over to the space program.

Mr. BLACK. Let me make several comments here. First, I think you are reading more into my statement than was intended about the highways.

Secondly, I think your analogy as far as the space program is an apt one. We did not reach the moon by saying this year we are going 9 miles toward the moon and next year 9 more after that. We set a target for reaching the moon and mapped out a program for accomplishing it.

I think to some extent that is what we are doing here in this field of emissions. Heretofore, it has been on a year-by-year basis, based on what our present technology is capable of doing.

Now the Secretary has said we are setting some goals that we expect the industry to meet in 1980. We are also going to set interim goals that we expect the industry to meet in 1975. We expect the industry to work toward this. This is why I say I think the private sector is going to have to take a more substantial role in this.

We are not going to conduct all the research and say next year you can do this much more. We have set a long-range goal which we think is realistic and which can be met. As far as the highways are concerned, I think, as I say, what we are doing doesn't depend on the completion of the highways. We will go ahead with the development of low-emission vehicles, but I think we would concede that since we do have so much more work to do on our highway system that certainly we ought to keep this total problem in mind as far as any future work to be done on the highways is concerned.

Senator CANNON. Of course, if you are suggesting relocation, you know the highway program was certainly a massive program and a very expensive program, and I am glad you followed up on the analogy to the space program.

When we established the goals of putting a man on the moon, I happened to serve on the committee at that time, and we did that by committing ourselves to spending some money.

Here, for example, you recommend that a million dollars this year would be about correct. If we had suggested proceeding toward a 10-

year goal of putting a man on the moon at a million dollars a year in the research and development phase, we wouldn't be starting to build the boosters by now.

Mr. BLACK. Again, the million dollar figure is only one part of a larger effort within our Department and within the whole Federal Government. Furthermore, as I indicated, we don't think that the Federal Government is the only one who is or should be active in this field. That figure we are talking about is a fiscal 1970 figure. As I indicated earlier, the President will speak to this in his budget message, which is going to come up next Monday, and in his environment message which will follow on February 10.

So, I think you will have to judge the program for the future on what comes out of these.

Senator CANNON. Senator Muskie?

Senator MUSKIE. I think it might be helpful if we reviewed the budgetary figures or the authorization figures and the budgetary figures, but before doing so, I would like to make two points and see if you agree with them.

I am quite sure from your statement and from what you have said in response to questions that you will agree, but would like to make this clear.

First of all, in the subcommittee we have always recognized that research is a critically important factor if this country really is to roll back the tide of pollution—air, water, and otherwise, and secondly, that research takes a long lead time. You don't produce instant results in the laboratory by appropriating money.

So, you have got to start spending money when you get it, if you are to meet the problem created by long lead time considerations. Now, in the 1967 Clean Air Act we set up two authorizations, (1) for section 104, research, and (2) for section 309, programs, including enforcement.

The figures were, I think, in section 104, research, for fiscal year 1968, \$35 million; for fiscal year 1969, \$90 million.

This last year we had before us in the Congress new authorizing legislation for fiscal year 1970 because we were not authorized for 1970.

The House and Senate enacted different figures for authorization. The Senate approved \$90 million to continue the level of authorization which had been approved for 1969.

The House approved, I think, \$20 million or \$21 million which reflected the full budget request of the administration for last year. Am I correct up to this point?

Mr. BLACK. Yes, sir; those figures are correct.

Senator MUSKIE. In conference the issue between the House and Senate conferences was whether or not the authorization for 1970 ought to be the budget request of the administration or the authorizing committee's estimate of what was needed.

The House position was that since the administration was prepared to spend only \$21 million, it was pointless to authorize \$90 million. The Senate position was that since \$90 million was our estimate of the research level that ought to be made, it was our responsibility as the authorizing committee to say what we thought was the necessary level.

We compromised at \$45 million, or one-half the figure that we had thought essential for 1969.

Finally, the Senate approved increasing the appropriation, the bill that was vetoed last night, from \$21 million to \$45 million.

Now, is that extra \$24 million the wrong amount of money in the wrong place at the wrong time?

Mr. BLACK. I think, Senator Muskie, I would rather respond to that in a general way.

First, this program is one—

Senator MUSKIE. I have no doubt about your preferences. If you don't like the rhetoric because it is too familiar, then, let me ask you this. Do you think—in light of the considerations you and I have agreed upon here, that research is critical and that it involves long lead time—that \$45 million is too much for section 104, research, at this time?

Mr. BLACK. That is a question that I think would have to be answered by the professional program people in this Department. We have a number of programs at HEW, those of us who came in last year have found out, that you can fund at only certain levels effectively, and that involves some of the programs involved in our present controversy.

Senator MUSKIE. We have learned in several programs, notably health programs, that the Congress can prod the bureaucracy for higher levels of program activity by appropriating more money than the bureaucracy requests.

The 1967 act was enacted in part at least over the initial objections of the administration, so, the Congress mandated an air pollution program in 1967. As part of that mandate, we said research is essential. Without it we will never fully lick this problem.

Now, somebody must speak for those people in the Department who program research. You do not, I take it?

Mr. BLACK. I am not a program person. I hope that the people who operate this program will have an opportunity to come back after the President's message and answer that kind of question for you specifically.

I think it is quite possible, as I said, that in a number of our programs, certainly we don't dispute the need for additional research. We don't think, as I also said, that the Federal Government can do it all, but we are not saying that this is as much money as we should spend effectively.

Senator MUSKIE. We are not talking about the Federal Government at all. I have in my hands here a program for progress titled "Automobile and Air Pollution," part 1, it is a 1967 report, issued by the Department of Commerce in October 1967.

I assume this report had the endorsement of the program people of that time, whatever may be the position of the program people in this administration. With respect to research in this field of automobile

emissions, and this report is two and a half years old, recommendation 14 was this:

Recommendation 14: The Federal Government should initiate a 5-year program in total amount of approximately \$80 million to support innovative developments usefully in the establishment of future emission standards in the following areas;

- (a) Energy source for vehicles.
- (b) Vehicular propulsion systems.
- (c) Emission control devices.
- (d) Special purpose urban cars.
- (e) General purpose vehicles.

There are five programs.

The recommended support level is seen as a modest investment for future air quality and amounts to approximately 13 cents per year for each vehicle currently in operation in this country.

The Government should not become involved itself in vehicle manufacture or in the design of complete vehicles for consumer use. The specific intent of this recommended program is to provide support for that research and development which is necessary to demonstrate potentially attractive alternatives for automobile pollution control.

This was said in 1967—presumably after considerable thought. It is a long report. It looks to me like an intelligent report. That is 2½ years ago. Yet, you are now spending \$4.5 million or roughly a third of the annual investment in research for automobile pollution control that this report recommended.

May I suggest that this report is consistent with the authorizations put in the law by the committee and the Congress in the 1967 act. I don't expect from what you have said to get a final, definitive answer from you, and I am using this colloquy to drive home the point.

The state of the Union messages don't create the programs necessary to deal with our air pollution problem, and I would hope that the environmental message we get on February 10 will come to grips with the realities of environmental pollution problems. If the President hasn't had this report brought to his attention I suggest that you and your program people bring it to his attention, and I hope there is something better than this in the Department.

If there isn't, it is an indictment of the previous administration and this one to the extent that you haven't used the last year. We are criticized for not using the last year to solve the crime problem of this country.

Maybe you should have done something about this problem in the last year. I want to back off from that partisan rhetoric at this point; we get sucked into it quite easily around here in an election year. But this is a serious point I am making. Research is important.

As of this moment so far as this administration's intentions are concerned, we have last year's budget for research in this field, we have the refusal to increase that budget last year. We have last night's veto message which may have been on other grounds than last year's refusal, but so far as we know the veto criticized all of the increases approved by the Congress in that budget, including this one in this vital field of research.

The figures are in the record, and I am not going to belabor the point about research. I want to make it clear, because we are not going to forget the point, and if you would like to comment additionally at this time, I would be happy to have you comment.

Mr. BLACK. I would appreciate that opportunity. Let me say first that obviously we have no obligation here to defend what has gone on in the past. This administration has been here for a year.

Our opportunity, as you know, Senator, as a realistic matter, to have very much impact on the 1970 budget was limited by the time when we came in, first, and second, by the inflationary pressures of this particular period. As far as the 1967 report and recommendations there concerned, I think those are something which obviously will be judged and taken into account by our people, but I think our own program will be produced in time.

I think, furthermore, I wouldn't want the total efforts of this administration to be judged even by our next budget but by the results that we can produce over a period of time.

I think that the question first is how far, how fast you can go. Second, there is a question how far the Congress is willing to go. Mr. Auerbach has pointed out in fiscal 1969 the authorization on 104 was \$90 million, the President's budget was \$31 million, the appropriation was \$18 million. We have to be able to take Congress with us.

I hope certainly that we can come up with a program that will answer in detail the questions that you raised and that Congress will find attractive in meeting the problem.

As I say, we are not in a position of having to defend all that has gone on in the past, but when I was going over this subject with some of our people in our Department I raised some of the same questions that you have. I said we have a budget of roughly \$100 million in the air pollution field. We are spending \$5 million for automobile pollution, plus another \$2 or \$3 for enforcement of these standards. We have recognized that automobile pollution accounts for half of the total pollution problem. Aren't we a little out of balance?

The answer I get is that at this point anyhow we have been able to accomplish a dramatic reduction in automobile pollution with technology already available to us. Here we have reached a point where with these 1971 standards we have reduced automobile pollution with the hydrocarbons and carbon monoxide approximately 75 percent for each since this program got underway.

In other areas of pollution, technology was such that we could make almost no reduction without spending much greater sums of money, which helps explain what seems to be disproportionate amount of money going into other areas.

Now, the problem we face is that we have reached this 75-percent point. Our projections are that the emission curve is going to continue to go down through the 1970's, but what we are concerned about is that 1980 period when you go up. You are right, it will take a long leadtime on research, and I would certainly expect that as time goes on a greater proportion of our research funds will be going into this problem because that last 25 percent is going to be the difficult area in which we try to reduce pollution.

So, I would think we will be devoting a greater share of our money to vehicle emission research. But without disputing at all what you say about the Federal Government's role in this program and the intent of Congress, I do want to emphasize that a good part of our thinking to set these long-term goals, looking again to this 1980 period when this curve is going to start rising again, is to stimulate and encourage much more research on the part of private industry.

Senator MUSKIE. First, let me make two or three points very briefly. I don't want to belabor this.

(1) It has been the intent, I gather, this past week to say to the country, that we are going to get something better in the way of pollution control out of this Government, out of the Congress, hopefully, and out of the country.

So, it isn't a question of doing something well. It is a question of doing something better. You and I have agreed that research is one of the important keys to it. You are not going to get research unless you are willing to pay for it. And you have got to put massive amounts of money, relative to past expenditures, into research, if you are going to do the job. You can't fuff that one over.

The amount and the levels of spending we have had are not adequate. I have been as impatient about that with the Congress and with the last administration as I am going to be with this administration if it doesn't measure up to the targets that we think, after years of hearings, are necessary.

That report of 1967 was not implemented as it should have been by the last administration. I was simply asking whether it will be in this administration. I hope we get an answer on February 10. I gather you can't give it to us.

The second question I would like to put to you is this: Am I right—I gather I am—in assuming that 1975 and 1980 would be the next target dates for new standards on the automobile?

Mr. BLACK. That is the present thinking, that we will set long-range goals instead of these year-by-year piecemeal goals, yes, sir.

Senator MUSKIE. As I recall the testimony in 1966 or 1967, before our committee in Detroit, and Senator Baker can correct me on this if I'm wrong, it seemed to me the testimony was that the present internal combustion engine could be improved so that the projected 1968 standards for hydrocarbons at that time could be reduced to 100 parts per million with the then-current fundamental concept of the internal combustion engine, and conceivably to 50 parts per million.

You have said here this morning that one of the reasons you are postponing any tightening of the standards before 1975 is that we have gone as far as we can with present technology. That reasoning does not appear to be, consistent with the testimony we got back in 1966-67.

I gather there can be improvement without radical changes in the internal combustion engine prior to 1975. Is that different than your information?

Mr. BLACK. I don't mean to leave the impression that there couldn't be or wouldn't be any other improvement between 1971 and 1975. As I indicated, by 1971 we already will have made very dramatic

progress. We think in setting standards for 1975 instead of just setting goals for 1972, we are going to stimulate the industry to greater efforts of its own.

We think further it is not probably that the industry is going from 1971 standards to 1975 standards in one great leap. You are going to have some reductions as they move toward the 1975 standard.

Senator MUSKIE. Let's give you the benefit of our experience. When we wrote the 1967 law, we provided for standards in 1966, and it was with that target before us and in the projected legislation that industry finally, after initially objecting to any national standards at all, was able to persuade itself that it could implement standards in 1968.

If we had started out with a target of 1970, we might have ended up with 1972 or 1973, instead of 1968. The approach to this is not to stretch out the targets. The approach is to apply the pressure now, and not wait until 1975. I think you have just got this 180 degrees reversed.

Mr. BLACK. I think you are overlooking one thing there, Senator; possibly another. We are also planning to promulgate some standards for things other than hydrocarbons and carbon monoxide—nitrogen oxides and the particulates.

Senator MUSKIE. We were told in these hearings that we could set standards governing oxides of nitrogen in 1970 or 1971. Do we have them?

Mr. BLACK. I hope that we will.

Senator MUSKIE. But you don't have them now, and you are postponing them until 1975?

Mr. BLACK. No; not until 1975. They will come into effect before 1975.

Senator MUSKIE. When?

Mr. AUERBACH. I think tentatively nitrogen oxide standards will be established probably for the 1973 model year, in advance of the 1975 model year.

Senator MUSKIE. What is the standard in California?

Mr. AUERBACH. They have set standards to take effect in the 1971 model year.

Senator MUSKIE. Why can't we have that nationally?

Mr. AUERBACH. It is on the basis that California requires a more stringent approach to the problem.

Senator MUSKIE. You don't think we require it in the rest of the country?

Mr. AUERBACH. Nitrogen oxide controls will be required in the rest of the country. The basis for California having them earlier is a provision in the law allowing waivers if California requires more rigorous control.

Senator MUSKIE. I know, but as we made clear in the legislative history, we gave California this authority because California's problem is so tough, but we also said that we would hope that as soon as technology is developed to meet California's problems that it is applied to the rest of the country.

Now, obviously you are going to lag 4 years behind California in order to give the rest of the country the benefit of California's problem, pressure, and development. Is that the philosophy?

Mr. AUERBACH. Not 4 years, Senator; no.

Senator MUSKIE. What is it?

Mr. AUERBACH. Two years.

Senator MUSKIE. Why should it be two?

Mr. AUERBACH. Because we have not yet published air quality criteria for the country as a whole against which to judge air quality needs and figure out appropriate emission standards.

Senator MUSKIE. We are talking about national standards. That is what the 1965 act provided, national standards. They are not going to vary from State to State.

Mr. AUERBACH. But I would assume they have to bear some relationship to air quality needs.

Senator MUSKIE. With respect to the automobile? I don't expect 50 different standards for automobiles.

Mr. AUERBACH. Not 50 different standards, but some relationship to air quality needs across the Nation as a whole.

Senator MUSKIE. I wish you would go over that more slowly, and spell it out. We are talking about one automobile, manufactured for national use, and you are telling me that we have got to delay the California standards applying them to the rest of the country because there is going to be some difference?

Mr. AUERBACH. No, sir.

Senator MUSKIE. If there isn't going to be any difference, why shouldn't we get it at the same time?

Mr. AUERBACH. What I was trying to get across is we are in the process of developing air quality criteria for nitrogen oxides, which, of course, are related to the whole photochemical smog problem, in addition to being a pollutant themselves.

In order to determine what emission standards are needed for motor vehicles, we need to relate them to present levels of nitrogen oxides, and to the effect those levels generally have on people and property, so that we can figure out standards which will assure us of having a reduction of nitrogen oxides emissions to such an extent that air quality will be improved and not impaired.

Senator MUSKIE. You mean it is conceivable, after you have finished with your criteria on nitrogen oxides that the rest of the country may get a less stringent standard with respect to nitrogen oxides than California?

Mr. AUERBACH. I wouldn't want to guess on that right now. It depends on what the criteria—

Senator MUSKIE. I can guess on that right now. I will tell you that won't be good enough.

Senator BAKER. Would the Senator yield on that point just for a moment?

Senator MUSKIE. Yes.

Senator BAKER. Might I ask the witness whether it isn't true, as I think Senator Muskie will recall from the various hearings we have had on this subject, that there is a close relationship between the emission of oxides of nitrogen and the emission of unburned hydrocarbons from automobiles, and that the problem varies from one part of the country to another? In the Los Angeles basin, for example, the problem of photochemical smog from oxides of nitrogen causes the great

green smog that hangs over that basin, while in the city of New York, unburned hydrocarbons and carbon monoxides are the essential source of the grayish-black smog that hangs over that city.

When you set about the business of reducing the amount of oxides of nitrogen, at least according to present technology, you increase the amount of unburned hydrocarbons; by the same token when you decrease unburned hydrocarbons by raising combustion temperatures, you increase the oxides of nitrogen.

So you don't have a uniform problem around the country, and it may vary from area to area as it does vary in the situation in Los Angeles and the situation in New York City.

Is that an accurate characterization of the problem?

Mr. AUERBACH. Yes, that is generally true. Another pertinent factor that must be taken into account is that in reducing nitrogen oxides, you are getting yourself involved in what is basically an ecological problem; that is, you are altering the ratio of nitrogen oxides to hydrocarbons in the atmosphere, and if you alter it just a little, it is possible that you will result in creating more photochemical smog, instead of less.

So, it is important to keep the ratio of nitrogen oxides and hydrocarbon emissions to such a level that you are continually reducing photochemical smog, and not inadvertently causing an increase.

Senator MUSKIE. The interrelationship, of course, of these two problems is clear in the record. Nevertheless, the objective is to develop a national automobile, isn't it?

Mr. AUERBACH. Yes.

Mr. BLACK. Before we leave this total point, I want to repeat one other thing that we think is going to make a very substantial contribution to the reduction of emissions in these years immediately ahead, regardless of what we do to the standards that we put on paper, and that is to see that the production model vehicles are actually meeting the standards of the prototype.

I'm sure your committee recognizes this problem. It is one that we are coming to grips with, and it is one of the things we have been working on during this past year. We haven't been ignoring this problem, and we will come forward quite soon with some detailed plans on how we want to change our procedures so that we can get better conformity of the cars that are actually out there on the highways.

Senator MUSKIE. There is not only that problem, but there is the problem of quality control in the manufacture of automobiles. Automobiles are not uniform in their performance when they come off the assembly line. The variations have been acceptable as to other factors of pollution. I am not sure they are going to be with respect to emission from automobiles.

So quality control is going to be important as well as inspection systems of some kind or another, which simply highlights this.

Here in the space of 5 minutes in colloquy with Senator Baker and me, you have highlighted three difficult problems: the interaction of the nitrogen oxide problem, and the hydrocarbon problem, quality control of manufactured vehicles, and inspection to follow up the performance during the life of the vehicle.

All of these problems are only going to yield to research. All of them are interrelated.

It just seems to me that the timetables you have set and the budget levels we have had up to now all reflect something less than the sense of urgency that we need if we are to solve these problems.

I am just stating this for the record again, knowing that we have got to wait, apparently, until the February 10 environmental message. I'm content to wait, but if we are subjected to the criticism of being slow again, I will be happy to refer to this record, because these hearings do take time, and I don't know when this subcommittee will be able to open hearings again.

We have got some 30 days of hearings in my subcommittee on other aspects of the environmental problem. So, if you can hasten the message, at least this part of it, with respect to this bill, it would be very helpful.

Mr. BLACK. In all candor, I think my prospect of doing that would be slim.

Senator MUSKIE. In all candor, I will agree with you.

Mr. BLACK. But I would ask you, Senator Muskie, not to prejudge our program, to wait until the President has come in with his environmental message, and until we have submitted the legislation and have taken the administrative action that we can take to back it up.

Senator MUSKIE. You know, since we don't have the program, since we have got to try to anticipate it, I guess the best we can do here today is to put up the red flags of our concern. That is not an unfamiliar technique around this town.

Mr. BLACK. We have no question of your concern, and I can assure you that we share it. I will, as I said, use whatever influence I have to see that the committee is not scolded for acting slowly on this particular legislation.

Senator MUSKIE. That really isn't my principal objective.

Thank you.

Senator CANNON. In your statement you say:

Our intention of getting the private sector to shoulder a bigger share of the burden was announced, as you may recall, in August of 1969 . . . and we have since been examining various plans of action.

In August of 1969 wasn't the automobile industry announcing that the battle against automotive air pollution was being won? Wasn't that a statement that was made at that time?

Mr. BLACK. I am not familiar with that broad a statement.

Senator CANNON. Let me ask you if the President's Environmental Quality Council announced that air pollution would continue to decrease until 1990 and then it would begin to rise again.

Mr. BLACK. 1980, I believe.

Senator CANNON. I think they said 1990.

Mr. AUERBACH. If I might interject something here, we have never agreed with the claims of the automobile industry that the battle against motor vehicle pollution has already been won.

Senator CANNON. If you have been studying the ways of stimulating the private sector since August, why aren't you prepared to address yourself to S. 3072 today?

Mr. BLACK. I think we are going to stimulate the private sector, as I said, with these goals that we have set which we have been addressing ourselves to since August. We think that is one of the great ways to stimulate it.

Let me say I don't want to leave the impression that I am closing the door on our support of this legislation. I think I can say as far as the objectives of it are concerned we are in general accord.

As I indicated in the statement, whether we agree with every detail of this particular approach is a question that would be answered later. Certainly, we recognize the tremendous influence and powers of Federal procurement. It has been used effectively in many other areas, and, as we have said in our statement here, it certainly has great potential in this particular program. I don't want to leave the impression, Senator Cannon, that we are totally negative to this or oblivious to our responsibilities.

Senator CANNON. Of course, the bill was introduced in October, and you were invited to testify about a month ago, I believe. I have an excerpt from a "Supplementary Stimulation Plan for Development of Low Pollution Motor Vehicles." I assume this is from your planning and programming people:

An incentive program would involve a system of graduated incentives to encourage firms to pursue independent research and development programs. Such independent research, if successful, could sharply reduce the level of federal funding of R&D and probably accelerate the availability of commercially feasible low pollution potential of vehicle," and also quoting from that same report, "The main ultimate incentive will be government purchase of such vehicles by Federal, State and local governments for fleet use.

That is sort of the main thrust of this bill, at least a good bit of the thrust of this bill, and despite the fact that that is your internal memorandum on low emission development, you are still not prepared to take a stand or position on them today.

Mr. AUERBACH. That is right. I don't think I am familiar with that particular report you are alluding to, but obviously I think the Department with or without this legislation would have been remiss in its obligations if it hadn't been considering a procurement program.

That is why I said earlier it certainly is one of the things under consideration, and it is one that we recognize that potentially can be effective. But it depends we think on how it is tied in with other parts of this effort, and this is something I am simply not prepared to say until you have had the President's total package.

Senator CANNON. I think that I should cover just one part that you and Senator Muskie had some colloquy about, and that related to the 1969-70 budget request and appropriation.

You said you didn't have any control, of course, over the 1969 one. In the 1969 one the request was \$31.3 million and the appropriated figure was \$18.7 million. In 1970 the request was \$18.7 and the appropriated figure was, up until last night, \$45 million. Is that correct? Do you agree with those figures? I am talking about section 104.

Mr. BLACK. The President's budget, according to my figures here, for 1970 was \$21.9 million.

Senator CANNON. \$18.7 is the figure I have, but—

Mr. BLACK. That was the appropriation last year.

Senator CANNON. That included 2.7 in reprogramed funds?

Mr. BLACK. The appropriation for last year was \$18.7, and the budget this year represented an increase of over \$3 million over last year's appropriation.

Senator CANNON. You say he gave \$2.7 million additional from reprogramed funds for section 104, but the Congress provided \$45 million which Senator Muskie pointed out.

Mr. BLACK. I would simply point out the amount the President requested this year for the 1970 budget was more than the Congress appropriated last year.

Senator CANNON. Technically, that is not correct, because \$2.7 million of that was reprogramed funds. The requested appropriation was exactly the same, as I understand it.

Senator Baker?

Senator BAKER. Mr. Chairman, thank you very much. There have been five Senators ahead of me, and I am the first Republican who has had a chance to question the witnesses, which distresses me a little, except that through the good grace of the chairman of the principal committee in the pollution field, Senator Muskie, I was permitted to ask a question about oxides of nitrogen.

But I do appreciate the chance to address a few questions to the distinguished Secretary.

I would first say that I am a little concerned at the partisan hostility that I think is pervading these hearings. I said earlier, and I repeat now, that I think that this field of air and water pollution, improvement and control, is too vital to too many people in this country to fall prey to any sort of predatory partisan politics.

I recall in my service on the Air and Water Pollution Subcommittee with Senator Muskie for 3 years that I can think of no single issue where there was a partisan polarization, and I hope that same bipartisan spirit of cooperation will continue in the months and years just ahead.

It is I am sure a disappointment that the administration's message on this problem isn't here today, but after all, the administration didn't set the dates for these hearings.

As I recall, I only received notification of them a few days ago. It seems to me that the difference between January the 27th and February 10th is a fairly small time to wait for the administration's proposal in these fields. Beyond that, I commend the Secretary for his depth of knowledge in these fields.

I would especially address this question to him on one particular point. Would you agree with me that in the course of the last several years, dating from the passage of the Clean Air Act of 1965, in the field of automotive pollution and other fields we have found out a great deal about what will work, and we have also found out a great deal about what will not work in the control of pollutants, and especially in the field of automotive emissions; would you agree that is the case?

Mr. BLACK. Yes.

Senator BAKER. Would you agree that it may appear now that the ultimate solution may lie in a basic modification of the internal com-

bustion engine and of its fuel in order to obtain some sort of realistic abatement of the smog problem in our problem areas and throughout the United States?

Mr. BLACK. Senator Baker, I think, as I understand it from the people in our Department who work in these fields, that this is quite probable. As I said in my prepared statement, it is an open question with us. We certainly think that you have to attack all parts of the problem at the same time, and this is something that we will be taking a look at, particularly here, of course, when we get into the areas of particulates.

Senator BAKER. Would you also agree, Mr. Secretary, that in the final analysis this problem of air pollution will yield to solution only when we consider propulsion systems for automobiles, for trains, for airplanes, and for whatever purpose, as well as all the other aspects of the ecology and population distribution of the United States taken together, including the production of energy, the industrial capacity of this country, mass transportation, highway transportation, rail transportation, air transportation, agriculture, forestry—all of these items do interrelate and must be considered as part of the problem of the pollution of our air envelope?

Mr. BLACK. Precisely. That is why we are trying to present this sort of unified approach to the problem.

Senator BAKER. Would you expect that is the sort of unified approach and perspective that we might see forthcoming from the administration next month?

Mr. BLACK. I think you will indeed.

Senator BAKER. Would that be the first time that we had had such an integrated overall approach to the question of air pollution?

Mr. BLACK. I think this would be the first environmental message of this particular kind, just as the attention the President gave to this whole question of environment in the state of the Union address was the first of that kind.

Senator BAKER. With that one partisan lick of my own I want to return to my expressed hope that all of us will get down to the business of approaching this problem dispassionately and with concern, and no one has shown more concern than my distinguished subcommittee chairman, Senator Muskie, and others on the Democratic side of the aisle. But this must not become a partisan football.

Senator MUSKIE. I would agree with Senator Baker as to the tone that ought to be set in these hearings on this subject. I would recall, however, that the Republican members of the subcommittee took considerable pleasure out of my chastising the previous administration for failing to measure up to our expectations in the field of automobile emissions, and since I was willing to do it with my own administration when I felt it fell short of what the country had a right to expect, I think I have a right to do the same thing with respect to this administration. I hope I don't abuse the privilege of being partisan, I will try not to.

Senator BAKER. If the Senator will yield, I don't think he has or will, but I will point out respectfully that he might have waited until the message came up.

Senator MUSKIE. I sometimes have found that the best way to insure that the message is strengthened, is perhaps to raise doubts about it in advance.

Senator BAKER. These issues are usually settled at the polls, and this one has probably been settled for the time being, at least.

Mr. BLACK. I will advise the President that you are awaiting his message with interest.

Senator CANNON. Thank you very much, Mr. Black and Mr. Auerbach.

Mr. John Chapman, Deputy Administrator, General Services Administration.

Mr. Chapman, we are delighted to have you here and have you testify. Inasmuch as I have been admonished to keep this as a nonpartisan issue by Senator Baker, I would simply say that yesterday GSA had a statement in support and this morning they present a statement saying wait until February 10. So, that is about as nonpartisan and as dispassionate as I can be.

Thank you very much.

STATEMENT OF JOHN W. CHAPMAN, DEPUTY ADMINISTRATOR, GENERAL SERVICES ADMINISTRATION; ACCOMPANIED BY ROBERT M. O'MAHOONEY, COMMISSIONER, TRANSPORTATION AND COMMUNICATIONS SERVICE; AND H. A. ABERSTELLER, ASSISTANT COMMISSIONER FOR PROCUREMENT

Mr. CHAPMAN. Mr. Chairman and members of the subcommittee, I am pinchhitting this morning in the absence of our Administrator, Bob Kunzig, who looked forward to testifying but unfortunately came down with the flu, and just could not make it.

I am pleased to be here as his representative to testify before this subcommittee on the proposed Federal Low-Emission Vehicle Procurement Act, S. 3072, a bill to stimulate the development, production, and distribution of low-emission vehicles in order to provide the public increased protection against the hazards of vehicular exhaust emission. I am accompanied today by the Commissioner of the Transportation and Communications Service of the General Services Administration, Mr. Robert M. O'Mahoney.

I am particularly pleased for this opportunity because President Nixon characterized the problems of pollution in his State of the Union message on January 22 as "the subject which, next to our desire for peace, may well become the major concern of the American people in the decade of the seventies."

More specifically, the President said, "The automobile is our worst polluter of the air. Adequate control requires further advances in engine design and fuel composition. We shall intensify our research, set increasingly strict standards and strengthen enforcement procedures, and we shall do it now."

The General Services Administration endorses the objectives of S. 3072. Of course, air pollution is but one aspect of the overall problem of degradation of the environment, and pollution from motor vehicles is but one aspect of air pollution.

Offering incentives to produce low-emission vehicles through a guaranteed procurement program, such as is envisaged by S. 3072, must therefore be considered in the context of an overall Federal program. As has been mentioned frequently in previous testimony, it is anticipated that the President will make known his recommendations with respect to such a program in his February 10 message on the environment.

I consider it particularly significant, Mr. Chairman, that the bill which we are discussing today was introduced by Senator Magnuson on October 27, 1969. On that very day, in Los Angeles, the Administrator inaugurated an experiment in the use of natural gas to power General Services Administration motor pool vehicles.

Commissioner O'Mahoney will, at the close of my statement, provide the committee with a report on the status of that experiment, but I think it would be useful at this point to give the committee a brief summary of the highlights of our efforts in this direction thus far.

The General Services Administration operates throughout the United States over 51,000 vehicles in 97 motor pools. These vehicles are operated on a business basis; that is, the agencies which use the interagency motor pools pay to the General Services Administration the cost of operation of the vehicles, and the fleet is operated out of a revolving fund, with each of the agencies paying for the use of the vehicles on a lease/rental basis, as appropriate.

Our initial experiment in California at the West Los Angeles Veterans' Administration hospital has begun with 24 vehicles, 12 operated with natural gas and 12 similar vehicles operated on gasoline for control purposes. The aim of this experiment is to demonstrate that vehicles may be operated so that virtually no pollution results; that the use of natural gas instead of gasoline results in a reduction of pollutants by 90 percent; and to establish that these vehicles can be so operated on a commercial basis.

Thus far, our experiment in California has been highly successful—so successful, in fact, that the Administrator has authorized the conversion this February of an additional 40 vehicles at the General Services Administration motor pool operated at the Mississippi test facility of NASA.

In March, about 30 additional vehicles at the GSA motor pool at the Manned Spacecraft Center in Houston will be equipped so that they may use natural gas. I emphasize to the subcommittee that the Administrator hopes to do this at little or no cost to the Federal Government, with the hope of some potential savings to the taxpayer and most importantly with the result that the fight against pollution will be advanced.

To this extent, as President Nixon said, America will begin to pay "its debt to the past by reclaiming the purity of its air, its waters, and our living environment."

In addition to our dual-fuel experiment, we are developing a program with the Ford Motor Co. to test the effectiveness of emission control equipment on production model cars after they have been in normal operation for 1 or 2 years.

This program will involve a part of GSA's fleet of 827 cars at Cape Kennedy, Fla. GSA mechanics will perform mechanical work in accordance with Ford Motor Co. service instructions in order to determine emission control advantages of tuning up pre-1968 used cars which are not equipped with emission control devices, as well as later models which are so equipped. This program will commence next week.

I appreciate, Mr. Chairman, this opportunity to present the views of the General Services Administration. At this time, I would like to ask that Commissioner O'Mahoney report to you the status of our dual-fuel experiment. Following Commissioner O'Mahoney's remarks, we will be happy to entertain any questions the subcommittee might have.

Senator CANNON. You may proceed, Mr. O'Mahoney.

Mr. O'MAHONEY. Mr. Chairman, we have some slides which we will use to illustrate this report. I think we will need the lights out.

I might point out to the committee, Mr. Chairman, that the gentleman sitting behind the slide box over here is Mr. Elwood T. Driver, the project director for our dual-fuel program, and he is on loan to us from the National Highway Safety Bureau. He is a safety engineer with the Bureau.

Our program had its beginning last July when Administrator Kunzig directed me to investigate the dual-fuel vehicle system. Mr. Kunzig's interest in the system was sparked by the fact that most of the 325,000 vehicles operated by the civilian and military agencies of the Federal Government were purchased through the General Services Administration.

The Transportation and Communications Service of the General Services Administration operates more than 51,000 vehicles in 97 interagency motor pools throughout the United States, including Alaska, Hawaii, and Puerto Rico.

Our investigation of the system led to the dual-fuel tests underway at one of our most smog-plagued cities—Los Angeles. After analysis of the dual-fuel system, we decided to launch a test of the system on our vehicles. The GSA motor pool at the VA center in Sawtelle, Calif., was chosen for the test because of the smog problem in Los Angeles and the technological assistance available in the area.

I might add at this point this system was developed by the Pacific Lighting Co. and the California Gas companies that serve the Southern California area.

The nature of the VA motor pool operation also involves a great deal of stop-and-go driving, giving GSA an opportunity to evaluate the use of compressed natural gas under the most difficult and pollution-producing driving conditions.

Mr. Chairman, here you see a slide, a logo as the Madison Avenue people call it, which is on each of the vehicles in our test program in Los Angeles and which will also be on the vehicles that will be used in further development of the test.

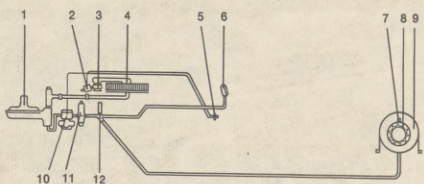
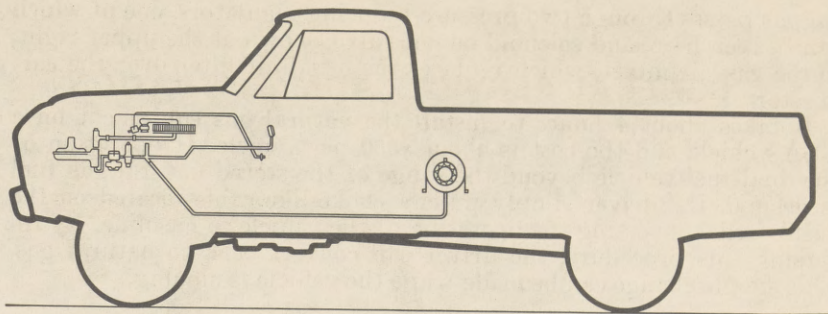


SLIDE 1

The 12 vehicles operating on natural gas display this emblem which indicates they have been converted to the dual-fuel system. Twelve control vehicles, identical as possible to the 12 natural gas vehicles, are also being used, operating on gasoline only, so an accurate comparison can be made of the pollution and cost of operation.

The system enables the vehicle to operate alternately on natural gas or gasoline. Natural gas, the same fuel used for cooking and heating, moves from pressurized cylinders, located in the bed or trunk of the vehicle, to a standard carburetor, undergoing pressure reduction at two stages. The fuel comes through here, this is one pressure reduction valve and this is another, and then the fuel goes into the carburetor at this point. The natural gas and gasoline can be used alternately through the same carburetor.

Ceremonies launching the GSA dual-fuel project were held at the VA Center in Sawtelle, Calif., on October 27 last year. We were pleased to have as our guest at the ceremony the distinguished senior Senator from California, Senator George Murphy. He is seen here, with Administrator Robert Kunzig, examining the dual-fuel engine.



1. 2nd Stage Regulator
2. Gasoline Solenoid Valve
3. Gasoline Carburetor
4. Gas-Air Mixer
5. Fuel Selector Switch
6. Natural Gas Fuel Gauge
7. Pressure and Temperature Safety Valve
8. Shut-off Valve
9. Conventional 220 Cu. Ft. Gas Cylinder
10. Natural Gas Solenoid Valve
11. 1st Stage Regulator
12. Natural Gas Fill Valve and Pressure Safety Valve

SLIDE 2

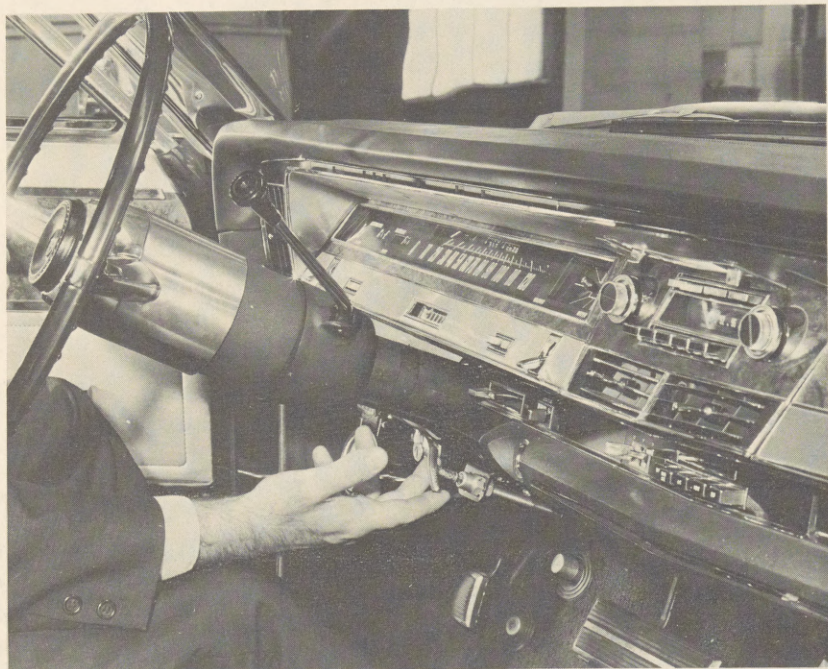


SLIDE 3

Mr. Kunzig is pointing at the carburetor device, which is the heart of this system. Here we see the inside of the hood of the car. The natu-

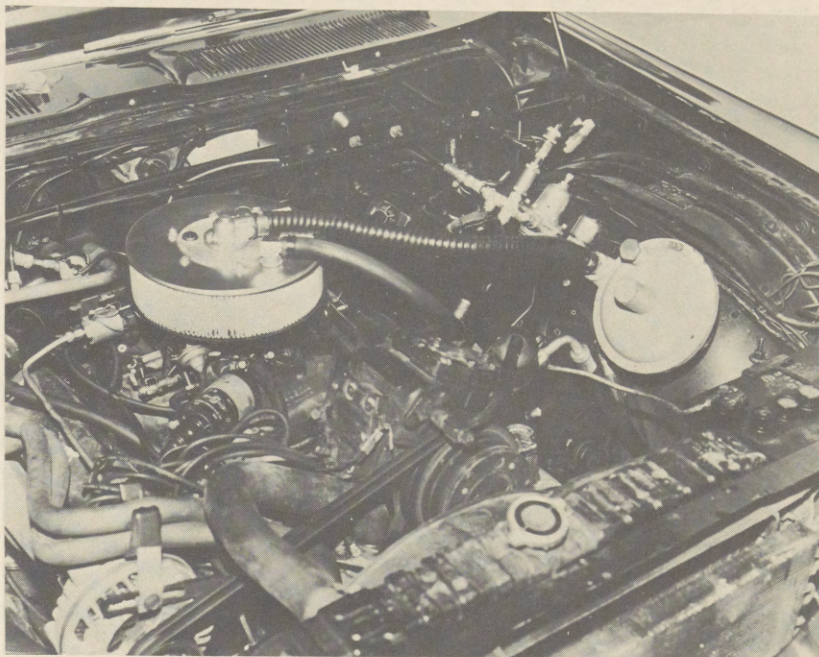
ral gas passes through two pressure-reducing regulators, one of which can be seen here, and solenoid on/off valve, shown at the upper right, to the gas/air mixer, which replaces the usual air filter over the carburetor.

It takes about 4 hours to install the natural gas equipment on a GSA vehicle and the cost is about \$350 per vehicle. If operation of the dual-fuel vehicle beyond the range of the stored natural gas fuel is desired, the driver simply pulls a choke-like cable located on the dashboard, converting the operation of the vehicle to gasoline. By reversing this procedure, the driver can convert back to natural gas. This simple change can be made while the vehicle is moving.



SLIDE 4

I might add I have gone through this cycle myself on a freeway in Los Angeles, and it works very well and very smoothly. The natural gas refueling center at West Los Angeles is located in this quonset-style hut at the GSA motor pool. It houses a natural gas manifold system and a compressor for refueling the dual-fuel vehicles with natural gas.



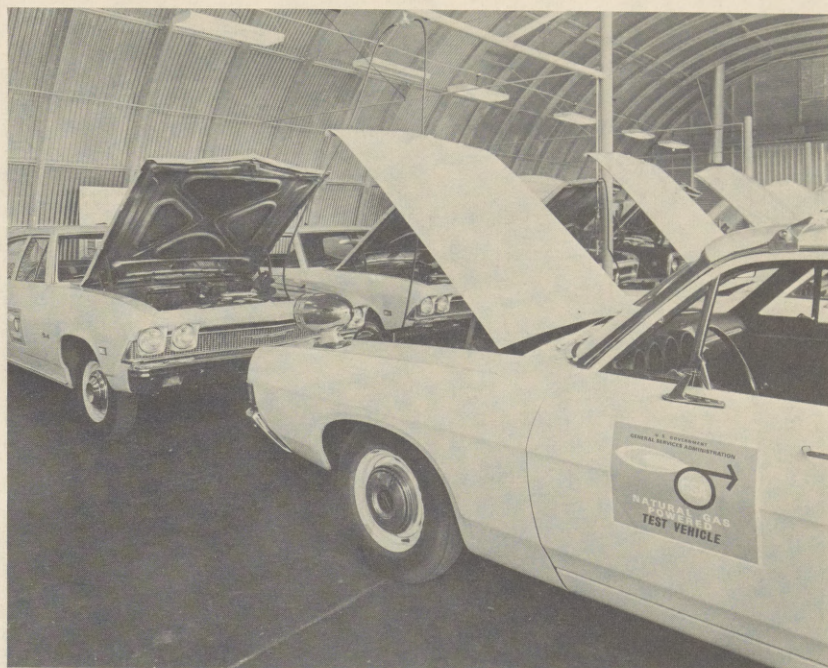
SLIDE 5

In this picture, Mr. Chairman is a mockup of an engine. This particular engine operates on natural gas. It is a Ford six-cylinder 250-cc. engine, which has been on display in the lobby of the GSA building and is now en route to Mississippi where it will be used when we inaugurate the system there. It will be returned and will be available for inspection in the GSA lobby in March.



SLIDE 6

It is not necessary to remove the tanks, in fact, the tanks in the vehicle stay in the vehicle. To refuel the vehicle, the operator simply raises the hood and connects a high-pressure hose to a "quick disconnect" fitting. Natural gas storage tanks and a compressor, located at the facility, enable GSA to repressure the entire fleet each evening. Vehicles which operate on a 24-hour basis can be "quick loaded" in a matter of minutes. The entire fleet can be mass-loaded in 3 hours.

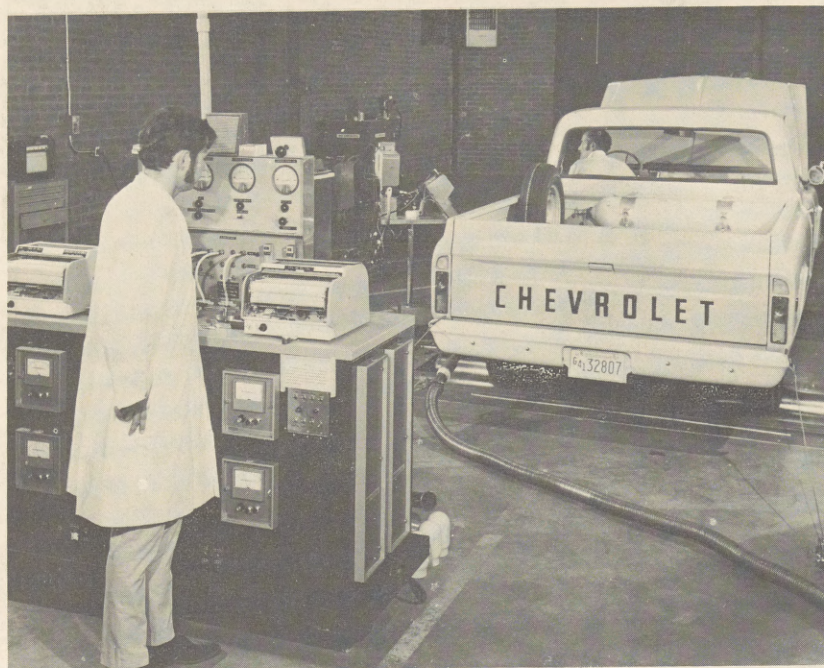


SLIDE 7

The West Coast Field Testing Laboratory is conducting the pollution-testing portion of the General Services Administration dual-fuel project. The laboratory is a part of the Public Health Service under the Department of Health, Education, and Welfare.

Before the GSA vehicles were put on the road, all 24 were tested by the testing laboratory, including the 12 control vehicles and those actual equipped with the dual-fuel system.

An electronic instrument called the infrared spectrophotometer was used to measure the degree of hydrocarbon and carbon monoxide emission from the exhaust of each vehicle. Twelve of the vehicles will be retested approximately every 4,000 miles. And that retest will now occur around March 1.



SLIDE 8

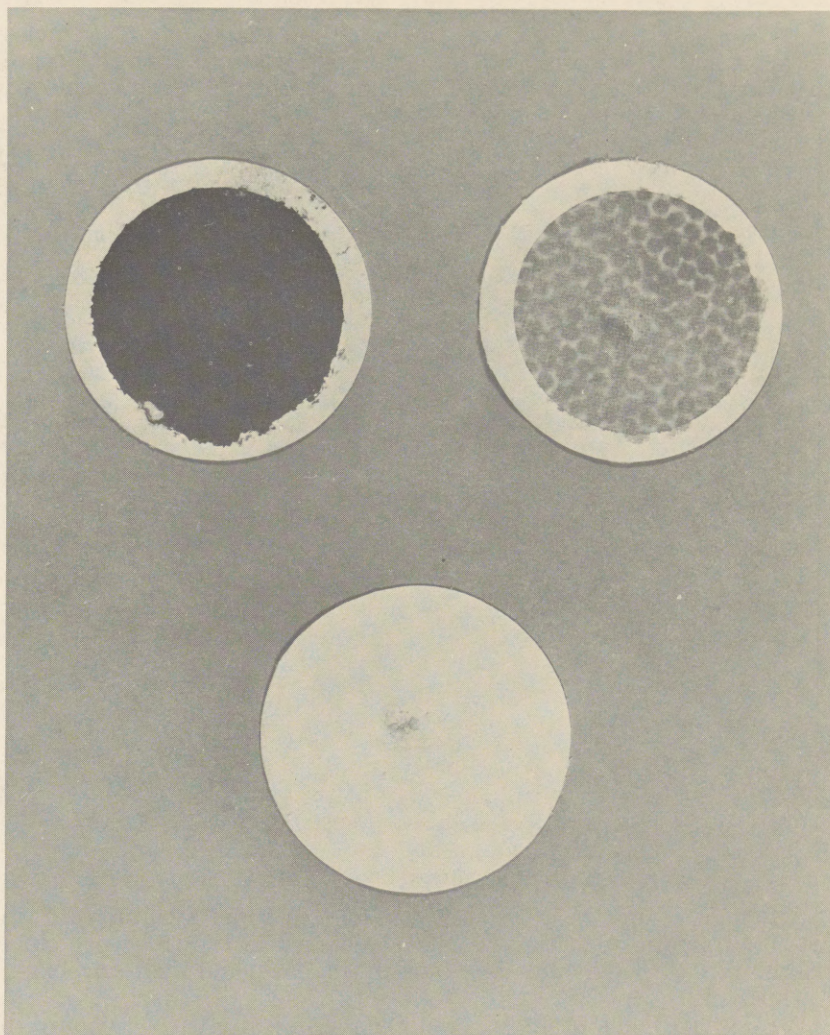
This I think, Mr. Chairman, is a rather dramatic demonstration of what this system achieves in the area of pollution reduction.

The three filters pictured in this slide are a graphic example of the clean-burning properties of natural gas.

They are the results of actual exhaust emission tests of GSA vehicles conducted by the West Coast Field Testing Laboratory for the Natural Air Pollution Control Administration. The tests conducted in that laboratory were shown in the previous slide. The upper left disc shows the deposit on a filter which came from the exhaust of a 1960 1½ ton truck. Its gasoline-powered 264-cubic-inch engine did not contain smog control equipment.

This antedated the pollution control devices required now by Federal law. The upper right shows the deposits on a filter which came from the exhaust of a 1969 ½-ton pickup truck. Its gasoline-powered 250-cubic-inch engine was equipped with smog control devices.

The bottom filter shows the clean-burning properties of natural gas. The exhaust of a 1969 ½-ton pickup truck, running on natural gas, produced only a slight discoloration. These filters are part of the seven-cycle HEW test which is routinely run at this laboratory. Each of these filters were subjected to the identical seven-cycle test and show the identical passage of exhaust fumes over the filter in the test.

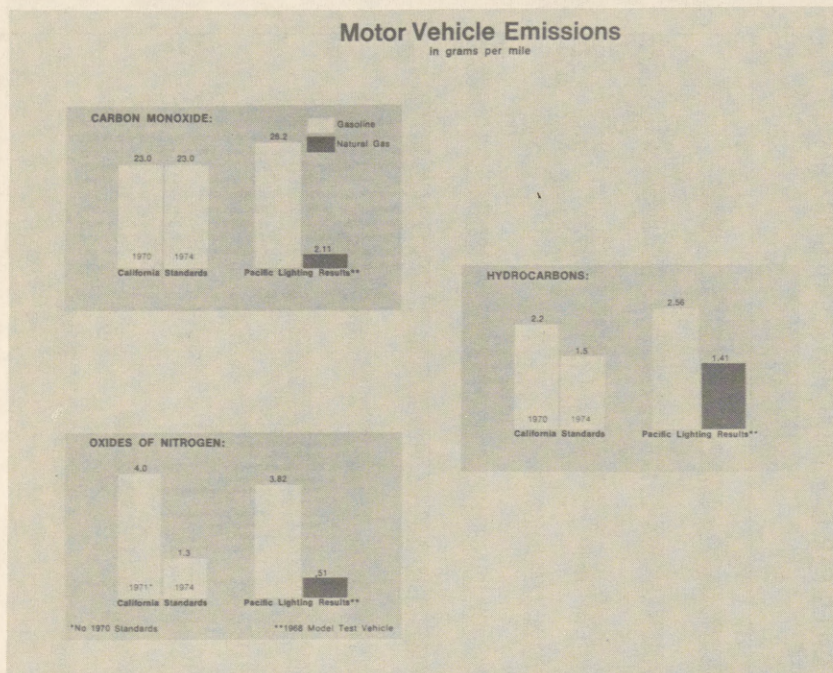


SLIDE 9

Our test program at the West Los Angeles Veterans' Administration Hospital calls for an analysis by the HEW laboratory of the exhaust emissions of our test vehicles, both gasoline and natural gas, on March 1 or after 4,000 miles, on each vehicle. This information will then be compared, both as to reduction and amount of air pollution emitted at the beginning of the test, and the relative pollutants produced by the test and control vehicles. For this reason, we, at this time, do not have available for the committee precise test information to indicate the reduction in air pollution which results from use of natural gas fuel in GSA vehicles.

The slide which you are now viewing shows the reduction achieved by this system on test vehicles operated by the Pacific Lighting Co.

That company has, by the way, operated approximately 35 vehicles for more than a year using this system. All indications at this time are that the GSA test vehicles will meet or exceed the results achieved by Pacific Lighting.

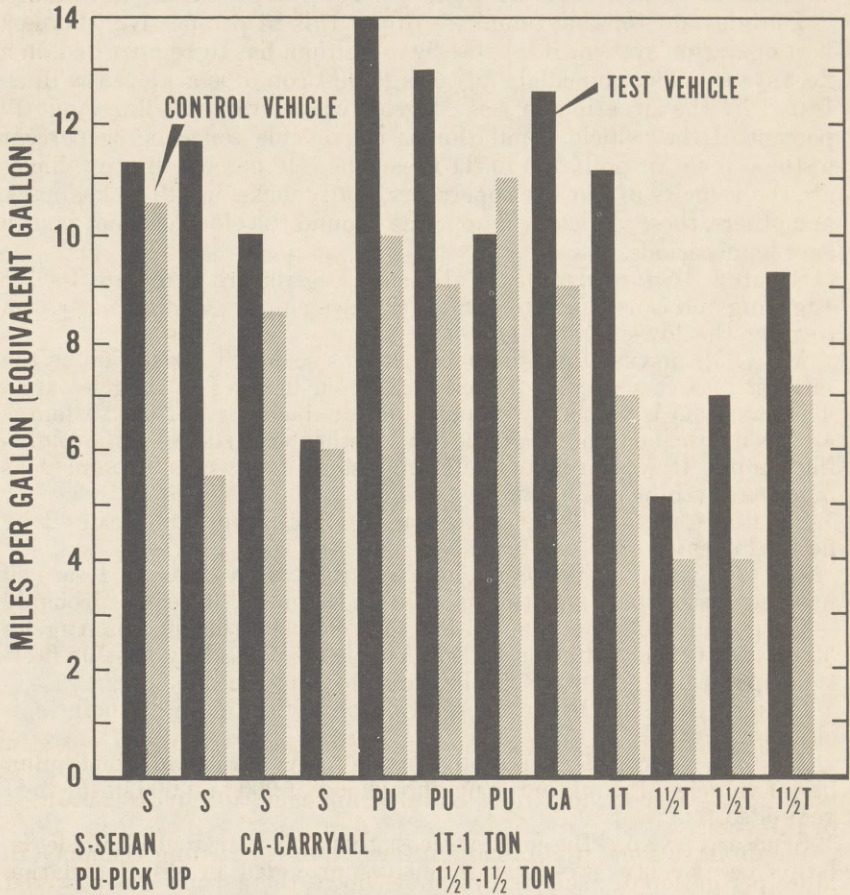


SLIDE 10

Although I apologize for the state of this slide, I think you can see the dramatic reductions that are achieved in the three principal pollutants—carbon monoxide, oxides of nitrogen, and hydrocarbons—by this fuel.

We do have some preliminary information concerning economy in miles per gallon of fuel. As this slide shows, the natural-gas-powered vehicles depicted by the solid bars achieved better fuel mileage than their counterpart control vehicles. Natural-gas-powered vehicles averaged 10.5 miles per gallon. The gasoline-fueled vehicles averaged 7.1 miles per gallon. These mileages are low. That is, there is a high fuel consumption. This is another indication of the value of this test at the VA hospital because these vehicles are heavy stop-and-go and slow-speed vehicles. They operate within the confines of a hospital area at low speeds, and there is a great deal of engine-idling time on the engines. This accounts for the low mileage both with gasoline and natural gas. Specific data on maintenance, labor, and material costs are not available since the project has only been in operation a short while. Our dual-fuel drivers have noted significant benefits in quick engine starts, smooth low-speed operation, and reduced odors and noxious fumes. Refueling is easy, clean, and efficient.

MILES PER GALLON SAWTELLE PROJECT RESULTS NATURAL GAS vs GASOLINE



SLIDE 11

I might add at this point, we really expect dramatic reductions in the field of repairs—in oil changes, spark plug changes and tuneups. This has been the experience of the Los Angeles Gas Co. We have no reason to expect that we won't have a similar experience.

It will be necessary to operate the vehicles for a year to test what we believe will be the result, which will be one oil change a year.

In sum, what we hope to achieve in using this system is—

- (1) Carbon monoxide—80 percent reduction.
- (2) Hydrocarbons—90 percent reduction.

- (3) Oxides of nitrogen—70 percent reduction.
- (4) Complete elimination of lead.

Essentially what we are doing is demonstrating in commercial conditions that natural gas can be used economically for fleet operations to the benefit of the fleet operator, at the same time achieving a substantial reduction in air pollution for the benefit of the public.

I might add for the committee to put this in perspective, this is a fleet operation system. It, almost by definition, has to be operated on a fleet system. The immediate advantage that could be achieved is illustrated by the situation in Los Angeles where, we are told, about 10 percent of the vehicle population is responsible for some 35 percent of the vehicle air pollution in the area. These 10 percent of the vehicles are the vehicles of our fleet operators, mail trucks, milk trucks, buses, and others, those vehicles that operate around the clock and not just in rush hour periods.

Senator CANNON. Did the California Legislature stimulate Pacific Lighting and cause them to perfect this system, or go into this system to meet the low-emission goals?

Mr. O'MAHONEY. I'm not so sure it was so much legislation as the interest of a few very dedicated gentlemen in the Los Angeles area. The man who is primarily responsible for the design of the system is an aeronautical engineer, and he got together with some Pacific Lighting people. It was probably self interest in his own environment as much as anything else.

Senator CANNON. What percentage of air pollution is caused by fleet vehicles?

Mr. O'MAHONEY. There are no exact figures on this. As I said, it has been estimated, and this is only an estimate, it really probably is not possible to know exactly, but they estimate that in Los Angeles 35 percent of the pollution in Los Angeles is caused by fleet or fleet-type operations—delivery trucks, taxicabs, and the like.

Senator CANNON. Is the Pacific Co. converting more of their vehicles over now?

Mr. O'MAHONEY. They plan to convert a very large additional number of vehicles. I think in the neighborhood of 900 or 1,000 in the next year or so.

Senator CANNON. Based on the cost that you indicated if this legislation became law, wouldn't incentives provided in this legislation permit the acquisition of vehicles?

Mr. CHAPMAN. I didn't quite get that question, Senator.

Senator CANNON. We have provided in here 125 percent to GSA for the purpose of acquisition of vehicles. What I am saying is, based on your cost experience at this time, would that be an adequate amount to authorize the conversion or the procurement of these vehicles?

Mr. CHAPMAN. Yes. It authorizes an additional 25 percent over our present limitation. That limitation is now \$1,650 for a sedan or station wagon. Twenty five percent would give us an additional \$400 or so, and this equipment costs in the neighborhood of \$350.

Mr. O'MAHONEY. I might add, Senator, that we hope to bring the cost down. The cost we are paying now is the initial cost in fairly low volume procurement. Most of the equipment you saw in that system

is on the shelf, existing devices, and the only thing in it that is unique or new is the dual-fuel mixer which costs about \$65. The rest of the equipment can be procured, we think, at lower prices.

Senator CANNON. Do you think that 25-percent premium in the legislation would preclude any systems other than, for example, this one? Would it preclude electric or steam type systems, or do you have any facts on which to base that?

Mr. CHAPMAN. I don't have any information on those types; no, sir.

Senator CANNON. What pollution levels do you think can be reached by this type of vehicle, this type of compressed natural gas construction?

Mr. O'MAHOONEY. Using rather round figures, Senator, and I wouldn't want the ecologists and the specialists in this area to bring me up short, we are talking about bringing pollutants down to somewhere between 10 or 15 percent. We are talking about reductions on a scale of 85 to 90 percent of that pollution produced by vehicles which meet the 1969 Federal standards.

Whether or not this in fact will be true, we will have to await the results of our tests in March, and the other tests later in the year. Our results may not be that good.

Senator CANNON. Do you think that the premium we have provided here should be on the suggested retail price, or should be on the statutory price limitation? I'm thinking now as a practical matter, as to whether or not we can provide an incentive within that area.

Mr. CHAPMAN. I've got some figures which may or may not be helpful to the committee relative to the approximate amount of our annual procurements—we procure about 20,000 sedans and station wagons annually, and they are the ones which have the present \$1,650 limitation. Until recently, as you know, it was \$1,500.

We procure annually about 80,000 trucks of all sizes. Our annual procurement of these vehicles—and this, of course is not just for GSA, it is for all of Government—runs in the neighborhood of \$140 million.

If this bill were to apply to all vehicles, it would cost an additional \$56 million annually. If it applies just to station wagons and sedans, it would cost an additional \$8 million, and I confess that there is some confusion at least in my own mind as to whether the intent of the bill, when it refers to "primarily passenger-carrying vehicles" is in fact limited to sedans and vehicles, as some of us think, or does it apply to trucks also?

Senator CANNON. I think the position of the committee would be that it does apply to trucks also.

Mr. CHAPMAN. It uses the words "primarily passenger-carrying vehicles." That is the language we find in the bill. Perhaps the committee might want to clarify that.

Senator CANNON. The committee may give some further consideration to that, but I think that was the intent.

Mr. CHAPMAN. The difference is, if it includes all vehicles, under our current procurement level it would increase our costs by about \$56 million; if it were just the station wagons and sedans, about \$8 million.

Senator CANNON. Senator Baker?

Senator BAKER. Mr. Chairman, thank you very much.

I would like to ask one or two questions about the fascinating concept of natural gas engines. With respect to those miles per gallon you showed on the chart, I noticed the vertical column at equivalent gallons. Is that based on a match-up of cost per B.t.u., gasoline versus natural gas?

Mr. O'MAHONEY. It is the equivalent, Senator, of 100 cubic feet of natural gas per gallon of gasoline, which is a ratio arrived at by measuring B.t.u.'s.

Senator BAKER. So it is an energy content equivalence comparison instead of a cost of equivalence?

Mr. O'MAHONEY. It is, and it is a little on the conservative side.

Senator BAKER. How does the cost equivalency compare?

Mr. O'MAHONEY. About 25 percent less for natural gas.

Senator BAKER. And the conversion of a typical production reciprocating engine, is there any experimentation or development on reciprocating engine or an external engine that would use natural gas to see what emission results you might get there, or what efficiencies you might get?

Mr. O'MAHONEY. There has been some experimental work on natural gas powered aircraft engines by Pratt and Whitney in Florida—I believe West Palm Beach. I don't think it is active at this time.

Senator BAKER. If you convert a standard gasoline-burning reciprocating engine to natural gas utilization, almost by mechanical axiom it can't be as efficient as if you designed the reciprocating engine to burn natural gas.

I wonder if there was any exploration of this?

Mr. O'MAHONEY. That is correct, there is some exploration. There is another system. You can use liquid natural gas, and we do have in the future plans to utilize liquid natural gas to give our vehicles a lot larger range. When this is done, there will have to be a conversion of the engine. It will not be a dual-fuel system, but a single-fuel system.

Senator BAKER. Which ought to, intrinsically, be more efficient?

Mr. O'MAHONEY. It ought to. We lose about 5 to 10 percent efficiency now with natural gas, over gasoline.

Senator BAKER. You will probably have a penalty of costs, too, because there are certain aspects of the production of reciprocating engines that are designed for liquid fuels that you don't need to have in natural gas.

Mr. O'MAHONEY. That's correct. But the fuel actually is 130 octane. We are not getting the octane out of the natural gas that we could get. But to do that, we would have to modify the engine, and we would have to modify it in such a way that it couldn't be used with gasoline.

Senator BAKER. What do you do, put it at higher compression, higher combustion temperatures?

Mr. O'MAHONEY. Higher compressions, recamming, spark adjustments.

Senator BAKER. Do you have a problem then with oxides of nitrogen from the higher compression and combustion temperature?

Mr. O'MAHONEY. No; the oxides of nitrogen reductions still hold. There has been some question in the past about this, but it is true.

Senator BAKER. Is this stripped natural gas, that is, the type that is ordinarily transmitted by mains and laterals to a home, or is it wet natural gas?

Mr. O'MAHONEY. Absolutely, it comes right off the line. We take the gas in West Los Angeles right on the VA incoming line.

Senator BAKER. Would it be better to use natural gas unstripped, wet gas?

Mr. O'MAHONEY. I don't know the answer to that, Senator.

Senator BAKER. What about the range of these vehicles? I saw your tank in the back of the pickup truck. How far can you go on a tank of that kind?

Mr. O'MAHONEY. We have on each of the vehicles in California two tanks, which gives you a range of about 80 miles, and this is sufficient for their operation. This is a limiting factor. That is why it is a fleet situation, vehicles that operate within range of the refueling facility.

Senator BAKER. Do you have any figures on what you could do rangewise with liquid natural gas?

Mr. O'MAHONEY. We could get the same range that you get out of a normal tank of gasoline.

Senator BAKER. Do you have any design penalties such as insulation to keep the gas cold?

Mr. O'MAHONEY. There is loss of space due to the tanks in the sedans. It is about three times the size of the present gasoline tank. There is practically no loss in the larger vehicles because there is a lot of waste space. But in sedans it would almost require redesign of the sedan.

Senator BAKER. It certainly wouldn't be impossible by any means, and some of us might welcome that design change.

Let me ask this last question, if I may, Mr. Chairman. Would you give me, and I realize this is a highly subjective evaluation, but would you give me some judgment of the relative safety of the use of liquid gasoline as a motor vehicle fuel versus the use of liquid fuel natural gas as a compulsive fuel?

Mr. O'MAHONEY. It is safer. That is more than a subjective judgment. It isn't by accident that my project director is a safety engineer. I was counsel to the National Highway Safety Bureau for 2 years before I took this job, and I am very conscious of safety.

Senator, it is safer because it has a lower ignition point by a significant amount. In the event of a catastrophic accident where there would be rupture of the fuel lines, the fuel goes up, it escapes in the air. Were it to ignite, and it is less likely to ignite, it would just burn or blow itself out. It is not collected in a pool or pond.

We are going to run some tests on this in conjunction with the Department of Transportation.

Senator BAKER. What kind of tests?

Mr. O'MAHONEY. Some barrier crash impact tests. Just take a system in a vehicle and crash it to verify what I just said. All the data indicates it is safer than gasoline.

Senator BAKER. I must say that what you have told us of this system and what you visualize for its future development is possibly the most exciting new concept in motor vehicle propulsion I have heard. What are the disadvantages? Why can't we go ahead with a massive effort to make the conversion of passenger vehicles to the use of liquified natural gas?

Mr. O'MAHONEY. The primary problem, Senator, is the matter of supply of gas, and when I say supply, I mean logistics of supply, storage and the capacity of the natural gas industry of this country to provide gas at the consumption point. We get various statistics. We have looked into this quite thoroughly, and we are continuing to study it, but the pessimistic estimates are that it would take, to fuel the approximately 100 million vehicles that are roughly on the roads now, about a 50 percent increase in the present capacity of the natural gas system, and that just can't happen too soon. That is, that can't happen very rapidly. There is a question of the resource itself, how much there is.

But the indication is that there is adequate natural gas. It just isn't available at the right places. There are about 14 liquid natural gas plants now in the United States, and this is a new development which may solve that problem—for example, I was in Alaska last week; we have a new liquid natural gas plant on the Kenai Peninsula which is exporting natural gas in large quantities to Japan in liquified form. The liquified form for the future probably offers the most feasible supply solution on a nationwide basis.

Senator BAKER. I'm afraid I'm noted for saying this is my last question, and asking another; but I am going to, if I may.

Are there any problems in the storage and distribution of liquified natural gas, for instance, in the service station concept, that you know of or visualize that would make it more difficult or costly than the present distribution system of gasoline?

Mr. O'MAHONEY. There would be problems with it. I am by no means an expert. The primary problem is evaporation and keeping it cool, and that is a problem both in storage at the fueling station and in the vehicles themselves.

Senator BAKER. It would also be a convenient way to air condition an automobile in the summertime.

Mr. O'MAHONEY. Yes. It could be used as a device to air-condition the vehicles.

Senator BAKER. Thank you.

Senator CANNON. I appreciate your appearing here.

We will stand in recess until 9:30 tomorrow morning.

The witnesses will be Dr. DuBridge, the Ford Motor Co., and Mr. William P. Lear.

(Whereupon, at 12:20 p.m., the committee was adjourned, to reconvene at 9:30 a.m., Wednesday, January 28, 1970.)

FEDERAL LOW-EMISSION VEHICLE PROCUREMENT ACT

WEDNESDAY, JANUARY 28, 1970

COMMITTEE ON COMMERCE,
SUBCOMMITTEE ON ENERGY, NATURAL RESOURCES,
AND THE ENVIRONMENT,
COMMITTEE ON PUBLIC WORKS,
SUBCOMMITTEE ON AIR AND WATER POLLUTION,
Washington, D.C.

The subcommittee met at 9:40 a.m. in room 5110, New Senate Office Building, Washington, D.C., Hon. Philip A. Hart (chairman of the Subcommittee on Energy, Natural Resources, and the Environment), and Hon. Edmund S. Muskie (chairman of the Subcommittee on Air and Water Pollution) cochairing.

Present: Senators Hart, Pastore, Cannon, Moss, Cotton, Goddell, Randolph, and Muskie.

Senator HART. The committee will be in order.

We had delayed, hoping that one or more of the able minority members might be present, but I am told that some of the comments I should make as we start were, at least in summary form, transmitted late yesterday afternoon to the minority.

Now, in the course of the hearings yesterday, and I shall assume any responsibility that properly would attach, one aspect involved "who shot John," who is or isn't dragging feet, who seeks to move aggressively in the effort to clean the air, so far as the development of a low-emission vehicle may accomplish that end.

I would like for the record this morning to state simply the chronology, the facts.

In March of 1969 the Senate Commerce Committee published a report that was entitled "The Search for a Low-Emission Vehicle." That report recommended the enactment of legislation requiring the Government procurement of low-emission vehicles.

Second, in April of 1969, the chairman of the Commerce Committee, Senator Magnuson, wrote the General Services Administration and asked for their comments on the report's recommendation. The General Services Administration responded that it "strongly endorsed" the proposed legislation, and it made some helpful suggestions for drafting it. The Post Office Department also reacted favorably to the procurement proposal.

Then, in October, Senator Magnuson introduced the Federal Low-Emission Vehicle Procurement Act (S. 3072), before us. Prior to the

introduction of that bill committee staff had communicated with their counterparts in the Department of Health, Education, and Welfare and the Department of Transportation.

On December 5 of last year, the Senate Commerce Committee invited the Air and Water Pollution Subcommittee to sit in joint hearings with its Energy, Natural Resources, and the Environment Subcommittee to consider S. 3072. Tentative hearing dates of January 27, 28, and 29 were set.

Then, on December 22, last year, the Senate Commerce Committee issued a press release announcing hearings on January 27, 28, and 29. At that same time Senator Magnuson sent invitations to Secretary Finch, General Services Administrator Kunzig, Dr. DuBridge, and Secretary Volpe, asking them to appear on January 27.

Now, the responses from the Administration were mixed:

First, Secretary Finch never responded. When called several days before the hearing, his office could not say whether he would or would not appear. On Monday, the day before the hearing, Monday of this week, the committee was finally informed that Assistant Secretary Black would appear on behalf of the Department of Health, Education, and Welfare.

Second, General Services Administrator Kunzig sent the committee immediate confirmation of his appearance on January 27, and only serious illness prevented him from testifying. Notwithstanding the Budget Bureau's last-minute editing of the GSA statement, the testimony contributed, I believe, to our legislative effort.

Third, this brings us to Dr. DuBridge, our first scheduled witness this morning. Two days after the committee invited him to testify, he responded, requesting he be scheduled on the 28th or 29th. On January 5, the committee confirmed a January 28 appearance. Subsequent staff communications indicated Dr. DuBridge's continued availability to appear in support of the bill. But yesterday things changed.

At 1 o'clock yesterday afternoon the committee was notified that Dr. DuBridge would not be able to appear at today's hearing. Instead, he would attend a hearing before the House Science and Astronautics Committee.

As of late yesterday afternoon the House Science and Astronautics Committee did not have Dr. DuBridge scheduled as a witness.

Fourth, Secretary Volpe was prompt in his response to the committee and made arrangements to testify on January 29. As far as we know, Secretary Volpe will still appear.

Now, in his message to the Nation, the President asked that the automobile, our worst polluter of the air, be cleaned up now. Now is when we are sitting, and now is when we would like to hear their helpful comment with respect to this legislation.

And those are the facts.

Senator PASTORE. Will the Senator yield?

Senator HART. Yes.

Senator PASTORE. This, to me, is rather shocking, disconcerting, and not easily understood.

Now, this, to me, is developing into a pattern, so to speak, the idea that the heads of these agencies take it upon themselves to decide whether or not they are going to appear before Congressional Committees.

We have a very responsible duty to perform, and as the chairman of this subcommittee has pointed out, pollution is one of the pressing problems that confronts the American people, and I don't have to go beyond the President's address to the joint session of the Congress to illustrate that point.

It strikes me that this committee has every right to know how the heads of these Departments feel on these very important subjects, and this idea that they promise to come one day and then for some unknown reason decline to come, I think is a disservice to the Congress of the United States. But even more importantly, I think it is a disservice to the American people.

I would hope that the President, himself, would intervene in this matter, and cooperate with the Congress to the extent that we can work in a spirit of partnership, if these problems are to be solved.

We have been castigated, time and time again, for dragging our feet. And here we are. We came back here January 19; we are working assiduously on the floor of the Senate, we are holding these meetings as expeditiously as we can, and all we are asking for is the cooperation of the executive department.

Now, if that is asking for too much, I think the American people are entitled to an answer.

Senator HART. Thank you, Senator.

Senator MOSS. May I express my frustration, as the chairman has stated here. It is indeed a pattern we have been running into; and not only do we have trouble getting witnesses to appear, but more often they will appear saying, "We cannot say anything now; we have got to wait; there is going to be a pronouncement coming out next month or next week," or something of the sort. And they are apparently unable or unwilling to come down and testify before the committee.

It is a frustrating thing.

Senator PASTORE. Not even that reason is given. The reason that was given here in the case of Dr. DuBridge was that he had another commitment; and upon investigation, we find there is no such commitment.

Now, if it is that they don't want to reveal the policy of the administration before a pronouncement by the President, I think they have just cause to make that argument, and I think that we are reasonable enough to listen to it. It isn't a question of who breaks out in the public press first. It is a question of who accommodates the public interest.

I think, myself, that if that is the reason, that reason ought to be given; but that reason was not given.

Senator MOSS. It was given yesterday by Secretary Black, who was filling in for Secretary Finch. He was unwilling to say what the position of the Department was, because the President is going to make some pronouncement on the 10th of February. Until that time, his mouth was sealed.

Senator PASTORE. I understand that Dr. DuBridge gave the reason he had another commitment.

Senator MOSS. That's right.

Senator PASTORE. Now you are telling me that Volpe is going to come anyway?

Senator HART. As of the moment.

Senator PASTORE. Aren't we a little mixed up here?

Senator HART. I think we will leave to the judgment of those neither in the administration or Congress as to who is mixed up, who is attempting to move forward, who seeks cooperation, so long as the facts as I have related them are available, and I will stand by the judgment to be made based on those facts.

Which brings us now to our first witness, Dr. S. William Gouse, Jr. Dr. Gouse is from the office of science and technology of the Office of the President.

Dr. Gouse.

STATEMENT OF DR. S. WILLIAM GOUSE, JR., OFFICE OF SCIENCE AND TECHNOLOGY, OFFICE OF THE PRESIDENT, WASHINGTON, D.C.

Dr. GOUSE. Good morning, Mr. Chairman and members of the subcommittee, I appreciate the opportunity to express my views on the Federal Low-Emissions Vehicle Procurement Act (S. 3072) of 1969 under discussion today. It is well established that automotive vehicles are a significant contributor to our air pollution problem, and as such deserve serious attention. The solution of this problem will require simultaneous attacks, one of which could be making available certain incentives, such as offered in this bill.

While I generally favor the bill's objectives, such a procurement incentive approach must be viewed as only a part of a more comprehensive national effort to reduce pollution from motor vehicles. Whether the procurement approach contemplated by this bill should be adopted at this time is a question to be considered in the context of that broader national effort.

The President, in his forthcoming special message on the environment, will be addressing the Administration's overall goals and programs in this regard. In the meantime, it may be useful to the Committee if I made some general comments about the problems related to the introduction of low-emission vehicles.

We must be careful to make an assessment of the impact of introducing new automotive fuel or propulsion systems. For example, a Rankine cycle powered vehicle using an organic working fluid might pose no particular problems for the small number of vehicles in a demonstration program. However, this organic fluid might be toxic or might produce noxious vapors in an accident situation when it might be exposed to flame.

If one were to look further ahead to a potential vehicle market of millions, one must consider the implications of the final disposition of such a vehicle or the potential impact of highway accidents in order that we do not introduce some other problem which can be equal to or greater in magnitude than the one we solved.

Certain gas turbine concepts require the use of high nickel alloys.

Again, this poses no problem in demonstration numbers or perhaps even for the truck market, but when considered in terms of our total automobile power plant market, the drain on nickel supplies may be more than we wish to accept.

Still another possibility is that the noise characteristics of a few new vehicles might be completely acceptable, but with a streetful, this situation could become unbearable.

The General Services Administration has been conducting tests with compressed natural gas vehicles. This kind of fuel is suitable for fleet-operated vehicles that are maintained in a central garage. The Government and the private sector operate many such fleets and the concept of a special fuel does not pose undue problems for this type of operation.

It is interesting to point out that if such modified fuel vehicles are satisfactory for Federal use, they might also be satisfactory for State and municipal vehicle use, or even for private sector fleets of taxis or rental cars.

It could well be that substantial Federal use of dual-fuel vehicles could show that such fleet operation is economically attractive when one considers the maintenance as well as the initial costs.

I would like to caution the subcommittee, however, on the extent to which dual-fuel vehicles might meet our general automotive transportation needs. Although the concept looks quite attractive for fleet operations, it does not seem to have the characteristics necessary for national use. Quite apart from the adequacy of our natural gas resources for this or any other application, the fuel distribution system does not now exist and a large investment would be required to make such natural gas fuels nationally available.

The subcommittee should also be aware of the fact that evolutionary changes to the present motor vehicle propulsion system, such as modifications to permit operation on compressed natural gas, are relatively inexpensive. However, the investments required to bring about a major innovation would be substantial.

Thank you.

Senator HART. Thank you, Doctor. You voice caution, and I am sure all of us sense that as we seek to reduce pollution by modification, with the substitute of new powerplants, we must be sure there are not bad or worse side effects.

Would you have any comment with respect to the problems involved in further controlling the internal combustion engine? Your general remarks were directed to further controls on the internal combustion engine.

Dr. GOUSE. I think the automotive industry is clearly betting that they are going to be able to make the internal combustion engine clean enough to meet the long-range goals. There is a fairly good chance that they are going to achieve this. There is a small but finite chance that they won't—not a big one—but big enough to worry about.

In that context, one should begin thinking of other solutions. It is reasonably certain that the industry will be able to provide a vehicle that is satisfactory when it leaves the plant. It is less clear whether the lifetime characteristics of this vehicle will be satisfac-

tory, and what kind of a burden it would put on the consumer for replacement of parts or equipment.

Senator HART. Do you have any observations to make with respect to, in the case of the turbine engine, the noise, as you now understand it?

Dr. GOUSE. Yes. The noise problem can be controlled to a level which would be satisfactory. A significant part of the noise one hears in present experimental turbine powerplants has to do with auxiliary equipment on the turbine which has not been developed in parallel with the turbine itself.

If one looks at these auxiliary pieces of equipment in the light of the technology that exists in other areas, the noise can be handled.

I think a more serious problem in the turbine is mass production. No one has ever mass-produced anything like a turbine. The kinds of purchases made by the aircraft industry are really very small in numbers when compared to the automobile market. One could not go out and buy machinery with which to mass-produce turbines. It just doesn't exist.

The company that goes into this business first is taking a very big risk, because it not only has to develop a turbine, it has to develop the machinery with which to produce it.

The second company can have the benefit of all the mistakes that the first one makes in regard to the tooling, which is perhaps more critical than the turbine itself.

Senator HART. The Senator from Rhode Island?

Senator PASTORE. Doctor, could you give us an idea just what effort your Department is putting in the liaison between yourself and the manufacturers of automobiles?

Dr. GOUSE. We currently have an ad hoc panel in the office of science and technology which has just recently visited the major automobile producers, and will visit, next week, some other people outside of the industry.

Senator PASTORE. Who are the members of this ad hoc committee?

Dr. GOUSE. I am the secretary of the panel; Dr. David Ragone of Carnegie Mellon University, is chairman. The members are Prof. Ernest Starkman of the University of California at Berkeley; Mr. James Dooley, vice president of McCullough Corp.; Professor Lester Lichty of Yale University; Prof. David Wilson of MIT; Dr. Richard Strombotne, of the U.S. Department of Transportation; and Mr. John Brogan of HEW.

Senator PASTORE. When was this ad hoc committee formed?

Dr. GOUSE. In early December.

Senator PASTORE. Of 1969?

Dr. GOUSE. Yes. I couldn't give you an exact date.

Senator PASTORE. How many meetings have they had?

Dr. GOUSE. Three.

Senator PASTORE. Three meetings?

Dr. GOUSE. Yes. Or three trips, and each trip had meetings associated with it. If you wanted to count individual meetings, there would be more than three.

Senator PASTORE. Would you say this effort is intensive enough so that your Department knows scientifically what is being done and what aggressiveness is being pursued by the automobile manufacturers in overcoming this matter of exhaust pollution?

Dr. GOUSE. Yes, but not only on the basis of the three meetings. Each of the members of this panel has been actively involved in this problem area for at least the past three or four years, so each panel member himself was aware of a large number of activities before he joined the panel. This is why these people were chosen.

Senator PASTORE. Did I understand you correctly that you think the ultimate answer to this great problem in the automobile is one that rests upon the industry itself?

Dr. GOUSE. Well, if anyone is going to manufacture automobiles, it will be the industry.

Senator PASTORE. I know they manufacture the automobiles. But they are going to manufacture these automobiles for profit.

I realize that these gentlemen have a public interest in mind, but after all, they do respond to their stockholders and taxpayers and to the price of the vehicle as such; and, of course, that is the American way. I am not questioning that one single bit.

But the only point I'm making here is unless there is some initiative taken by the Government, a strong initiative taken by the Government, this thing is just going to die on the vine, unless someone pushes it along.

I would like to know from you exactly what effort are we putting into this, not only to inspire, but to make sure that this whole matter is pursued in such a way that it is carried out to full fruition.

Dr. GOUSE. I believe that the President will address that question in his message on the environment. I don't really know the details.

Senator PASTORE. I don't think there is anything to laugh at, at that. I think that is a sensible answer. And I don't think anyone should laugh at that answer.

Dr. GOUSE. I can assure you that we have looked very hard right now at what is happening in the industry and outside the industry.

Senator PASTORE. Thank you.

Senator HART. Senator Moss?

Senator MOSS. Could I ask a question about the practicality in your view of the natural gas as a fuel, compressed natural gas, whether it would be feasible to have an auxiliary tank of natural gas to drive in the inner city with an alternate of gasoline out of the city.

Dr. GOUSE. Technically it is clearly possible to do this, and for commercially operated fleets it is probably economically a good idea.

There is a considerable experience with dual fuel vehicles in industry, even in passenger busses, that shows that the reduced maintenance costs offset the higher initial cost over the life of the vehicle.

But where this has been done and done successfully it is with vehicles that return to a garage every evening and can be professionally refueled and maintained according to the requirements of the dual fuel system.

Handling a compressed natural gas or a liquified gas system on a national basis would be quite a bit more difficult than the liquid gasoline system we now use. The fuel distribution and handling machinery is more complicated because it must be pressurized.

I am certain we could solve the safety problems, but they are more difficult than the safety problems we now have.

The question one has to answer is what are the costs and what are the benefits for general use of this concept as opposed to another.

I expect to see quite a lot of use of natural gas in fleet vehicles. I think companies find that it makes sense.

Senator MOSS. Is limited range, a serious drawback in ability to carry enough fuel to go a long distance?

Dr. GOUSE. Not for many fleet operations, because if you look at many rental cars, for example, they don't often go more than 50 miles. It is usually from the airport to downtown and back.

This means a rental car operator would most of the time only operate off the natural gas and the gasoline in reserve would handle the situation if someone went further. But most of the time he runs off of gas.

Many taxis operate the same way with a succession of very short trips. The total mileage in any one normal operating period is not large.

Senator MOSS. I gather that your feeling is at the present time this looks like a partial answer maybe for fleet operation and within the confines of the city, but it does not offer a hopeful avenue for resolving the whole problem.

Dr. GOUSE. I would not want to give a definite answer. I think we are still looking at this carefully. I would be cautious about saying that is the way to go. I am not saying that we should not go that way, but I do not think the answers are available.

On Manhattan Island, during the day, most of the vehicles that operates are fleet vehicles. You could have a substantial impact on Manhattan Island with dual fuel vehicles.

Senator MOSS. Thank you, Dr. Gouse. Thank you, Mr. Chairman.

Senator HART. The Senator from Nevada, Senator CANNON.

Senator CANNON. Doctor, are you doing anything in your office other than the committee studies that you are talking about? Are you doing anything in the way of demonstration projects or research efforts with private industry or things of this sort?

Dr. GOUSE. The Office of Science and Technology does not usually undertake direct studies of that nature nor does it get involved in direct project management.

I think the office will be involved in helping to plan any program that might come into existence.

Senator CANNON. There are several projects underway now. Do you have a close liaison with those projects?

Dr. GOUSE. Yes; I know the people.

Senator CANNON. If you do, could you tell us something about these projects that are being carried out now?

Dr. GOUSE. You are aware of the General Services Administration project?

Senator CANNON. Yes, we had a demonstration on that yesterday, and we were filled in on their project which sounded very interesting.

Dr. GOUSE. The Urban Mass Transit Administration of the Department of Transportation is conducting experiments on buses. They are trying to make a critical evaluation of the usefulness of Rankine cycle powerplants for buses and have a project underway in San Francisco.

They are also working with the automobile industry on attachments to diesel-powered buses which would reduce noise and pollution, and the potential usefulness of turbine-powered buses.

That same administration also was involved in a minicar project in Philadelphia. That project was concerned with developing a personal transit system, but a very useful fallout was the development of a hybrid-powered vehicle which combines an internal-combustion engine and batteries in a very interesting way, and it leads to a powerplant with very desirable emission characteristics.

The Department of Health, Education, and Welfare has several study programs underway now. They are looking into fuel modifications, Rankine cycle powerplants for automobiles, et cetera.

In fact, they are planning the first, at least public, evaluation of the Rankine cycle by competent people, and hopefully that study will answer for us once and for all can a steam engine of one sort or another make it or not.

They are also planning to undertake programs on some interesting ideas in batteries and in gas turbines.

Senator CANNON. Are all these projects coordinated by someone or are they just separate projects that are let out by different agencies as you have indicated?

Dr. GOUSE. Well, each of these groups has an official membership in the panel I recently described. We all meet together and discuss. I think there is quite good communication.

Senator CANNON. Who establishes the performance standards for these various projects? Are they established by each agency that sets up that project?

Dr. GOUSE. I am not certain I understand what you mean by performance.

Senator CANNON. Let me pin it down. The San Francisco project which you defined—there are certain performance standards that are established. Are they established by the agency which is responsible for that research project? Or are they established by the State of California? or who?

Dr. GOUSE. I think both, because the funding for the project is joint between the State of California and the Federal Government.

The standards were to meet emission criteria that are desirable from the long-term point of view.

And the other performance criteria has to do with bus transportation; that is, this device has to fit into a bus where a powerplant goes and be able to move the bus around the way a bus must be moved with the same kind of safety reliability.

Senator CANNON. Are the performance standards less stringent or more stringent than those presently existing, let us say, in a normal bus?

Dr. GOUSE. I would say they would be at least equal in terms of mechanical performance.

Senator CANNON. So you would expect to achieve at least equal performance.

Dr. GOUSE. Otherwise it would not be very realistic. It is clear we can build something that is not as good but that is not a very useful thing to do. We want it to be at least as good in economy and customer acceptance and better in emission.

Senator HART. We have been joined by the ranking member of the committee on the minority side, Senator Cotton. If Jennings Randolph will permit us to turn to Senator Cotton.

Senator RANDOLPH. My pleasure.

Senator COTTON. Mr. Chairman, I am not a member of this subcommittee except ex officio as ranking minority member of the full committee.

Senator HART. We treat you as a member and hope you will be with us as often as you can.

Senator COTTON. Thank you.

I was called from another committee on which I serve because of statements made by the distinguished chairman of this subcommittee to the effect that he felt that this committee was not being treated with proper consideration and respect by the heads of the departments of the administration who have been invited—I assume invited rather than summoned—to appear here and testify on the pending legislative matter, S. 3072.

In view of the fact that these statements were made with the press here I considered it my duty as the senior Republican member to make a statement.

I always dislike to get involved with what appears to be any partisan strife. We have had very little of that in this committee, and I hope we will continue to have as little as possible. Nevertheless, I felt that in justice to the department heads involved and in view of the fact I had been approached on this matter I ought to come over and for the purpose of the record make a brief statement.

However, I wish to preface my statement by saying that I have profound respect and a very warm feeling of friendship for the distinguished chairman of this subcommittee, the Senator from Michigan. I know that anything that he said was motivated by his dedication in this very important subject of dealing with the air pollution from motor vehicles. But I do think that certain explanations ought to be made.

Now, in the first place, during the latter days of the first session on several occasions—at least on two or three—as ranking Republican member of this committee I was called upon by heads of departments downtown—and I think possibly by members of the White House staff—to request the distinguished chairman of this committee, Senator Magnuson, or a chairman of the subcommittee, to postpone hearings because the administration was in the process of preparing its position on pending legislation. Therefore, the parties involved did not want to come up until they could determine their own approach and be able to present it fully to the committee.

I did make those requests and I want the record to show that I was treated with great consideration, even though in some cases we did not make good on our promise.

For instance, on behalf of the Department of Transportation, I requested Senator Magnuson give more time on the railroad passenger bill in order that the Department might present a plan that it was in the process of working out. Senator Magnuson very courteously and very kindly said he would give us to the opening of this session. We did not make good on that and the day before yesterday I personally went down and spoke to the distinguished Secretary of DOT, Secretary Volpe, who told me why he had not made good on it. I told him that we were not waiting any longer.

Now, the present hearings were set by the chairman of this subcommittee, which is his privilege, his right, and his duty. He set them, however; we did not.

Four departments were invited to appear, HEW, Transportation, General Services Administration, and the Office of Science and Technology.

I was told they disliked to come up when the President is going to send up a message on the environment within the next 2 weeks and some specific legislative proposals. Their lips would be sealed more or less. Therefore, they wanted me to approach the Senator from Michigan and ask him to at least defer their appearance until they could come up and speak freely and know that they were representing the administration.

I refused to do so. I did not even go near the Senator from Michigan. I then proceeded to tell each of these departments that here we are in the situation that like it or lump it the respective representatives are bound to claim that the Democratic Congress is dragging its feet on the President's program and the Democrats are going to claim the administration is not tending to its homework and is not getting its recommendations up here on time. Probably both those statements could contain some truth and some exaggeration.

Perhaps it is something we cannot avoid, but in this particular instance, although I personally cannot guarantee it, Secretary Volpe told me that he expects to come up himself tomorrow before this committee.

I suggested to these Department heads that they could come up and express their endorsement of the objectives sought by this bill and its authors, and say frankly that they cannot go into specifics until they had a little more time. Also—and I will say this frankly—I took pains to call up a friend on the White House staff to express to these Department heads that as far as I was concerned, as ranking Republican on this committee I was not going to ask the Democratic chairman of the committee or the chairman of the subcommittee on behalf of the administration to postpone a single hearing. They can call the hearings. They have the power to call the hearings.

Now, sometimes when I go home to New Hampshire they want to know why my colleague is mentioned so often in the papers and I am not mentioned as often. I always smile and say you understand when a political party controls the Senate, as now is the case with the Demo-

crats, almost all are the chairmen of some subcommittees, with the power to call and set hearings; call in the press and make up statements and get in the headlines. We poor downtrodden Republicans, on the other hand, just cannot do that. [Laughter.]

But that is legitimate and that is proper. And I want to assure my very good friend from Michigan I am not criticizing him.

I have served with the Senator from Michigan for many years, and there is no finer man in the Senate. However, I do not think it is quite fair to take the position that the departments downtown are slighting this committee or failing to show the proper consideration if they send up representatives particularly when I suppose they send up these poor representatives because the department head just cannot come up and approach the subcommittee with the frankness and clarity that he would be able to if these hearings were 2 weeks from today.

But we have been complaining—by we, I mean our side of the aisle has been complaining that Congress was not moving and getting legislation through—and if we make that sort of complaint, we cannot complain if the majority side and the chairmen of committees and subcommittees go ahead with the business.

If we do complain, we are in a completely inconsistent position.

Now, my purpose is to call attention to these difficulties. The President has indicated in his state of the Union message that he was deeply interested in this matter of pollution of the environment. I am informed from the White House and from the departments that he is sending up a message and some legislative proposals. If he does not send the necessary legislation, then he is going to submit his suggestions, for what he would like to be incorporated in the particular bill that is before us.

May I repeat, this is not in criticism of the Senator from Michigan. He has called this hearing because he is deeply devoted to this cause. But, I do want to make it very clear that the action of any department head in sending someone up to represent him is not an intentional lack of respect for the Commerce Committee. It is simply because of the fact that I expect that the President of the United States is as busy or almost as busy anyway as anyone of us, and perhaps they are slow in getting their recommendations up here.

But the fact remains that the recommendations are coming and there will be no requests as far as this committee is concerned to defer hearings.

We are not going to be put in the position of holding up legislation. I commend the distinguished Senator from Michigan for starting right off at the beginning before we get occupied with other subjects and airing this very vital question fully.

I was notified that the Senator from Rhode Island, Mr. Pastore, with his characteristic fairness took care of the situation to the extent that perhaps my statement is unnecessary. However, owing to my position because of the fact that I have an understanding that there will be no more requests for deferment, and the majority members of this committee were very considerate during the last session in granting deferments, I felt compelled to make my position crystal clear.

I thank the chairman for permitting me to make this statement, and I am sure he is not offended by anything I have said.

Senator HART. I am impressed, and grateful. I do thank the Senator. I think what he has done is put in the record, along with the facts I have recited, the chronology that will enable others to judge, and perhaps the long-term effect of this short-term flurry is that we will get a little tougher message, a better bill, and maybe even a recommendation for money.

Senator COTTON. When you talk about money, that is something different.

Senator HART. As we noted, this is actually a joint subcommittee hearing with the Subcommittee on Air and Water Pollution of the Public Works Committee, chaired by the Senator from Maine, who has long been urging all of us to act.

This morning we are delighted that the chairman of the Committee on Public Works, Mr. Randolph, is here.

Senator, did you have any comments you would like to make?

Senator RANDOLPH. Thank you, Mr. Chairman. Yesterday when these very significant and timely hearings began, the Committee on Public Works, through its Subcommittee on Air and Water Pollution, was represented by the knowledgeable Senator from Maine, who chairs our subcommittee, and a very active member of the minority, the Senator from Tennessee, Mr. Baker.

It is my responsibility and privilege to join today, at least for a portion of the time, this hearing, as chairman of our full committee.

Mr. Chairman, I would not want to label the subtleties or the substance of the discussion that has just taken place, but I would want to add for the record, and I can say that I doubt if there is a committee in the Senate where there is less of partisanship, in fact an absence of partisanship, than our Committee on Public Works. This attitude, I am sure, is reflected in the Commerce Committee and other committees on the Hill.

That, perhaps, is by way of pleasantry, but it is a documentation of the fact.

I do wish to add that I think on a broader scale than even this hearing, there must be a recognition of the membership of the Senate that we have the responsibility to initiate legislation on Capitol Hill. We have the responsibility to be creative on Capitol Hill. We have the responsibility to strengthen and finalize in subcommittee and committee hearings legislation which, in a real sense, was born here, within the viewpoint of one or more members, and was brought to fruition. This is in no wise to downgrade the position of the Administration, be it Democratic or Republican, sending messages and following with specific legislative proposals which are advanced to us.

I think that there is a need, a very real need, for a return to responsibility within the Congress to, as I say, initiate and create, and to actually draft legislation. This can be a joint effort with the Executive; it should be. There is the area, understandably so, of often very real cooperation. I am not in anyway attempting to lecture anyone this morning. I certainly would want to lecture myself, if I were.

But I ask unanimous consent, Mr. Chairman, to place in the record at this point, a very brief discussion of this matter which I had on the Senate floor on Monday during a colloquy between the Majority Leader, Mr. Mansfield, and the Senator from Louisiana, Mr. Ellender.

Senator HART. Without objection, so ordered.
(The information follows:)

Mr. MANSFIELD. I yield.

Mr. RANDOLPH. Mr. President, since the discussion by the distinguished majority leader (Mr. Mansfield) and the colloquy with the able Senator from Louisiana (Mr. Ellender) concerns the responsibility of the administration and also the equal responsibility of the legislative branch of Government in reference to messages and measures that would be acted on following the recommendations of the administration, I would say again what I have said on prior occasions in this Chamber. I recognize the responsibility of an administration, be it Democratic or Republican, to propose legislation to Congress. I believe, however, that Congress must bear a certain degree of criticism from the American people for not proposing and passing legislation which originates on Capitol Hill.

It is the duty of Congress not only to pass legislation, I say to my distinguished majority leader, but also to propose legislation, and through the process of subcommittee and committee hearings, to develop legislation.

So I think when we consider the matter of administrative recommendations for legislation we should not forget that it is historically right that Congress itself move forward, especially when the initiative in many vital areas it not taken by the administration.

It is well to have comity between the executive and the legislative branches.

It is helpful to have understanding. It is encouraging to have cooperation. We can and must work together for the national good.

Senator RANDOLPH. Mr. Chairman, I wonder—Dr. Gouse, you are familiar with the address delivered last night from, I believe, Worcester, Mass., by the Secretary of Transportation, John Volpe?

Dr. GOUSE. No, I am sorry; I'm not.

Senator RANDOLPH. I presume it was delivered last night, although it could have been on another occasion, but I heard it last night on my radio as I was driving in my car. I felt that it was delivered last night.

But he made certain very—let's say "emphatic" statements, Mr. Chairman, and those members who sit here from the several committees and subcommittees, about the nearness, as it were, to an automobile, a powered automobile, that would answer at least a substantial portion of the problems that are very ugly and very real today.

So I ask unanimous consent also, if I may, I will secure the part or parts of that speech which are pertinent to this hearing, and place that material, with your agreement, in the record.

Senator HART. Without objection, we will welcome it.

(The excerpt from Secretary John A. Volpe's statement follow:)

Our bill proposes a long-term, \$10 billion program to provide funds on an assured basis for the construction, expansion and improvement of public transportation in a growing America.

It is not just a big city bill, designed to build subways and rapid transit systems. It will provide for sharply upgraded bus transportation, it will enable the use of exclusive busways on urban freeways, and will provide for such things as "maxicabs," buses that provide door-to-door service in response to programmed demands. And it provides, too, for such things as new turbine buses, which practically eliminate the sort of air pollution we get today from conventional buses, as well as being far quieter.

Senator HART. Senator Muskie, did you have any questions?

Senator MUSKIE. Primarily, I'm sorry I didn't get in earlier. I evidently missed an interesting discussion.

I would like to ask just one question bearing upon Dr. Gouse's testimony. That is, on the compressed natural gas vehicles. I noticed the story in this morning's Washington Post on some of your experi-

ence with them. Is the natural gas supply such that we can seriously contemplate the use of natural gas for commercial purposes?

Dr. GOUSE. If you think in terms of fleet vehicles, taxis and motor pools, the natural gas supply seems adequate. If you look for the total automobile population operating on natural gas, I think there is some question. This question is being looked at right now.

Senator MUSKIE. Do you have any estimates of the supply of natural gas?

Dr. GOUSE. We have. But I am not familiar with the numbers.

Senator MUSKIE. I wonder if you would supply those for the record? I am interested not only on this bill, but for our own hearings.

Dr. GOUSE. I would be happy to.

(The information follows:)

RESOURCE ASPECTS OF AUTOMOBILE USE OF NATURAL GAS

The use of natural gas in fleet cars would not cause a serious drain on natural gas resources. It might be feasible to have a million such cars operated on natural gas. Many other fleet vehicles would not be converted because the nature of their use would make the problem of fuel supply impractical. If an average car logs 10,000 miles per year, it would require about 100,000 cubic feet of gas. Thus, a million cars would require only 100 billion cubic feet per year. This is less than one-half of one percent of our current natural gas consumption. Its resource impact would thus be small even though gas supply is now tight.

We currently have about 85 million automobiles. If it proved desirable and otherwise feasible to use natural gas for all cars, the transition would take 5 to 10 years. By then there will likely be 100 million cars on the road. These would require some 10 trillion cubic feet of natural gas per year. To fuel all these cars with natural gas would increase consumption at that time by about one-third.

In the present and near future supply context, an extra 10 trillion cubic feet per year looms very large. However, the nation is in the process of seeking means to increase its gas supply. Not only are means of increasing production from conventional sources of supply being studied, but there is a whole array of promising new sources such as imported liquid natural gas, larger volumes of gas from Canada and Alaska, gasification of coal, and stimulation of tight gas formations with nuclear explosives.

These new sources will be required in any event to meet growth in existing markets but with enough lead time it is possible that in time substantial segments of the automotive market could be supplied with methane. Moreover, crude oil for gasoline production released by conversion might, with suitable technology, be gasified. The costs are not known at present, but they may not be substantially different from that of producing gasoline. Conversion of all automobiles is thus not completely impossible from a resource standpoint.

Senator MUSKIE. The use of natural gas seems to be a very sound answer to the automobile pollution problem, but the fuel supply seems to be a critical question; am I right there?

Dr. GOUSE. And also the rather substantial investment in distribution and handling facilities. It is a little more complicated than liquid gasoline, because of pressurizing it from one tank to an automobile.

Senator MUSKIE. Do you have cost estimates at all?

Dr. GOUSE. No, I don't. I'm sure that General Services Administration does, though.

Senator MUSKIE. Am I correct in concluding from the story I read this morning that any conventional automobile could be quickly converted, easily converted, to the use of natural gas?

Dr. GOUSE. Yes, this has been underway for a long time for special purposes.

Senator MUSKIE. Without any great engine modifications?

Dr. GOUSE. No, it calls for the substitution of some components, and the addition of some components that do not now exist. And the price estimates vary from \$250 to \$350 per car. Part of that estimate depends on how many you are going to do.

Senator MUSKIE. The gas mileage is better.

Dr. GOUSE. The gas mileage is better, maintenance is quite a bit better, and you can probably recover the initial higher price over the life of the vehicle in reduced maintenance costs.

Senator MUSKIE. So, the really critical question is fuel supply in terms of the general public?

Dr. GOUSE. Yes, and the cost to set up a distribution.

Senator MUSKIE. Thank you very much.

Senator HART. This subcommittee, on Friday of this week, will conduct a hearing in the nature of an oversight of the Federal Power Commission. It is my understanding that one member of the Power Commission has said that there is not sufficient natural gas available to supply the automobile population. We will get into that with the Chairman of the Commission on Friday.

Senator MUSKIE. That is my impression, too, because the State of California, especially Los Angeles County, would like to convert to natural gas year around, and is unable to because of an inadequate supply.

Dr. GOUSE. It would be very expensive to get it all there from where it is.

Senator PASTORE. Will the Senator yield for just a question or two?

Senator HART. Yes.

Senator PASTORE. I think you said something that some experimentation is being carried on in the DOT on the question of alternative propulsion for buses; did I understand you correctly on that?

Dr. GOUSE. Yes, sir.

Senator PASTORE. It appears to me that we have quite a number of buses on the road that use diesel oil.

Dr. GOUSE. Yes, sir.

Senator PASTORE. Which seems to emit in exhaust a tremendous volume of smoke and soot, and things of that kind, including odor. As a matter of fact, you take your life in your hands if you follow one.

Now, the question I'm asking: Is this something that could have immediate attention? In your opinion, while the volume of this emission may be more insofar as diesel oil is concerned, as compared to gasoline, which one creates more contamination insofar as public health and pollution is concerned? Could you answer that question?

Dr. GOUSE. If you look at the total pounds of pollutants emitted, trucks and buses are a smaller fraction compared to the automobile. If you look in certain very special areas where the bus population might be very high, and the automobile population would be low, in those areas the bus would be the major contributor.

Senator PASTORE. I am not talking about the overall picture. I am talking about specifically if that particular bus used gasoline instead of diesel oil, which one of the two would be more dangerous insofar as the element of pollution is concerned? That is my question.

In other words, if it is more dangerous with diesel oil, then why don't we move right in and try to do something about that?

Dr. GOUSE. It probably wouldn't change a great deal.

Senator PASTORE. If we use that argument, we will never get anything done.

Dr. GOUSE. No; if you substituted the fuel, you would have to change the engine to the kind that is in an automobile, rather than a diesel engine. And the automobile engine is not as economical as a diesel. So it would burn more fuel.

Senator PASTORE. But isn't that what we're talking about, changing engines? We have been talking about that all morning, haven't we? All this adds up to doing something about the combustion and that sort of thing.

Dr. GOUSE. I don't think you would save on that trade. You would come out about the same. Going to natural gas is quite a different thing than switching gasoline for diesel oil. You are going away from a liquid fuel, to a gaseous fuel, and one without any lead in it.

Senator PASTORE. In other words, do I understand you correctly; insofar as the difference between gasoline and diesel oil being used by trucks and buses is concerned, that that is miniscule?

Dr. GOUSE. The difference would not be worth worrying about, because you burn more fuel with one, and although it might be slightly less dirty, the total amount of fuel burned would be enough so it would add up to the same. The smell would go away. That is particularly obnoxious, but it may not be dangerous.

Senator MUSKIE. Our testimony is that the diesel emissions are as noxious as gasoline engine emissions. They are more obnoxious in the sense of odor.

I would be interested to know if you concur in the testimony we have received.

Dr. GOUSE. In terms of the unburned hydrocarbons and the carbon monoxide emissions, that is so. In terms of the oxides of nitrogen that are produced, that probably isn't so.

Senator MUSKIE. What is the difference there?

Dr. GOUSE. The diesel runs at a higher temperature than does the gasoline engine, so it would produce more oxides of nitrogen. It offers more complete and efficient combustion, so it produces less hydrocarbon and carbon monoxide.

Until we learned more, our initial views were that hydrocarbon and carbon monoxide were the principal elements in smog, and that is why they were attacked first. But as more information is obtained, we are finding that the nitrogen oxides are an equally important component and must also be controlled. So, on balance, the two probably come off fairly close.

Senator MUSKIE. Let me ask another question on this same subject that I think could relate to this bill.

We last conducted hearings in Detroit. It was then my impression that the state of the art with respect to turbine engines was almost to the point where we could apply that to buses and trucks. They are too heavy and cumbersome for passenger automobiles. We rode a gas turbine bus. One thing we were told then was that the mass production

techniques have not been developed for the gas turbine engine. We produce 2,000 turbine engines a year for the airplane industry, but we are talking about tens of thousands, maybe hundreds of thousands when we talk about buses and trucks. Has there been any advance in that respect?

Dr. GOUSE. Yes.

Senator HART. Doctor, before you reply to that, if I may, our next witness will speak for an automobile company which I understand in the 1971 model year will be in production with turbine trucks. I want to caution you that in back of you there may be someone planning an answer inconsistent with what you have in mind.

Dr. GOUSE. I think we will be consistent. Yes; the manufacturing technology for mass production of gas turbines is not in hand at the present time.

Senator MUSKIE. Nothing has been done on it in the last 4 years?

Dr. GOUSE. Oh, yes; but the easier solution to the problem seems to be, at least for automobile applications, to develop the gas turbine to the point where you can use materials that are more easily handled on a mass-production basis.

Senator MUSKIE. That is the automobile. But I have talked to Senator Pastore about this privately, and it seems to both of us from a public relations standpoint, that since there is almost in hand an engine that could reduce the bus problem, it seems silly not to develop that technology and to apply it to buses.

Dr. GOUSE. I believe you will be able to buy gas turbine buses very shortly.

Senator PASTORE. I have had many, many people say to me, if you want to do something about pollution, why don't you do something about all that smoke and soot that emits from these buses; and I'm asking you the question, if we did change it over to gasoline, would we improve the situation any?

Dr. GOUSE. You would get rid of the soot, but we are also going to get rid of the soot by adding certain components to the present diesel, and the gas turbine is virtually ready for marketing by some companies for trucks and buses.

Senator MUSKIE. That is good to hear.

Dr. GOUSE. But not for cars.

Senator HART. We will hear more about that later in the morning. Senator Goodell?

Senator GOODELL. I shall be very brief. What potential is there for at least minimizing this problem through improved fuel? For instance, the oil companies put in various additives such as lead, to, as I understand it, make a lower-quality fuel acceptable in the automobiles today. This means that a great deal of lead is emitted into the air. Do we know that lead is a dangerous substance in the air?

Dr. GOUSE. We know that lead isn't good for people but it is not clear what the lead in the air does.

Senator GOODELL. Do we know that it isn't good for people?

Dr. GOUSE. We know that a lot of it isn't good, but we don't know whether the present levels are harmful or not. There is very conflicting evidence on this, on the health aspect of lead in the atmosphere.

Senator GOODELL. What emissions from automobiles or from trucks and buses right now are dangerous to human beings?

Dr. GOUSE. The carbon monoxide, the hydrocarbons, and the nitrogen oxides at various levels of content.

Senator GOODELL. Sulfur oxide?

Dr. GOUSE. Sulfur too, although there isn't much of that in gasoline. There is very little sulfur from gasoline.

Senator GOODELL. This is from your heating oils?

Dr. GOUSE. Right, the lower grade oils would have sulfur.

Senator GOODELL. We could at this stage now, by act of Congress or regulation, prohibit certain dangerous additives from being emitted into the air in this fashion. We could certainly prohibit the emission of lead in gasoline. Technology would permit the production of gasoline without lead additives, would it not?

Dr. GOUSE. Yes.

Senator GOODELL. Would this be desirable?

Dr. GOUSE. In some ways it would be. The information that is in the literature indicates that certain devices to be added to the internal combustion engine to control the gaseous effluents function more effectively and longer if the fuel has no lead. So, with a nonleaded fuel, one might be able to have cleaner emissions.

Senator GOODELL. In other words, you not only eliminate the lead, but you would facilitate the prospect of reducing some of the other dangerous emissions?

Dr. GOUSE. That's right.

Senator HART. Doctor, thank you very much for your responses which were very helpful. As I indicated, our next witness is from the automobile industry, and a very distinguished leader of the industry, and particularly knowledgeable in the field that the subcommittee is now studying, the vice president for engineering for Ford Motor Co.

STATEMENT OF HERBERT L. MISCH, VICE PRESIDENT, ENGINEERING, FORD MOTOR CO.; ACCOMPANIED BY DONALD JENSEN, DIRECTOR, AUTOMOTIVE EMISSIONS OFFICE; AND ROSS TAYLOR, ASSISTANT CHIEF ENGINEER OF ENGINE ACTIVITIES AND CHIEF ENGINEER OF ADVANCEMENT ACTIVITIES

Mr. MISCH. Thank you, Mr. Chairman, members of the committee. My name is Herbert L. Misch. I am vice president of engineering for the Ford Motor Co. I have with me today Mr. Donald Jensen, the director of our automotive emissions office, and Mr. Ross Taylor, the assistant chief engineer of our engine activities and chief engineer of our advance engine activities.

I appreciate very much this opportunity to present the views of Ford Motor Co. with respect to S. 3072, which is a bill to stimulate the development, production, and distribution of low-emission motor vehicles.

At the outset I want to emphasize Ford Motor Co.'s support of this bill and our determination to do our part to improve the quality of the environment. At a news conference last December 10, Mr. Henry Ford II pledged that Ford "will achieve products and manufacturing

facilities that do not significantly contaminate our atmosphere, waters or landscape. I cannot emphasize too strongly," Mr. Ford said :

My own personal concern and that of Ford Motor Company with removing automobile-related pollutants as a threat to environmental quality. This concern will be reflected not in words but in specific, concrete actions based upon all the scientific, engineering and manufacturing skills at our command.

Referring to S. 3072, Mr. Ford said :

We think that this bill is an excellent concept * * * If properly drawn * * * it could create a market which does not now exist. It would thereby strengthen competitive incentives and provide a realistic opportunity to test the economic and technical feasibility of incremental progress in reducing vehicle emissions. This, in turn, will provide a better basis for orderly tightening of the standards governing vehicles sold to the general public * * * I can promise you that Ford Motor Company will be competing vigorously in the new market * * * (the bill) will create.

The purpose of my appearance here today, therefore, is to support S. 3072 and to cooperate with this committee in making constructive suggestions that we feel will make the law more workable, while insuring maximum benefit to the public.

From the wording of the bill, and the explanation by its authors, we understand that the legislation is aimed—as it should be—at the development of low-emission vehicles which might ultimately be suitable for wide public use. The proposed bill recognizes this intent by specifying the cost level indicated in section 5 of the bill. The limit of 125 percent of normal Government procurement and maintenance costs proposed in the bill establishes, we believe, a reasonable price range with sufficient incentive to encourage development of vehicles suitable ultimately for public use.

The bill, of course, provides sufficient flexibility to encourage development of a wide range of various types of low-emission vehicles, some of which would be suitable only for specific narrow application. Ultimate success will depend, however, on solutions which have widespread application.

Our first suggestion has to do with the concept of a "suitable substitute" which runs through S. 3072. As we read the bill, its objective is to stimulate competition in the development of very low emission vehicles that will be usable in the same modes as vehicles currently in the hands of the public. We think the matter could be clarified by changing section 4 to require that the Board publish minimum vehicle performance criteria so that all proposed suppliers would know exactly what the requirements would be. It might be that the Board would want to have more than one set of criteria depending on the application intended for a vehicle. For example, the criteria for vehicles suitable for the general motoring public may be different from the criteria for specialized vehicles designed only for city driving, but whatever the criteria adopted for any particular class of vehicle, they should be applicable to all possible power plants.

Ford Motor Co. intends to be a competitor under this legislation, but we would want the assurance that both our company's efforts and those of competitive bidders, including those presently outside the auto industry, are directed toward meeting the same criteria. Uniform

minimum vehicle performance criteria if created by the Board established by this bill would provide for meaningful assessments of various approaches.

As we read S. 3072, no propulsion system is specified or preferred. Therefore, it is immaterial whether the low emission vehicle is powered by an internal-combustion engine, electricity, steam, gas turbine, or other power source, as long as the various criteria the Low Emission Certification Board establishes for a low emission vehicle are met. This is as it should be. If all modes of propulsion are embraced in the competition, that competition should be even more rigorous to the ultimate benefit of the public. We therefore endorse the latitude provided in S. 3072 which allows either internal-combustion engines or alternate power sources.

It is extremely important that the Board's definition of a low emission vehicle should relate to control of those substances which are specified in either existing or proposed control standards for production cars. At the present time, standards for motor vehicle emissions have been established by the Department of Health, Education, and Welfare for control of carbon monoxide and hydrocarbons. Air quality criteria for CO and HC are now being drafted by the Department with an announced release date in the spring. NO_x controls will be initiated in California for 1971 models with U.S. criteria due next year. At the present time then, the low emission vehicle would be defined in terms of control of HC, CO and NO_x emissions. This relationship to existing and future control requirements is important in order to obtain reasonable consistency between emission control policy and low emission vehicle development policy.

We think it important, also, that the bill provide for the publication of test procedures. These may have to vary from concept to concept, but we recommend that the present language of section 206 of the Clean Air Act relating to certification of motor vehicles be utilized in this proposed legislation. That would take into account lead time problems and also permit logical progression from field experience with GSA cars to mass production for the U.S. public.

Field experience is particularly important to us or any other manufacturer. A vital reason for our support of this bill is that it would enable us to work cooperatively with the Government in obtaining valuable field experience with our vehicles over a variety of operating conditions before entering into volume production.

Let me give you an example of how Ford Motor Co. currently is embarking on such a cooperative program with the Federal Government to gain field experience.

As you know, the full benefit from present emission control systems will be delayed because of the necessity for awaiting attrition of the older, unequipped cars now on the road. Therefore, as you were told by the GSA witness yesterday, in order to achieve cleaner air as soon as possible, Ford is embarking on a field experiment with GSA to determine if used car emission controls are feasible. We found promising results in tests on a limited number of vehicles at our research and

engineering center. As a result, we are negotiating a program with GSA to see if these used car emission controls can be equally effective when used on a much larger sample of cars in varying conditions of repair. Installations and maintenance would be performed by GSA mechanics as they should be done in a garage, rather than by highly skilled engineers. This would permit realistic field evaluation of our attempts to reduce used car emissions.

Measurement of vehicle emissions, as you undoubtedly know, is extremely complex, requiring very sophisticated instruments. We have just built a unique, self-contained mobile emission test laboratory which will be used for this field experiment with GSA.

I have, Mr. Chairman, a few pictures and descriptions of this laboratory unit which I would like, if I could, to pass around.

Senator HART. We would appreciate seeing them.

Mr. MISCH. Because of your deep interest in low-emission cars, we have made arrangements for our mobile laboratory to be here at the Senate Office Building on Thursday, February 5, at 9:30 a.m. We also will have here low emission concept cars available for your inspection. We would like to extend an invitation to the committee to look at them. Also we can demonstrate a concept car which is being tested in that mobile laboratory. This concept car is an outgrowth of our interindustry emission control program, a program that was started in April 1967.

Senator HART. As you probably sense from some of the questions this morning, and I know from your long relationship with many in an effort to get a handhold on this air pollution, your invitation is gratefully accepted. I think all of us will try and persuade as many of our colleagues as we can to see what is really—I do not want to downgrade the art department, but maybe it is not as exciting as the sketch, but at least it looks like an exciting kind of thing to see.

Mr. MISCH. As a brick and mortar engineer, I think the art department did not do justice to it.

Thank you. We hope that you will be able to join with us, and we would like for our people to arrange with your staff for the most convenient method of having you see the laboratory.

Senator HART. We want to cooperate fully.

Mr. MISCH. Thank you very much. I mentioned that included will be one of our concept cars. I would like to say that the inter-industry emission control program was actually started by Ford and Mobil Oil with the idea of developing a virtually emission-free car by combining the best potential combinations of fuel hardware. We opened this research project to all other oil companies and auto manufacturers. Nine others have joined with us.¹ Ford is the project manager.

At the outset of the program, objectives were established which we believe would define a virtually emission free vehicle.² Those values today would be considered extremely low. After extensive research efforts, we have four basic concepts which meet the objectives of the

¹ American Oil Co., Atlantic Richfield Co., Fiat S.p.A., Marathon Oil Co., Mitsubishi Heavy Industries, Ltd., Nissan Motor Co., Ltd. (Datsun), the Standard Oil Co. (Ohio), Sun Oil Co., and Toyo Kogyo Co., Ltd.

² See attachment on p. 73.

program in the laboratory. So now we are busy evaluating the concepts on the proving ground to determine which has the greatest merit with regard to durability and performance. Our next step will be to evaluate the producibility and reduce the concepts to a production design.

Some of the vehicles in this program are operated on leaded fuels and others are operated on unleaded fuels. Because of the uncertainty of the availability of unleaded fuel, we are taking both approaches; so, therefore, the technology at least is being pursued in both directions.

Senator PASTORE. If we go along, sir, in this pursuit, what is it that we naturally have to give up in the motor vehicle, speaking now about the noise and speed and comfort and things of that kind? Are you going to address yourself to that?

Mr. MISCH. I certainly can.

Senator PASTORE. I do not want you to be specific, but I know as an engineer you envision that as we go along this line, something else has to be given up in turn in order to avoid and eliminate the pollution.

Mr. MISCH. Yes, Senator Pastore.

Senator HART. Do we have to give up something to get an emission-free automobile?

Mr. MISCH. We do not like to talk in terms of compromise, but we like to talk in terms of the fact that every good product involves tradeoffs, and I think this is your point.

Senator PASTORE. That is my question; yes.

Mr. MISCH. As we see it at the moment, the major tradeoffs in the reduction of emissions from the internal-combustion engine system, are possibly fuel economy and therefore operating economy and, secondly, cost and complexity of the systems.

We have not arrived at the point in development where we can say we have concept systems that will demonstrate reliability and durability of today's vehicles, and, of course, it may be that one of the tradeoffs is that we will have to be satisfied with durability that is less than today's vehicles.

We would need to quantify this and have everyone know what the tradeoff was. It is these two that I believe would be paramount.

Senator PASTORE. How about speed, because if we can invent something that will not go as fast as some of the modern cars, maybe we would save a lot of lives, too?

Mr. MISCH. I do not think we can say categorically that the power supply that provides the speed of today's car is necessarily a negative with regard to air pollution. In many instances I think down the road we may be looking at larger displacement engines in order to have a better situation from a pollution standpoint. This is one approach as a matter of fact.

The power in our vehicles—let us talk passenger cars now rather than trucks for the moment—the power in our vehicles is primarily determined on the basis of the requirement for acceleration, the nimbleness to move in and out of traffic, getting on to freeways and so on. It is the power over and beyond the power required for steady State driving. In other words, the power available for acceleration that determines the overall power and, therefore, the size for the

powerplant, it is not the top speed potential. I question that limiting the top speed would have a major impact on our pollution problem.

Senator PASTORE. Of course, if you did not have that power of a fast getaway, you would not take the chance to use it. I mean people venture the way they do only because they know they have the power to do it with. If you have a slow moving car that is 5 or 6 years old, you are not taking the same chance as one of these new cars or these sport models with all the noise and all the speed and all the power. They are just zooming off.

Mr. MISCH. I agree, Senator Pastore. I get back to your original suggestion of the necessity of looking at tradeoffs.

One of the other factors in our vehicle highway system is efficient utilization of the total system. Therefore, in our highway system we do want to move the largest mass of vehicles and consequently the largest mass of people through those transportation systems, and the nimbleness of traffic would have something to do with this.

It would have to be looked at on the basis of the total effect of efficiencies on the transportation system as I see that.

Senator RANDOLPH. Mr. Chairman, I am reluctant to ask at this time, but I would like to follow because of the question of Senator Pastore. I think he has a valid reason for asking this and other questions.

Last year in this country we had 1,500 traffic deaths at grade crossings. The study within our Subcommittee on Roads and Public Works indicates that in many, many of the instances this was an effort to beat the train. What is your comment?

Mr. MISCH. Well—

Senator RANDOLPH. They felt they had the power, see.

Mr. MISCH. I am certain that regardless of the type of motor equipment that is provided, it would have to be operated by people and the judgment of people would become a major factor in whether or not it was operated appropriately or not.

Senator RANDOLPH. You think, then, that the ultimate power, the built-in speed is not a factor?

Mr. MISCH. It is my own opinion that I would not give up the nimbleness and command of a vehicle for any gains that might be had by a limitation of power. I personally would prefer the opposite.

Senator PASTORE. That is not my question. My question is this: In this trade-off that we speak about in order to eliminate pollution, if the trade-off has to be the fast getaway and the high speed, all I am saying is that is a very salutary trade-off. I am not saying that you should do it deliberately. I am not saying that the automobile manufacturers should deliberately try to cut down their speed or eliminate the fast getaway of the motor vehicle. I am not saying that. But if it is necessary in this development in order to avoid pollution that we must have to make that sacrifice I say it is better not to pollute and not to have the fast getaway and not to have the high speed.

In other words, I think it would be a sensible trade-off and in the long-run I think it would save lives. That is all I am saying. Do I make my position clear?

Mr. MISCH. Yes, sir; I think we would agree with you.

Senator HART. Mr. Misch, first of all, thanks for the comments you make with respect to the support in general of the approach of the bill.

May I inquire, had you finished the statement?

Mr. MISCH. I think I have covered all the points I hoped to cover in the statement. I just want to reemphasize that we in fact do support the concept of S. 3072 and we certainly sincerely hope that our suggestions we have made here with regard to the bill are in a direction that is helpful to the committee.

(The attachment follows:)

ATTACHMENT I

Concept emission package "A" incorporates (1) thermal reactors, (2) a secondary air pump, (3) enriched and staged carburetion, (4) exhaust gas recirculation, (5) an IIEC crankcase valve to control "blow-by" gases, (6) evaporation control, and (7) over-temperature controls.

This package uses reactors (similar to enlarged exhaust manifolds) and secondary air (not passing through a carburetor) to cope with hydrocarbons and carbon monoxide, and exhaust gas recirculation (feeding some exhaust gas back through the engine's carburetor) to control nitrogen oxides.

Concept emission package "B" combines catalysts and exhaust gas recirculation systems. It consists of (1) a catalytic converter for control of hydrocarbons and carbon monoxide; (2) exhaust gas recirculation and enriched carburetion to reduce nitrogen oxide emission levels, (3) IIEC crankcase valve, (4) programmed protection control, and (5) evaporation control.

Programmed protection involves the use of a small computer containing a logic system to feed exhaust into the catalytic converter or by-pass it depending on information received from engine water temperature, vehicle speed, engine load, and catalyst bed temperature sensors.

Concept emission package "C" uses dual catalyst converter systems. It incorporates (1) a dual converter containing a nitrogen oxide catalyst followed by a secondary air manifold and a hydrocarbon-carbon monoxide catalyst, (2) a secondary air pump, (3) enriched carburetion, (4) exhaust gas recirculation (5) IIEC crankcase valve, (6) programmed protection system, (7) evaporation controls, and (8) non-leaded fuel.

Concept emission package "D" makes use of direct air injection and exhaust gas recirculation. The package includes (1) air injection into cylinder heads, (2) a secondary air pump, (3) enriched and staged carburetion, (4) exhaust gas recirculation, (5) IIEC crankcase valve, and (6) evaporation control.

In this approach, air is pumped into cylinder heads to achieve better combustion and thus better hydrocarbon and carbon monoxide control. Exhaust gas recirculation is used for nitrogen oxide control.

Senator HART. The suggestions I am sure will prove helpful. They will sharpen our realization of how this may in fact affect the producer, because the objective, as you so clearly state, is to make economically feasible a more aggressive pursuit of an emission-free vehicle. You make a point which strikes home with me: that it would give the manufacturer with this assured but limited Government market experience, before you do go into massive volume production. This means, as I understand it, you would be able to turn over a more reliable product to the general consumer after you have had this opportunity to do business with the Government. That would be all to the good.

I am a history and Greek fellow, myself. Gas, emission and piston—all of that is a little fuzzy. Let me see if I understand something that seemed to be said this morning.

There is a catalyst converter: it is available. If you could get gas that is lead-free and by tomorrow have that converter on every car, including the old ones, and lead-free gas in the gas tank, what would be the effect with respect to air pollution? It is my understanding it would be cleared up, as far as the automobile; is that correct? Do I oversimplify, or does my Greek and history background show through?

Mr. MISCH. No, I don't think you oversimplify as long as I understand. You said if the catalyst was developed and available—

Senator HART. No, I was making an assumption that perhaps is wrong. I assumed that such a catalyst converter is available.

Mr. MISCH. That assumption, I believe, is questionable, because as we have said, we can demonstrate the effectiveness of these catalysts in the laboratory, but we have yet to determine what we would consider to be reasonable life with leaded as well as with unleaded fuels. There is no question that without the lead in fuels it is easier to find a catalyst and develop catalysts that will live. Catalysts by nature depend upon a great deal of surface of catalyst material. It is a surface kind of phenomenon that takes effect, and it always amazes me that the catalysts we are dealing with have a tremendous surface, something like 100 to 200 square meters of surface per gram of catalyst.

I only say this to indicate that the surface is so important, and lead does have an effect—call it blocking—effect on the surface. It coats the surface, and this is entirely dependent on the amount of catalyst and the amount of flow-through of lead, as to how long before it blocks the chemical surface.

I guess we would have to say at the moment that with catalysts we have been more successful without lead than with lead.

Senator HART. You wouldn't want to sharpen that by saying that with lead the damage to the air is a fixed percentage greater than without lead?

Mr. MISCH. There are several things that are involved here which make it difficult to give a clear and concise answer.

For one thing, in the internal combustion engine, the use of lead, as we see it, does have an effect in the basic combustion chamber of the engine with regard to the volume of hydrocarbon emissions as a result of deposits that are formed in the chamber. Without lead, these deposits are different in nature, and we do notice a lesser emission of hydrocarbons than when the basic engine is operated on a leaded fuel.

However, when we talk about the downstream treatment, if you will, of the effluents of an internal combustion engine, if we could find a catalyst that were effective and could absorb the throughput of lead without deteriorating too rapidly then I would say the end result of the treated effluent out of the end of the exhaust would be the same.

This is what we would be trying to do.

Senator MUSKIE. Will the Senator yield?

Senator HART. Yes.

Senator MUSKIE. You are talking about an "if." Isn't it true that a vanadium converter, for example, has a life, according to some tests, of 1,500 miles with lead in the gas, 15,000 without leaded gas?

Mr. MISCH. There are several that have that relationship.

Senator MUSKIE. That is the order of magnitude that Senator Hart was seeking.

Senator HART. Senator Moss?

Senator MOSS. No questions.

Senator HART. Senator Cannon?

Senator CANNON. You are talking here about the Ford plans. These are your temporary plans, let's say, if we could put them in that context; aren't they? This is to try to cure the problem that exists right now, rather than new engine development.

Mr. MISCH. Rather than alternate power sources; you mean alternate to the combustion engine? Is that your question?

Senator CANNON. That's right.

Mr. MISCH. The concept cars we listed in the attachment of my statement do deal with internal combustion systems only.

Senator CANNON. Address yourself to this problem, this truck and bus problem now, as you see it; will you?

Mr. MISCH. We have been doing extensive work in gas turbine research and development. It started around 1952, as a matter of fact, and we have been carrying on this development ever since that time. We have now a gas turbine engine that is designed primarily for truck and bus use, and is in the range of 300- to 350-horsepower size that is fairly well down the road from the development standpoint.

We still are not home in many instances. We still haven't had complete success with developing adequate durability for truck operations, which is in the range of 250,000 to 500,000 miles of operation between any overhauls. We are not there yet.

Senator CANNON. How far away are you?

Mr. MISCH. It is a little bit hard to say. We hope every day for another breakthrough, another improvement. It is a pick and shovel sort of development now, where we are down to reasonably well-defined problems that we can give a lot of attention to, and a great deal of development time. We hope by the end of 1971 or early 1972 we will have some gas turbine engines in limited production, probably not for trucks and buses yet, but maybe for stationary installations. This will give us some additional experience needed for final development of truck turbines.

This is about the timetable. It isn't firmed up yet, but this is what we are shooting for.

Senator CANNON. What kind of target date are you anticipating now for actual use in conversion of trucks and buses?

Mr. MISCH. As I say, we would hope by the end of 1972 we would be in a position to start.

Senator CANNON. These original developments here—when I say original, these first ones—is the problem that you have so much bulk and so much weight in this type of a development? Is this why you say for trucks and buses, rather than for automobiles?

Mr. MISCH. There are several things. In the truck and bus, of course, you are competing with a rather sophisticated, good performing, long-lived, but high-cost power source, such as the diesel engine; therefore, there is a market available which on a dollars-per-hour power basis, is

substantially greater than would be available for applications such as passenger cars, and certainly the first production of gas turbines for vehicles are going to be expensive.

One of the characteristics of gas turbines is that they are more expensive in the main than the reciprocating engines that they replace, but the other thing is we feel that such an alternative source must have some definite benefits before it is going to effectively replace that which is already there. It has got to have some attractions for the consumer.

Senator CANNON. How much lower are your turbine emissions, let's say, than your normal engines today?

Mr. MISCH. The hydrocarbon emissions and the carbon monoxide emissions from turbines are practically of no significance. They are that low. There is still a question with regard to oxides of nitrogen. However, we are working very diligently to develop burner systems that will produce fewer oxides of nitrogen.

But I would say at the moment we are not satisfied with the level of oxides of nitrogen from turbines.

Senator CANNON. Haven't the aircraft engine manufacturers overcome some of these problems?

Mr. MISCH. The aircraft engine manufacturers are interested in the main in developing thrust; that is, accelerating the gas and powering it out the back of a jet engine, and developing thrust in that way. Although it would seem as though the gas turbines we are talking about for vehicles are quite similar, in fact we are talking about developing turning power, if you will, so it will be geared to the wheels. That is the first major difference.

Second, the very size of the components make for great differences. An aircraft engine has gone a long way in increasing its cycle temperatures through such things as turbine cooling, where air is flowed over the turbine blades. This is possible in an aircraft turbine because the blades are at least big enough so you can see them. Some of them are as big as your hand.

But in a truck or a passenger car turbine, these blades are so miniscule we have no way we can apply these techniques. So we are a bit more limited on temperatures than the more modern aircraft gas turbine.

My point is that there are differences.

Senator CANNON. Would the premiums in the bill give you enough latitude to develop turbine engines for passenger cars?

Mr. MISCH. At present reading, I would say no. It is hard to answer that.

Senator CANNON. You would require some sort of massive development program first, is that what you are suggesting?

Mr. MISCH. Yes. The point is, we have a reasonably massive development program going on. We are not allowing anything to get in the way of our pursuit of the gas turbine as an alternate. I can see where this bill would provide a market if and when we had completed our development programs to the point where we had a product that we wanted to put into that market on a trial basis. I think the bill would have served that purpose. Yes.

Senator CANNON. Are you doing anything on the development of the so-called steam engine?

Mr. MISCH. We have some activity. The greatest share of our activity in our own research group is maintaining cognizance of the state of the art and what is going on. We have an arrangement, an interest, with Thermo Electron Corp., Waltham, Mass., which has done some interesting work on small Rankine cycle engines and Rankine cycle systems. We are following that work rather carefully, and where possible we are aiding them. At least we give them some automotive input for some of their thoughts and activities.

They have a program with the Department of Health, Education, and Welfare to consider a proposal of a Rankine cycle engine for a passenger car, and we are cooperating with technical devices and so forth in that area.

That is about the extent of our effort. We like what they are doing as being something worth pursuing. They have identified the basic problems, and they are working on those basic problems, rather than to create a total system and then reidentify the same problems again.

So they are narrowing down, and we think working in a meaningful fashion.

Senator CANNON. What is your timetable, based on your experience in research in this field when we can start to look toward a marked downward trend in the emission problem, the pollutant problem?

Mr. MISCH. I think we have to make this point first. We don't want to rely on history, because we want to look forward to progress. But we have to make the point that as of 1971, for vehicles on a nationwide basis there will be an 80-percent reduction of hydrocarbons as compared to an uncontrolled vehicle.

Senator CANNON. But that is just by doing some of the basic things that could have been done a long time ago, this big step?

Mr. MISCH. This progress to date has come by bits and pieces, and it has come as a result of very, very, careful, meticulous work in the whole area. We are doing what we are for 1971 because we have just learned how to do it. Frankly, in most instances, we are doing it in a way that I think is meaningful to this extent—the customer hardly knows we have done anything. That is unfortunate from a public relations standpoint, but it is very necessary if the product is going to continue to be satisfactory to the customer.

Senator Pastore asked about tradeoffs. I would say at the moment our tradeoffs have been minimal in getting an 80-percent reduction number in hydrocarbons, and 60-percent reduction in carbon monoxide. These are not minor accomplishments.

Senator CANNON. Except for the fact that your 80 percent is going to relate to the new automobiles and not to automobiles that are out on the road today.

Mr. MISCH. This is exactly right. I would agree.

Senator CANNON. So, really you haven't got the 80 percent of the total. You have got 80 percent of the new vehicles that are contributing to a problem?

Mr. MISCH. We have 80-percent reduction in the new vehicles, and it requires attrition of the old before it becomes totally effective, that is correct. So would the addition into the total system of any other alternate power source. It would face the same problem of having to go through a period of time.

Senator CANNON. No question, unless you went back and converted everything that is out right now, which is really not realistic.

Mr. MISCH. Yes.

Senator HART. Senator Randolph.

Senator RANDOLPH. Mr. Chairman, Mr. Misch, would you object if I mentioned General Motors?

Mr. MISCH. Certainly not.

Senator RANDOLPH. The late Charles Kettering said "my interest is in the future," and he was constantly innovative, of course, and made contributions.

But I am grateful for the interest which you are indicating that comes painstakingly step by step to make this future one which will give a quality of life that we do not now possess.

This is not really just a pleasantry. I feel to men like you and your associates we must give considerable accolade.

I want, Mr. Misch, to underscore what you have said in your testimony which I have read and reread. You really close your testimony by saying that there exists the uncertainty of the availability of unleaded fuel; is this correct?

Mr. MISCH. That is correct.

Senator RANDOLPH. And that is what you did say in essence.

Now, if there is this uncertainty, and Senator Cannon has highlighted the period of time and your contribution percentage-wise in the alleviation of our trouble, what do you really mean by the uncertainty?

Mr. MISCH. Well, we feel, of course, that the total system has to be analyzed. It goes beyond just the hardware of the vehicle. We stand ready to consider modification to the vehicle and the power system to conform to any revision in fuel that might be suggested and would be appropriate and meaningful from an economic standpoint on a countrywide basis. The uncertainty is just where is the balance here and where are the trade-offs. We are looking at the world from our porthole and there are several other portholes that have to be looked through in order to get the whole picture together.

That is the reason I am saying it is uncertain at this time as to whether or not there will be lead-free fuels available in such quantities as to be meaningful. I think that the petroleum industry has to have a great deal of input in making this determination.

Senator RANDOLPH. Mr. Chairman, a final question and I think I will couple it with a suggestion. I wonder if it would not be helpful if you would advise all of our colleagues in the Senate, not just those that are concerned with these hearings, about the exhibit here on Thursday, February 5.

Senator HART. Thank you for the suggestion. I hope Senator Muskie will join me in that invitation.

Senator RANDOLPH. This final question, Mr. Misch. How long has Ford been working on this problem?

Mr. MISCH. Well, over 15 years that I know of.

Senator RANDOLPH. And how much money would you estimate was committed to this effort?

Mr. MISCH. I don't think I have a cumulative figure over a period of time. I can give you a number, for instance, that will tend to quantify to a degree at least, the efforts in calendar 1969. This is representative of the last few years, and it has been building up over time to this level. In 1969 we spent about \$28 million in a technical effort on research and development of emission controls.

That is broken down basically to \$17 million of research and about \$11 million of engineering. All of this is dedicated to the vehicle emission problem.

I do not know that dollars necessarily quantify effort totally. We are putting every bit of technical talent we can to make a contribution in a meaningful way on the problem, and that is about the size of our activity now.

It would represent, I believe, in the United States something like 900 people working actively in our company.

Senator RANDOLPH. Thank you very much.

Senator HART. Senator Muskie.

Senator MUSKIE. You mention in your testimony that you have been working with the GSA on a low emission vehicle. What direction are those efforts taking? What kind of solution are you exploring?

Mr. MISCH. The things that we are exploring are actually limited to those which we believe could be accomplished by the average mechanic in the field. We are looking at incorporating those characteristics that we have been able to put into our 1970 vehicles now. It includes variations in spark timing, modifications in the air-fuel ratio of the carburetor, that sort of thing.

We do not have a single-kit approach, but we have several approaches that we intend to try in this used car program. We are aiming at being able to make our older cars meet the levels that are specified by the California used car requirement.

Senator MUSKIE. How does that level compare with the requirement for new cars?

Mr. MISCH. It is roughly double, is it not, Mr. Jensen?

Mr. JENSEN. I will put this in parts per million, because the used car law in California is expressed that way.

The new car requirement is 180 parts per million hydrocarbon and 1 percent carbon monoxide. In California the used car requirement is 2 percent carbon monoxide, 350 parts per million hydrocarbon, and 800 parts per million oxides of nitrogen.

So it is double on the two contaminants now controlled nationally. Oxides of nitrogen is a third contaminant that is added for used car controls.

California law specifies—regulations were just adopted I believe last Wednesday—that you should control all three if possible, hydrocarbons, carbon monoxide and oxides of nitrogen. If you cannot control all three, you must control two of the three and not raise the third.

Senator MUSKIE. How realistic is it to hope that the used car population as a whole can be brought into compliance with that kind of a standard by the techniques that you are exploring?

Mr. MISCH. It is a little early to say. I don't think it is realistic that 100 percent will be accomplished, but I think in certain areas at least we might be able to make a major accomplishment.

Senator MUSKIE. In California, for example, the automobile inspection system is a spot-check system. I forget now what percentage of all California cars are hit by that inspection, but I think it is a relatively small one.

That may work passably for safety devices for automobiles but it is not going to work to solve this problem because every car is going to have to be treated, is not that correct?

Mr. MISCH. That is correct.

Mr. JENSEN. If I may, Mr. Misch, Mr. Chairman, Senator Muskie, to get these on initially is the big problem. People as you know, will not do this voluntarily or they will not do it on a mass basis.

If our program is to be feasible, and if we get this going with exhaust controls, it may be a model for other States. The way it works in California is that, as the registration is changed on the used car back to 1955 models—on up to the point where they started to equip the new cars in 1966, you have to have the car equipped with an approved, accredited control system which meets specified levels. The control system has to be installed by an authorized "smog" station or licensed "smog" mechanic.

So this requires a period of time; it does not happen overnight, but ultimately as cars are resold—I think the average car is resold every 2 or 3 years—you do get emission controls on the used vehicle.

Senator MUSKIE. In a State like California where the problem is critical, those marginal pickups of improvement are important, I recognize that, but the answer to automobile emissions is not really the used car route, is it? I mean we should do what we can to improve the performance of the used car, but you have not yet satisfied yourself that you have the method, have you?

Mr. MISCH. That is right. We are not satisfied.

Senator MUSKIE. In the meantime the used car population is growing and you are getting used cars with the new technology built in for air pollution control. So the real answer in the long-run is the new car?

Mr. MISCH. The real answer is the new car, yes; that is right.

Senator MUSKIE. I set that background in order to inquire into the targets that the President and the administration apparently are exploring for tightening the standards for new cars. Has Ford been in consultation with the administration on the 1975 and 1980 deadlines that have been reported in the press?

Mr. MISCH. Yes. Ford has attended a meeting with the administration in which new standards were discussed.

Senator MUSKIE. You said awhile ago, I think in response to Senator Pastore, that progress is made by bits and pieces. If that is the case, does not it make more sense to make progress each year that you can make progress rather than wait until you have an accumulated reservoir of progress that you can build in, say, in 1975 and 1980?

Mr. MISCH. I think it makes more sense so long as the incremental advances can be accommodated without major revisions and without

a major turnaround. I do not think it makes sense to have a revolution every year so far as the total product requirements are concerned, but to the degree possible I think the improvements should be incorporated.

Senator MUSKIE. To pick a quotation out of something you said earlier, what we are looking for is thrust here, a sense of urgency, and I must say that I detect more urgency in the automobile industry right now than I detected at the time we had our last hearings in Detroit in early 1967. I think that is a fair evaluation; is it not?

Mr. MISCH. We know more now, sir.

Senator MUSKIE. You press your public opinion a little more, too, at least I hope you do, because it is there.

Mr. MISCH. That is right.

Senator MUSKIE. At those hearings in 1967, and I am referring to them now just to review some of the targets I think the industry witnesses suggested, one was that our target by 1980 ought to be overall levels of automobile emission that we knew in 1940. Does that have a familiar note? I remember the charts.

Mr. MISCH. Yes, we said that we should be arriving at an ambient air quality equal to 1940 by 1980, that is correct.

Senator MUSKIE. Do you still consider that a satisfactory target?

Mr. MISCH. Yes, I think so. If accomplished, I think it is a satisfactory target.

Senator MUSKIE. By that you mean ambient air quality attributable to the automobile?

Mr. MISCH. No. I would hope that this would be ambient air quality that is attributable to everything, all sources, but we were speaking specifically of the ambient air quality attributable to the automobile in the 1967 discussion, that is correct.

Senator MUSKIE. I do not recall what standard for hydrocarbons that that estimate was based upon. I think it was something like the present standard, was it not?

Mr. MISCH. I am not quite sure, Senator Muskie, but I believe it was around 100 or 120 parts per million number of hydrocarbons.

Senator MUSKIE. Do you still think that standard of hydrocarbons is still satisfactory?

Mr. MISCH. Our own HC target is below that, as a matter of fact, and the target we are working toward would have a downward trend compared to the previous curve in 1980.

Senator MUSKIE. I think at that hearing also the industry discounted the necessity to get down to 50 parts per million hydrocarbons by 1980. Do you have a recollection on that? Whether or not you do, what is your present view?

Mr. MISCH. My present view is that something near 50 parts per million is our target for the long range. We would consider it a part of a definition of a virtually emission-free vehicle.

Senator MUSKIE. Can you achieve that by 1980?

Mr. MISCH. We certainly hope so. That is what we are targeting for.

Senator MUSKIE. Is it possible that you could achieve it before then?

Mr. MISCH. There is a possibility we could achieve it before then.

Senator MUSKIE. Should we be committed to a 1980 target officially here in Washington when there is a possibility we can beat it?

Mr. MISCH. I think that we should be committed to targets that marshal all forces in one direction, and I think it is very meaningful that we have finite targets. Obviously, with the unknowns that exist, finite targets should not be made too near term. If they are and in spite of everyone's efforts they are missed, then they become like "crying wolf." If they are realistic, and are out where everyone feels they have a chance of success, I think that they serve the best public interest.

Senator MUSKIE. I think the target that is too comfortable is not good enough. I think the industry ought to have an uncomfortable target. Since there is some pressure here and some growing feeling of urgency, personally, on the basis of what you have said this morning, I would be against a 1980 target of 50 parts per million.

I have not in mind an earlier date, but I think that an earlier date certainly ought to be the target of the industry, and I am happy to hear that your industry target would meet that in your judgment.

Mr. MISCH. Our company target at least.

Senator MUSKIE. Your company target would meet that. I will be interested to watch that develop.

Has Ford taken a position on it in discussions with the administration up to this point?

Mr. MISCH. No; they have not.

Senator MUSKIE. You have always been cool toward the idea of the catalytic converter. Is that still your position?

Mr. MISCH. I would not say that is our position. A great deal of our effort is directed toward catalytic converters, and we still—

Senator MUSKIE. You have not found one that has satisfied you yet?

Mr. MISCH. That is right.

Senator MUSKIE. If you did, would not that be the best answer to the used car?

Mr. MISCH. The systems we see at the moment of catalytic converters that do a reasonably good job on all three contaminants—that is, the amount of hydrocarbons, CO and oxides of nitrogen—are so gross in size and are so complex that frankly, I think that used cars have got to be redesigned in order to incorporate them.

Senator MUSKIE. Are you promoting any research to the catalytic converter yourself?

Mr. MISCH. Yes, sir; a great deal.

Senator MUSKIE. How much money are you putting into that one?

Mr. MISCH. Specifically I cannot answer that on catalytic converters per se, but it is a major part of our interindustry program, for instance, and that interindustry program is funded cumulatively through the end of 1970 to a total of about \$9 million.

That merely represents, what I call the incremental costs of the various programs. But it accepts and makes available the inputs of all the various organizations that are part of the program. Their technical expertise is fed into this, so it would be hard for me to put a dollar value on the effort going into catalytic converters, but it is rather significant.

We are working with practically every organization that is also working in the catalytic converter business.

Senator MUSKIE. I would like to ask just a few questions with respect to fuels, if I may. I think our experience up to now has been—I was glad to note some change in your recent experience—that the oil companies and the automobile companies haven't been interested in talking to each other about these problems of air pollution. I know one oil company complained that their suggestions to the automobile companies were rejected, and there has been somewhat the same attitude in reverse. Nevertheless, it seems to me they are inevitably tied together.

I notice in the last page of your statement you refer to the association you have developed with some of the oil companies and I think with at least one other automobile company.

Mr. MISCH. There are six oil companies and four automobile companies in addition to Ford. The four auto companies are all foreign companies, however.

Senator MUSKIE. It is interesting that that program started in 1967, the same year that the Department of Commerce produced this report on the automobile and air pollution. One of its recommendations dealt specifically with the emission of lead as a problem of some urgency.

Concern over the use of lead additives is concentrated upon its possible effects in the following areas: (1) human health, (2) increased emission levels of other exhaust pollutants, (3) modification of atmospheric processes, and (4) deactivation of catalysts or absorbents which may be necessary to reduce the emission of other pollutants.

And the recommendation later was:

The Federal Government should immediately establish standards for the lead content in gasoline which would prevent any further increase in the total quantity of lead emitted to the atmosphere.

Now, has there been any discussion of this recommendation in the association you have with the oil companies, any effort mounted by you jointly or individually or separately to achieve that? I take it that you could not operate the modern automobile without lead or something like it to meet its performance requirements. Am I wrong in this?

Mr. MISCH. I would say that the automobile in the field undoubtedly would have to have a fuel that was the equivalent in many instances to the premium fuels of today that contain lead. We stand ready to modify our new vehicles to use unleaded fuels if and when unleaded fuels are available. And they would be modified to use the fuels of the description that was determined to be appropriate.

Senator MUSKIE. So, it would not require much of a technological effort to accommodate the automobile to lead-free gasolines?

Mr. MISCH. That is correct.

Senator MUSKIE. Have you discussed that with the oil companies with which you are associated?

Mr. MISCH. We have discussed it with the oil companies that are associated with us in the IIEC program; yes.

Senator MUSKIE. What are the problems that they pose with respect to the development of lead-free gasoline?

Mr. MISCH. I think, in the main, the obstacles are economic in nature. The ability of the oil industry to accommodate the production of unleaded fuels and furnish the needs of the country is a question involv-

ing economic trade-offs and timing. Facilities also would be required but are accomplishable.

Senator MUSKIE. Are they making any effort in that direction?

Mr. MISCH. I am sure they are, but I can't answer specifically.

Senator MUSKIE. In other words, it is not part of your joint common program?

Mr. MISCH. No; it is not part. Our common program was actually designed to determine as best we could the interrelationships of our hardware and fuels and their modifications. We did not on the basis of the program preempt a decision that lead was or was not required but we included in the program projects that would explore both.

Senator MUSKIE. Does this common program include any targets that they are undertaking to meet with respect to fuel composition?

Mr. MISCH. Yes. I would like Mr. Taylor to answer that.

Mr. TAYLOR. Senator Muskie, the IIEC program was founded in 1967 based on 15 principal projects, and many of these projects, with the agreement of the oil companies involved, dealt with means of controlling emissions that required lead-free fuels. The work has gone forward in the past 3 years on developing catalysts, particularly, that were dependent upon lead-free fuel as well as catalysts that could live on leaded fuel. This has been with the understanding of the oil companies that if this were the method found to be the most economical and the most judicious approach to meeting our IIEC targets it would have their full agreement. Studies have been underway within the oil industry to examine the total cost and time picture involved in producing such a fuel.

Senator MUSKIE. I get the impression from what you are saying that they are doing nothing about reshaping the structure of gasoline today as an effort to contribute toward a reduction in automobile emissions?

Mr. TAYLOR. I would say this, that part of the basic problem involved is a matter of equipment. All of the recent equipment, installation equipment and other processing equipment that has been put in by these companies in the oil industry with whom we are familiar is capable of making a fuel without lead. Much of the equipment of many of the other oil companies is not capable of this. Their older equipment would have to be replaced with a new form of equipment.

Senator MUSKIE. Maybe we need some new refineries.

Mr. TAYLOR. This is correct.

Senator MUSKIE. I guess the oil industry witnesses would be the best evidence we would have at this point.

I am disturbed in this associated effort that the role of the oil company really seems to be that of a passive bystander while your role is that of an activist. Is that unfair to the oil industry?

Mr. MISCH. That is a little bit unfair with regard to this program because we are actually quite pleased with the contribution of all members and much of the technical influence has come from the petroleum industry members. It has been significant. I think this and other programs like it go a long way toward having a mutual understanding. The work that has been done in the IIEC will help the members understand the relationship between fuel additives and our hardware better than they have understood it before.

I wouldn't want to leave today without making it completely clear that our petroleum industry members in this program have made significant technical contributions.

Senator MUSKIE. Suggestions as to how to run your business?

Mr. MISCH. That has been the delightful part of it. There have been technical contributions. I will give you an example. They have been instrumental in the development of a laboratory type of a generator to produce oxides of nitrogen in various and sundry quantities and forms. This has given us a tool so that we can start getting at some of the fundamentals. It is this sort of thing that I think has been a major technical advance and a great help to us and to our scientists and technicians.

Senator MUSKIE. I recall testimony we took in southern California which indicated that Richfield, I believe, had suggestions for modification of the automobile, the internal combustion engine, to take care of the nitrogen oxides problem. Has that been discussed between you?

Mr. MISCH. I think in the main, if I recall, the principle that was discussed at that time was the recirculation of exhaust gases, and this has been a consideration in the program and is being evaluated.

Senator MUSKIE. One other question on fuel. I have here a report of the National Academy of Sciences, 1969, which says:

It is estimated that the earth's coal supplies are sufficient to serve as a major source of industrial energy for two or three centuries. The corresponding period for petroleum, both because of its smaller initial supply and because of its more rapid rate of consumption, is only about 70 or 80 years.

Has the automobile industry concerned itself with such forecasts in projecting its own development?

Mr. MISCH. Our company has and we have people looking at it on a continuing basis. I can't speak specifically to it. I would say at the last reading I had we did not reflect quite that concern about the oil reserve on the information we had. This is just my impression of it. We certainly don't think we are going to run out of fuel in 70 or 80 years.

Senator MUSKIE. I realize that as new discoveries come in these projections are constantly advanced, but nevertheless this figure suggests to me that the pressures grow and I think in every discussion over oil import policy and so on the oil industry itself expresses alarm on these reserves. I don't know if the argument changes when they talk to you, but that is the argument we get when we discuss the oil import policy. I was wondering whether or not it was influencing whatever urgency you have about the development of completely new engine technologies in the future.

Mr. MISCH. Actually, most of the things we have been looking at, including the electric car, would have to, as a source of energy, use a major amount of fossil fuels.

Senator MUSKIE. Or nuclear energy.

Mr. MISCH. Or nuclear energy, that is correct. Our considerations to date have not reflected concern in the near term.

Senator MUSKIE. The trouble is that you and I are too close to the end of our lives.

Thank you very much, Mr. Chairman.

Senator HART. In your discussion with Senator Muskie on that lead-free gas problem, its unavailability and so on, all of us, as consumers, are invited to buy a lead-free gas now. The trade name is Amoco. Do I understand that it is a problem that certain refineries lack the equipment for all of them to pump lead-free gas; is that the only hangup?

Mr. MISCH. I don't pose as an expert in this area. It is my understanding that certainly the methods of refining are not exactly the same, and therefore the equipment isn't the same in each and all of the petroleum companies. That is one of the considerations.

I assume that another consideration is the crude oil itself that is used. The source of crude oil, causes some variations in their ability to provide lead-free fuels of given octane values.

Senator HART. In your gas turbine developments, the gas turbine does not require any leaded gas at all, does it?

Mr. MISCH. No, it doesn't. That is correct. It does not.

Senator HART. So that a switch to gas turbine is not conditioned at all on the increased availability of a lead-free gas?

Mr. MISCH. Well, actually, the gas turbine could operate very well on kerosene or diesel type fuels.

Senator MUSKIE. May I ask one other question?

Senator HART. Yes.

Senator MUSKIE. There has been increased speculation in the newspaper that the automobile companies are thinking of using a diesel fuel injection system, such as those used in racing cars, as a more effluent way of injecting fuel with the cylinder, getting better combustion and using less fuel. Are you looking into that at all?

Mr. MISCH. Yes, we are. We have been evaluating it. In some instances it might provide some incremental improvement. But not categorically, across all engines. The main advantage, as we see it, is the fact that it allows each of the cylinders to be operated more nearly at a chosen air-fuel ratio. What is called variations in distribution from cylinder to cylinder are minimized with that type of fueling system.

Senator MUSKIE. So that your emphasis, really, for now and for the foreseeable future, looking to 1980, is upon refining the present internal combustion engine?

Mr. MISCH. The greater share of our work is on that. We are not sure we are getting "home," so we are "covering the bet" with a significant amount of work in gas turbine and some work in the Rankine cycle engine.

Senator MUSKIE. Most of your field of urgency is directed to the internal combustion engine, and not the other?

Mr. MISCH. Yes.

Senator HART. Mr. Misch, which direction would you recommend Government research and development funds be spent; on internal combustion engine emission control, or toward an innovative low-emission technology of some sort? Where should we put our effort?

Mr. MISCH. I think it is important that the Government spend money in areas that will reduce the credibility gap, if you will, between our industry's technical activities, and what the rest of the technical world says, does and thinks. I think that it is necessary that the Government, therefore, does pursue or become engaged in evaluation

of research programs that will either point out that what we are doing is not in the right direction or confirm what we think are the facts. We then will all know if the way we are going is the right way.

But looking at the total picture, it would seem to me that, by and large, the explorations in the alternate power sources would probably be more appropriate, perhaps more fruitful in this regard than Government sponsored work in the internal combustion engine.

I wouldn't rule that out, but I just think perhaps in the main, reasonable programs could be pursued in respect to alternate sources that would be more useful and meaningful.

Senator HART. Even under this procurement bill, the manufacturer soliciting the business is not limited to presenting us with an improved—by that I mean a lower-emission internal combustion engine. Even here you would be encouraged to develop a low-emission technology other than internal combustion.

Mr. MISCH. That's right.

Senator HART. A somewhat practical question: You say in your statement that "the limit of 125 percent of normal Government procurement and maintenance cost proposed in the bill establishes reasonable price range with sufficient incentive to encourage the development of a vehicle suitable, ultimately, for public use."

I am not sure whether the bill is clear as to whether the base cost to which that 25 percent is added is the Government procurement cost which is controlled, or the normal purchase cost. Are you suggesting in your statement that the 125 percent cost be on the base price of Government procurement as now, or consumer procurement and maintenance cost?

Mr. MISCH. Actually, I guess I made an assumption. The assumption to me was that we are talking about the presently controlled limit—which I think is \$1,650—

Senator HART. It is.

Mr. MISCH (continuing). And just in round figures—say 25 percent of that would be \$400. Four hundred dollars added to the vehicles of today might be something that would be of interest, and palatable to the general public. That is how we arrived at that statement.

I don't feel strongly about which way it should be provided.

Senator HART. Senator Cannon?

Senator CANNON. No, thanks.

Senator MUSKIE. One final question. You talk about targets of 50 parts per million. How many years will this bill advance that target?

Mr. MISCH. My crystal ball is not quite that clear.

Senator MUSKIE. You regard it as an incentive, and we do, but can you see the prospects of this bill really operating as an important incentive, to advance these targets, or are you simply giving this a pat on the back as a gesture in the right direction?

Mr. MISCH. No, actually we are very serious about the fact that there is much to be gained by having programs such as this bill would motivate, that cause Government and industry to look at the same sets of facts. We would be partners and participants in evaluating some of these thoughts, rather than making claims and counter claims. If we have a mechanism so that we can all be working together and in a

meaningful way, we are going to get to the final conclusion of the problem a lot faster.

How much faster, I don't know. I don't think good knowledge ever hurt a problem-solving activity, and that is what I think we are going to do here.

Senator MUSKIE. You think this bill might significantly advance the state of the art?

Mr. MISCH. I think it might significantly advance it; that's right.

Senator MUSKIE. In such a way that it can measurably advance the targets?

Mr. MISCH. I would hope that would be the result, yes, sir.

Senator MUSKIE. So, if our present expectation is that we could reach 50 parts per million by 1980, this bill, if it is implemented, ought to advance that date?

Mr. MISCH. It ought to advance it. I can see no way it would retard it.

Senator MUSKIE. I would prefer it if you didn't say that. That is negative. I want to advance the tax date.

Senator HART. Maybe this is the way it could be phrased: If the standards that are established, either directly in the bill or by the Board that the Magnuson-Muskie-Jackson bill would create, are what people talk about as the target for 1980, and if the Board would fix the 1980 goal we are all talking for Government purchase immediately, then it is possible that we can make cars meeting the 1980 standards available for consumer use earlier than 1980, and perhaps substantially earlier than you would get, absent this kind of bill? Isn't it in the nature of the economics that it would have this result, inevitably?

Mr. MISCH. It would seem so.

Senator HART. Unless you couldn't, in fact, meet any of these limited procurement standards, and if you couldn't do that, you would be busy pursuing other technologies.

Senator MUSKIE. Is it true that you might be willing, with this kind of market available to you, to put a car on the road earlier than you would if the test was to be general public approval of the result?

Mr. MISCH. There is no doubt about that. That would be true.

Senator MUSKIE. If the Government is willing to experiment as a consumer, you would be willing to experiment as a manufacturer?

Mr. MISCH. Well—

Senator MUSKIE. I mean within looser limits, perhaps.

Mr. MISCH. Yes. It is more than just a willingness of the Government to be an experimenter. It is the fact that the Government has fleets of vehicles that are under proper maintenance control and operational control and so forth, so that meaningful technical data could be gleaned from such experiments.

Senator MUSKIE. Let me ask you this question. The first standards that we set for 1968 were applied and met in accordance with an averaging concept, because of the quality control problem which means you don't get exact carbon copies of vehicles. Some perform better than others. On the average, you get the standard set.

Here you are going to have a smaller number of cars. Does that mean you are going to have a better quality control?

Mr. MISCH. It is conceivable if there is a small enough number that you could determine in fact the specific level of each and every vehicle. It depends on the size of the grouping of vehicles.

Senator HART. Under this bill we are talking about this test procurement, but it is not limited just to the government purchases by the Federal Government, but States metropolitan areas could adopt a comparable policy that might encourage a still broader application of this proposal?

Mr. MISCH. That is as we understand it, yes.

Senator HART. Mr. Jensen or Mr. Taylor, did you have anything you would like to say?

Mr. JENSEN. No, thank you.

Senator HART. Mr. Misch, thank you very much. We will see you on February 5.

Our next witness is a figure well known, the chairman of Lear Motors, Mr. William P. Lear. Mr. Lear was here. In fact, he was pointed out to me. Well, more than anyone, Senator Cannon regrets Mr. Lear is not here, but we all regret it. He was here. Perhaps if he is, in fact, able to extend his stay in Washington we would have an opportunity in the morning.

Senator MUSKIE. We would like to hear from him.

Senator HART. Yes; we surely would. The statement has been delivered, and while it would be possible to put it in the record, we would not have the opportunity to question, to develop a broader understanding on our part.

Let's recess for a moment to see if Mr. Lears is in the immediate vicinity.

(Recess.)

Senator HART. Mr. Lear is unavailable, and will be rescheduled tomorrow.

Let me order printed in the record a letter from the General Motors Corp., dated January 12 of this year, to the chairman of the Committee on Commerce, Senator Magnuson, from the chairman of the board of General Motors, Mr. J. M. Roche.

I would assume that rather quickly copies could be made of this letter. It concludes, after describing the concern and interest of that company, in developing an emission-free engine:

Thus we at General Motors need no incentive, such as your bill would provide, to produce a low-emission vehicle. However, your bill could induce others to seek a solution to the problem and, therefore, because we agree on the necessity of achieving this result, we hope that Congress will give serious consideration to your proposal. I am taking the liberty of sending a copy of this letter and enclosure to Senator Muskie and to Senator Jackson.

(The letter follows:)

GENERAL MOTORS CORP.,
New York, N.Y., January 12, 1970.

HON. WARREN G. MAGNUSON,
U.S. Senate,
Washington, D.C.

DEAR SENATOR MAGNUSON: I have read with interest your remarks on the floor of the Senate in introducing the bill, sponsored by you, Senator Muskie and Senator Jackson, to stimulate the production of low-emission vehicles. I want you to know that I fully share your concern for the problem of air pollution and I agree that further progress toward achieving a low-emission vehicle is necessary. Moreover, as I have already stated publicly, you can be sure that General Motors Corporation is dedicated to reaching this goal.

From your remarks, it could be inferred that you and perhaps others question whether General Motors is willing to consider alternatives to the reciprocating internal combustion engine. I want to assure you that we are. We are actively exploring alternative power sources as well as trying to improve further the present engine. In the event it did not come to your attention, I am enclosing a copy of the recent statement made by Dr. Paul Chenea, vice president of General Motors in charge of our Research Laboratories, before Representative Jarman's Subcommittee on Public Health and Welfare. I am sure you will be interested in his report of what has been accomplished and what we are doing to achieve the goal that both you and General Motors seek.

In particular, your attention is invited to the statement at the top of page 2 that "General Motors is irrevocably committed to finding a solution to automotive emission problems at the earliest possible time.

And in seeking solutions that we will have no hesitation in using a power source other than the internal combustion engine if it will meet the needs of our customers, at a price they can pay, and will solve the emission problem." I fully endorse that statement.

The great challenge in the Seventies is to fulfill our responsibility to the American environment. We have committed ourselves to take the automobile out of the smog problem altogether. Our objective, as I have indicated, is to find new ways to further reduce emissions from the internal combustion engine and to explore through research potential new power sources which can be developed on a practical basis.

We must meet the transportation needs of our customers, at a price they can pay, and eliminate the automobile as a cause of smog. This has been our objective for some time. We have made substantial progress. Someday we will achieve our goal. We are coming closer every day.

Thus we at General Motors need no incentive, such as your bill would provide, to produce a low-emission vehicle. However, your bill could induce others to seek a solution to the problem and therefore, because we agree on the necessity of achieving this result, we hope that Congress will give serious consideration to your proposal. I am taking the liberty of sending a copy of this letter and enclosure to Senator Muskie and to Senator Jackson.

Sincerely,

J. M. ROCHE.

Senator HART. We are adjourned, to resume at 9:30 tomorrow.

(Whereupon, at 12:20 p.m., the committee was adjourned, to reconvene at 9:30 a.m., Thursday, January 29, 1970.)

FEDERAL LOW-EMISSION VEHICLE PROCUREMENT ACT

THURSDAY, JANUARY 29, 1970

COMMITTEE ON COMMERCE,
SUBCOMMITTEE ON ENERGY, NATURAL RESOURCES,
AND THE ENVIRONMENT,

COMMITTEE ON PUBLIC WORKS,
SUBCOMMITTEE ON AIR AND WATER POLLUTION,
Washington, D.C.

The subcommittee met at 9:30 a.m. in room 5110, New Senate Office Building, Washington, D.C., Hon. Philip A. Hart (chairman of the Subcommittee on Energy, Natural Resources, and the Environment) presiding.

Present: Senators Hart, Pastore, Cannon, Long, Spong, Randolph Baker, Cooper, and Dole.

Senator HART. The committee will be in order.

We welcome the very able Secretary of Transportation, the former Governor of Massachusetts, John Volpe.

May I explain, because there is a hearing on the nomination of a man to the Supreme Court, I have some problems this morning, but Senator Cannon very kindly has consented to serve as chairman, and I shall be in and out. But I look forward to hearing the Secretary's remarks.

Senator Cannon?

Senator CANNON. You may proceed, Mr. Secretary. We are very happy to have you here today and hear your views on the pending legislation before the committee.

STATEMENT OF HON. JOHN A. VOLPE, SECRETARY OF THE DEPARTMENT OF TRANSPORTATION

Secretary VOLPE. Thank you very much, Mr. Chairman and members of the committee.

I want to say I appreciate this opportunity to appear before you today to discuss the proposed Federal Low-Emission Vehicle Procurement Act (S. 3072).

Air pollution is one of the most serious problems facing America today, and the automobile is its principal cause. We are particularly concerned about this in the Department of Transportation, and we recognize fully the need to attack the problem on the broadest possible basis.

As a nation, we have taken justifiable pride in our pursuit of an ever-improving standard of living, holding out to our children the hope and promise of a better life. However, we now find that the automobile—which has been a major factor in raising our standard of living—has also become a major public health problem through its contribution to air pollution. Air pollution has become, literally, a black mark on our Nation. It could threaten our very existence.

The statistics on our national output of air pollution give us some indication of the magnitude of the problem. In 1966, about 190 million tons of pollutants were dumped into the air. Motor vehicles contributed about 90 million tons to the total. No other single source of air pollution approaches this magnitude. In our largest cities, the motor vehicle is a particularly heavy contributor to the pollution problem.

Air pollution affects us in many ways. It strikes at people, property, and even plant life. It is a national burden from the standpoint of health, economics, and esthetics. Because the automobile is by far the greatest contributor to air pollution, the outlook is particularly depressing when one considers that vehicular traffic will double in 15 years if the present growth rate continues.

Our choice is clear. We must solve the pollution problem or stop the growth. This is the message which I intend to handcarry to Detroit on the 12th and 13th of February. At that time, I hope to explore the problem in depth with each of the major automobile manufacturers.

The principal effort of the Federal Government thus far in attempting to control air pollution from vehicles has been the establishment of emission standards respecting the output by internal combustion engines of carbon monoxide and hydrocarbons. This effort has brought about some appreciable reductions on a per vehicle basis, but more needs to be done because of the continuing growth in the number of engines in use. There remains some doubt whether, over the long run, improvements in the internal combustion engine can be an adequate solution to the auto pollution problem. There is a body of technical opinion holding that, in the face of increasing auto use, it will be necessary to develop an entirely new propulsion system.

The Department is attempting to reduce air pollution from both public and private vehicles. In December, two new types of buses designed to reduce pollution were demonstrated. One was equipped with the new General Motors low-pollution device, sometimes referred to as the "environmental improvement kit." The other was an experimental turbine bus.

I want to say when the three different buses started up, the difference was so evident that even a 5-year-old child could have detected it. When we started a diesel bus of the type presently in use, the smoke, noise, and smell was just horrible. When we shut that bus off and started the bus equipped with the environmental improvement kit, we found it a great deal less noisy. The exhaust pipes, instead of being horizontal, were vertical, and you saw no smoke at all.

And then the turbine bus, of course, was completely noiseless and completely pollution-free.

Now, two bus projects are scheduled to begin. Diesel-powered buses equipped with the environmental improvement kit will go into service in San Francisco and right here in Washington to test their performance under normal operating conditions. We will make available nearly \$250,000 for these projects. We expect to provide the State of California an additional amount, about \$550,000, to conduct another test program involving steam buses.

I intend to use our urban mass transportation program as a major element in the fight against pollution. In every project for financial assistance to States and local public bodies for the improvement of equipment for use in mass transportation in urban areas, we intend to take full advantage of the opportunity and obligation to assure that the equipment will be designed and used to minimize air pollution. The Department of Health, Education, and Welfare is, of course, responsible for the establishment of standards for motor vehicle emissions. By statute, that Department has the expertise for determining the impact of pollution on our health and well-being, and we look to them for guidance and leadership.

Turning to S. 3072, the bill before the committee today, I would like to make only one or two points at this time. I believe the bill has merit. The bill would allow the Federal Government to pay a premium to procure low-emission vehicles as an incentive for the production of low-pollution engines. While there would, of course, be a question as to whether such a proposal would provide sufficient incentive for the accomplishment of the necessary research and development, it is an interesting approach to the pollution problem and is deserving of close attention.

In his state of the Union message, the President stressed the need to intensify research in engine design and to establish increasingly strict standards to alleviate the automobile pollution problem. Very shortly, he will submit to the Congress his program for pollution control. I would urge that the committee examine carefully the President's program.

Mr. Chairman, that concludes my prepared remarks. I would be happy to answer any questions the committee may have.

Senator CANNON. Thank you, Mr. Secretary.

I note in your remarks that you didn't give here—you say you would urge the committee to delay its consideration of S. 3072 until it has had an opportunity to examine the President's program.

Do you mean to delay consideration of this, or simply delay a decision as to what should be done?

Secretary VOLPE. That is a matter for the judgment of the committee. I would hope that before the bill is marked up or before it is considered on the floor, the committee would take the President's pollution message into consideration.

Senator CANNON. Mr. Secretary, you raise an interesting question about whether S. 3072 would provide sufficient incentive for the accomplishment of the necessary research and development.

I believe it would develop the incentive, but for the independent developer, it may be necessary to direct the money in existing programs to more research efforts.

Yesterday the witness from Ford Motor Co. said that it would provide incentive for them to do the research and development to capture the new market created by the legislation.

However, General Motors submitted a letter in which they said they didn't even need the incentive of S. 3072 to do the job.

Would you care to comment in light of that rather ambiguous position?

Secretary VOLPE. I have heard various, also conflicting statements, as to what is and what is not being done in Detroit with regard to both pollution and safety.

In order to satisfy myself of the situation as it actually exists, I had planned to go there this coming week. However, the President called the Environmental Quality Council meeting next week and also an Urban Affairs Council meeting. Therefore, I postponed my trip to Detroit until the following week. I will spend 2 days there looking at what they are doing, and hope to come back with a better understanding of the job they are doing and what we in Government also should be doing to bring this dreadful pollution problem more clearly into focus and solve it more rapidly.

Senator CANNON. I take it you feel we do need more research and development funds in that area?

Secretary VOLPE. Yes, sir.

Senator CANNON. May I say, Congress responded to that. We had another \$45 million appropriated in research and development funds that we lost as of the night before last and yesterday which would, of course, have been able to be diverted into innovative low-pollution vehicles.

I assume you will be coming back to request that or similar money before too long, is that correct?

Secretary VOLPE. With the approval of the agencies of Government that I must check with before I request funds, I would certainly do it.

Senator CANNON. Yesterday the distinguished chairman of the Senate Public Works Committee, Mr. Randolph, introduced for the record a copy of your speech in Massachusetts on Tuesday of this week.

In reviewing that speech, which incidentally was very good, I noted that the Department of Transportation is about to embark on the prototype safety car program.

Now, will that program designate low-emission criteria for the prototype car?

Secretary VOLPE. Yes.

In accordance with the mandate of the Congress the car is to be developed primarily to determine every possible measure and every possible way in which we can make cars that will provide the greatest safety.

However, I believe that while we are doing that, certainly we would be doing less than our duty if we didn't do everything possible to eliminate pollution or bring it down to the very lowest levels.

Senator CANNON. You said in your speech that the prototype would be powered by an engine which could effectively use low-pollution fuels.

Are you going to limit the development to engines using low-pollution fuels, or are you going to merely set emissions criteria in your requested proposal?

Secretary VOLPE. We will be developing two prototypes, Mr. Chairman, and members of the committee. Our hope is that they would be two different types. Then we can determine which of the two will do the better job, both by way of safety and pollution, and develop and build 12 more of the type that we believe will do the best job.

Senator CANNON. Mr. Misch of the Ford Motor Co. testified that he thought Federal research and development funds should be spent on innovative, inherently pollution-free technologies so that the automobile industry could be proved right or wrong.

Do you agree with that proposal?

Secretary VOLPE. I believe that the automobile industry has done a great deal over the years to try to improve safety and reduce pollution.

On the other hand, I am also convinced that whenever the Federal Government has stepped in with some programs to try to get that job done more rapidly, Detroit has responded. It seems that things happen a little faster when we get behind them.

So, it is my hope that the activity and the enthusiasm which I hope we can generate and the R. & D. we do ourselves, will accelerate the total process of developing what both you and I want: a very safe vehicle and one designed either to eliminate all the pollution or to bring it down to a minimum.

Senator CANNON. Will your request for proposals for the prototype safety car specify that low-pollution technology should be utilized, that is, specific technologies, for example?

Secretary VOLPE. I do not have the criteria yet. They are in the final stages of preparation right now. But certainly that will be our aim, Mr. Chairman.

Senator HART (presiding). Mr. Secretary, last fall another subcommittee, Antitrust Subcommittee, had some hearings on automobile repairs, and in connection with that a low-emission hybrid electric internal combustion engine minicar was brought up to the building here. I remember it vividly, because it had a body—I think it was plastic, and they had us hit it with a baseball bat. And the repairs were zero. And heaven knows what they would have been if it had been the car you and I drive.

But the project looked promising in terms of low-emission control, quite aside from the interest that the damage protection suggested. Recently that program was canceled. Are you able to tell us, or could staff tell us, why that minicar program was canceled?

Secretary VOLPE. Senator, let me say that I am a businessman, or I was. I like to get my money's worth whenever I buy something. Considering the amount of money we were spending and the possibility of getting back a sufficient return on our money—we did not believe that further development of that particular vehicle would prove anything that we couldn't get through the program that the chairman and myself were just discussing.

I just didn't want to see duplication here. We have learned something from that product. I don't think it is the kind of vehicle that you and I would particularly care about riding around in.

It did provide some safety factors and also proved that with a hybrid engine at this stage, you couldn't go very far or very fast—I don't mean 80 miles an hour—I mean 10 or 20. I did ride in it, as a matter of fact, out in California. It wasn't San Clemente, but north of San Clemente—and we didn't get very far. And you really had to push it to get up to, I think 10 or 15 miles an hour.

In other words, we canceled it, Senator, because I didn't feel that we were getting our money's worth. And I thought that the money could be better spent on the project which the Congress had already mandated, the 14 vehicles that the Chairman and myself have just been talking about.

Senator HART. Thank you.

Senator CANNON. Senator Baker?

Senator BAKER. Thank you. Mr. Chairman, I want to thank the distinguished Secretary for his statement, and commend the committee for its undertakings in this respect at this time.

I might ask this, Mr. Secretary, if I may. We heard testimony the day before yesterday about unconventional vehicles, and also some very exciting testimony about the undertaking of the General Services Administration in connection with its dual fuel system experiment in California. Does DOT have a similar interest in dual fuel concepts and other unusual fueling concepts, and do you have any plans to have experimental projects or demonstration projects such as Mr. Kunzig is doing with GSA?

Secretary VOLPE. One of the things that your present Secretary of Transportation has a habit of doing is to try to do a lot of reading. Included in that reading I have been doing was some material on the possibility of using natural gas. And several months ago, I sent a little scribbled note, which I am very prone to write, upstairs—and I hope you all understand, we have been here just 1 year—

Senator BAKER. Sometimes it seems much longer.

Secretary VOLPE. Sometimes it seems like 10 years; sometimes like 10 days. But I will say that I didn't select all the people in my Department. This is no excuse for what I am about to say, but it was indicated to me that this held out very little hope. I don't get satisfied very easily, and I sent it back up, and I did receive a more responsive note in which they indicated to me that GSA was working on this, and I told them as far as I was concerned that it ought to be explored fully because, if the steam engine didn't prove out, and the hybrid engine didn't prove out, maybe the natural gas would.

I think we ought to have some insurance policies here. There are those who maintain that the internal combustion engine can be cleaned up, and there are many who say it cannot. It seems to me we ought not to wait to find out whether or not it can be cleaned up. We ought to determine whether the natural gas, the hybrid engine, or the steam car are feasible—whether we will have something else to fill in with. The alternative is to wait 5 or 6 or 8 or 10 years to determine whether you can clean up the internal combustion engine and then start to work to see what we are going to replace it with.

That's not my philosophy. I believe we ought to start to back this up now. We are watching this natural gas experiment very closely, and consistent with the amount of funds we have available—most of the money in this area is over in HEW—we certainly will do everything we can, including furthering the experiment that has been started by GSA.

Senator BAKER. That was the last question I was going to ask you. You have anticipated it already. I would assume, knowing you as I do, you and the Secretary of HEW and Mr. Kunzig, having a high respect for all three of you, there would be a high degree of cooperation and coordination between HEW, DOT, and GSA in this matter of exploring the potentialities of unusual propulsion systems and trying to demonstrate their feasibility.

Secretary VOLPE. Absolutely.

Senator CANNON. Senator Pastore?

Senator PASTORE. First of all, let me say, John, it is nice to have you here. I was rather grateful for this little interlude—that is, waiting for my turn—because it gave me a chance to read your statement.

The thing in your statement which impresses me most of all is where you say that you are going to hand carry to Detroit on the 12th and 13th of February a message, because it is my humble opinion that if this job is ever going to be done, we will have to leave it to the automobile industry in large measure; otherwise, I don't think it is ever going to happen.

As you say, you have got to be a burr, so to speak, to be sure they don't relax and they keep going forward in this effort.

Now, you said here, insofar as the internal combustion engine is concerned, there are two schools of thought. Some think they can clean it up and some think they cannot. And your observation is, don't let us wait. Let's get going and do something about it.

Now, what do you intend to do about it?

Secretary VOLPE. We feel that in the total concept of the Federal Establishment, we ought to be developing the alternative methods to provide engines that will be ready just as quickly as they can be gotten ready—

Senator PASTORE. You don't mean by that that your Department is going to get into the automobile business?

Secretary VOLPE. Absolutely not.

Senator PASTORE. What do you mean by that—you are going to develop an engine?

Secretary VOLPE. HEW, which has the statutory responsibility, has already done, of course, a good deal of research in this field. But there is a great deal more research that needs to be done before we can decide whether a natural gas system, a hybrid engine, or a steam engine, will do the job as an alternative to the internal combustion engine. So, when we have determined specifically that the internal combustion engine cannot do the job, that is, eliminate the pollution as you and I want to eliminate it, there will be an alternative ready, and we will not have to wait another 4 or 5 years until the R. & D. is done.

The automobile industry is also doing some research, a great deal of research, in this field.

Senator PASTORE. I don't follow you. What do you mean, we ought to be ready with another alternative? Do you mean we ought to be ready with another engine?

Secretary VOLPE. Yes.

Senator PASTORE. Who is going to build it?

Secretary VOLPE. Eventually, the automobile industry will have to build that engine.

Secretary PASTORE. Doesn't that bring us to the point at the beginning? Isn't this something that has to be worked out between the Government and the automobile manufacturers of this country if it is ever going to be done?

Secretary VOLPE. As I indicated earlier, Senator, the automobile industry has indicated to me that they are doing a great deal in this field of alternative sources of power for motor vehicles. I'm going out to make certain that what they are doing does not have to be supplemented in any way, or if it has to be supplemented, we will not be duplicating any effort which they are making.

The President has stated to me personally that he does not want to duplicate anything which is already being done. So our efforts would be only supplementary efforts, because we recognize in the final analysis that we could spend 200 million, 500 million, or a billion dollars in this area, where we might spend only \$25 or \$30 million, or \$50 million. And certainly we are not going to be able to compete with what they can do. If we place the little burr there, as I indicated, to make sure it is done—

Senator PASTORE. I am still unclear as to who is going to develop this alternative engine that you are talking about, under your auspices. Who is going to do it? Are you going to give it out by contract?

Secretary VOLPE. Yes.

Senator PASTORE. Are you going to bring engineers in to start from scratch? How are you going to do this? If you give it out to contract, don't you go back to the manufacturers?

Secretary VOLPE. There are those who don't want the automobile manufacturers involved at all in the development of these alternative engines.

Senator PASTORE. Who are these people?

Secretary VOLPE. Ralph Nader is one. There are a few others who feel that maybe the automobile manufacturers might be prejudiced in this situation.

I personally don't believe that. I personally don't feel that the automobile manufacturers are people who are anxious to put pollution into the air. I don't believe they are anxious to put cars on the American roads that are unsafe.

On the other hand, I think I would have to agree that on those occasions where we have really done some pushing and urging, the action has been a little faster. That, I want to accomplish.

Senator PASTORE. Couldn't we do this—couldn't we set up standards that we feel scientifically could be met in order to minimize or to obviate completely pollution from motor vehicles, and then give the automobile industry a certain amount of time to meet those standards if they want to put cars on the market? Why wouldn't that be a good way to get this thing done?

Secretary VOLPE. It would be a good way to do it, Senator, except that you would have to know from a practical point of view—

Senator PASTORE. That is what I am talking about. We would have to make sure they meet these standards.

Secretary VOLPE. Therefore, we have to do some R. & D. to determine that the standard we set is a practical standard.

Senator PASTORE. Does that mean building a motor?

Secretary VOLPE. It means doing enough toward the building of that motor to ensure that we can say to them, "You can meet the standards; you meet them by 1972, 1975, or whatever we feel—"

Senator PASTORE. We did it on automobile safety. Of course, it never occurred to anyone until the Congress of the United States took the initiative on automobile safety, and then, of course, a lot of things they said were hard to do and would be very expensive to do, turned out to be that they were very feasible.

After all, the automobile industry is in the market to make money, and to make sure that their stockholders are happy and that their board of directors are happy, and that they make a profit on their investment. That is the American way.

On the other hand, they are not going to do any of these things unless sometimes they are compelled to do them. That is the function of Government.

I was wondering, from you, what do you think is the right way to approach this? Are we on the right road or aren't we on the right road? The Congress has passed certain laws. Do you approve of these laws we have passed?

Secretary VOLPE. Yes; I do. I think we have to go further, though. I think we have to go further in making certain that we can ask the manufacturers to produce that vehicle, that engine, within a certain time period and meet certain standards for the emission of pollutants.

Senator PASTORE. Would you mind too much at some later date, not too far distant, to render to this committee a little memorandum as to how much further you think we should go?

Secretary VOLPE. I would certainly be happy to.

Senator PASTORE. I would appreciate that.

(The following was subsequently received for the record:)

FUTURE ACTIONS BY THE FEDERAL GOVERNMENT TO REDUCE AUTOMOTIVE AIR POLLUTION

The Federal Government needs to extend its activities in several different ways to reduce automotive air pollution. First, there must be greater assurance that the vehicles being produced now and in the future do in fact meet the established exhaust emission standards. This can be done through a more comprehensive test program that examines representative samples of production model vehicles. Existing legislative authority must be extended to enable the Government to do this.

Second, exhaust emission standards for new vehicles must be progressively made more rigorous. The National Air Pollution Control Administration has the necessary authority.

Third, the composition of gasoline and its associated additives affect the amount of air pollution now being produced and the effectiveness of current and proposed emission control systems. Additional regulatory authority is needed to reduce the contribution of fuels and additives to air pollution. Currently, the authority exists to register additives, but that is not sufficient to allow the Federal

Government to take an active role in this area. For example, it may be necessary to limit the amounts of specific additives and to establish performance specifications to ensure the compatibility of the apparatus that dispenses the fuel with the vehicle that uses it.

Fourth, the existing programs of the Federal Government to examine alternatives to the internal combustion engine must be intensified and focused to develop a commercially acceptable virtually pollution free power plant for automobiles. This action is needed as an insurance policy against the possible failure of the internal combustion engine to meet future exhaust emission standards at acceptable cost. Consideration should be given to ways and methods of bridging the gap between mass production of novel power plants and their development.

Fifth, as part of the effort to accelerate the development by the private sector of improved methods and devices, including novel power plants, to sharply reduce exhaust emissions, the Federal vehicle fleet may provide a market incentive of the general type discussed in these hearings. A premium of 100% above the current statutory limit for passenger vehicles (other than buses) with particularly low exhaust emissions is suggested.

Sixth, the modification of existing vehicles to reduce their exhaust emissions while maintaining their performance needs further examination. At the present time we rely upon attrition of old vehicles with poor emissions and introduction of new vehicles with improved emission controls to reduce automotive air pollution. An effective retrofit program could shorten the time needed to clean up the air.

INFORMATION ON FUEL ADDITIVES

The National Air Pollution Control Administration (NAPCA) of the Department of Health, Education, and Welfare has supported several investigations of the relationship between gasoline additives and automotive air pollution. One such study is being carried out by the Dow Chemical Company under a \$104,000 contract. It is for the identification and evaluation of the products formed by the combustion of gasoline additives, with special emphasis upon lead compounds and particulates.

The Bureau of Mines at Bartlesville, Oklahoma, under an interagency agreement with NAPCA, is examining the gross effects of fuel composition and additives upon automotive exhaust emissions.

Senator CANNON. Senator Spong?

Senator SPONG. Thank you very much, Mr. Chairman.

Mr. Secretary, initially I would like to say I always welcome an opportunity to question you, and before I proceed, I want to say I would much rather the committee on this particular subject have an opportunity to examine the representatives of HEW, rather than the Department of Transportation.

I am delighted that you are here, but, in my judgment, under the existing law, the matters that we are talking about are more their prime responsibility than yours.

Secretary VOLPE. I indicated that in my testimony.

Senator SPONG. But in your testimony you conclude or you say on page 2 that the Department is attempting to reduce air pollution from both public and private vehicles.

How much enforcement do you contemplate the Department of Transportation would be involved in?

Secretary VOLPE. By way of enforcement our powers would be very limited except insofar as we are authorized under the Urban Mass Transportation Act to aid State and local public bodies to purchase vehicles or buses of one type or another designed to reduce pollution.

Under that statute I have authority to say, unless the city of San Francisco, Providence, R.I., or whatever city we might be working

with agrees to buy buses equipped to reduce the pollution almost completely or very substantially, we won't provide a grant. That is really the only enforcement power I have.

Senator SPONG. Is it under that act that the two bus projects you mentioned in your statement that you are proceeding with here in Washington and out in California?

Secretary VOLPE. Yes.

Senator SPONG. What I am concerned about is we are all going to do something about pollution now and everybody is in it and we all want to do something about it, but in every effort that the Government undertakes, whether it be in manpower development, education, mass transit, or many of these things, both here in the Congress among the committees and out at the administrative level among the administration, among the Government agencies, we find this great overlapping of effort.

I am a little hesitant about seeing suddenly two or three Government departments all going into this field pellmell.

Section 104 of title I of the Public Law 1948, the Air Pollution Act itself, provides for research relating to fuels and to vehicles. Do you contemplate down the road any budgetary overlapping between the Department of Transportation and HEW with regard to this area?

Secretary VOLPE. I do not contemplate any such duplication. As a matter of fact, I think you will find that the President's message in this area will clearly delineate where the responsibilities should lie.

Senator SPONG. I hope that will prove true, because I am a little tired of all these efforts and we suddenly find the departments of the Government competing with each other.

In this area as in manpower training and many others where we have examples, I just do not think we are going to get the job done if the departments are in any way in competition and if their duties, responsibilities and the appropriations therefor are not clearly delineated. Thank you very much.

Secretary VOLPE. I just want to mention, if I may, Senator, our work with HEW in a related field, air pollution from airplanes, I am sure you have read of our joint efforts in this field.

In other words, HEW did not go off on one track and DOT on another. Even though we have great responsibilities as far as aircraft are concerned, we worked together to help bring about more rapidly the modification of those jet engines that emit the most smoke. We will continue to cooperate with HEW, GSA, and other agencies that are involved in the air pollution problem.

Senator SPONG. As a plane watcher at National Airport, I look forward to progress in that direction.

Thank you very much.

Senator CANNON. Mr. Secretary, on that part of coordination that Senator Spong just raised, S. 3072 facilitates coordination through the Certification Board. Would you not agree that that should get at this problem of coordination between the different agencies?

Secretary VOLPE. There is no doubt in my mind that whether it is that type of vehicle or the vehicle that the President may suggest, which I cannot describe at this time, some type of vehicle must be uti-

lized that will preclude duplication and identify one agency to take the lead role. If other agencies are to play a part, they would follow the lead of that agency.

Senator CANNON. In your speech you mentioned that your urban mass transit bill would provide for such things as new turbine buses which practically eliminate the sort of air pollution we get today from conventional buses. Are there specific requirements in that bill that research and development funds or procurement funds be directed toward inherently low polluting engine technology?

Secretary VOLPE. There is a requirement which is derived from the existing act.

Senator CANNON. You also referred to the prototype safety car program as one utilizing an interesting systems approach to highway safety. In that systems approach is any consideration being given to the development of a vehicle that can operate in a dual mode system, that can operate in the conventional manner and also on controlled guidance systems that we have been hearing about?

Secretary VOLPE. Not at this point, Mr. Chairman, and I am awaiting the President's message, as I am sure you are, to see exactly where the line of demarcation will be to insure that we will not duplicate in any way work that would be done by HEW or some other agency.

There is no question in my mind that in the development of the vehicle I have been talking about, we would be working very closely with HEW. If we assume for the moment that HEW will be given the lead role here, that will not prevent HEW from asking us to take on this specific program.

Senator CANNON. I must say I have been hearing so much about the President's message that no one knows anything about, I am now having a great expectation about it. It is almost like looking forward to Christmas morning and opening the presents under the Christmas tree.

Senator PASTORE. Another question, Mr. Volpe. As we go higher in octane gasoline, does that add to pollution?

Secretary VOLPE. The lead in the gasoline is the item that causes us the most difficulty. I would prefer to ask Dick Strombotne, who is a technical expert in this field, if he might comment on that.

Mr. STROMBOTNE. As I understand it, the question was whether or not high octane per se has a large effect on air pollution; is that correct?

Senator PASTORE. That is correct.

Mr. STROMBOTNE. Certainly the design of the engine and the requirements for the fuel are very closely tied together so that one affects the other. It would not be quite fair to say that high octane per se was a cause of pollution.

Senator PASTORE. I would not know. That is not my question. Some automobiles use regular gas; other automobiles you have to use high octane.

Now, you put two cars side by side going 40 miles an hour; one using regular gas and the other using octane. Which one pollutes the air more or is it the same?

Mr. STROMBOTNE. It would be very difficult to say, Senator.

Senator PASTORE. Are we making any studies on this?

Mr. STROMBOTNE. Yes. There are many other factors besides the octane of the gasoline and the compression of the engine that affect air pollution.

Senator PASTORE. And we are studying that?

Mr. STROMBOTNE. Yes.

Senator PASTORE. How about all these additives that come over the air in their commercials, that you can start up in the winter or you can do this in the summer and all that sort of thing. Is anyone studying whether or not all these additives add to the pollution in the air?

Mr. STROMBOTNE. That is not being studied within the Department of Transportation, Senator. It may be within HEW.

Senator PASTORE. May be?

Mr. STROMBOTNE. May be. I would not be at all surprised that it is.

Senator PASTORE. On that memorandum you are going to send up, John, would you find out and let us know if they are doing it?

Secretary VOLPE. Yes.

Senator PASTORE. It may be a long time before we come to a satisfactory motor for reasons of economics, technology, and feasibility. But, in the meantime, it strikes me there is a lot of things we can do to cut down this 90 million tons that you are talking about. I mean, after all, these things do come gradually.

Shepard went up for only a short time in space, but if he did not do it, we would have never landed a man on the moon. We do not have to get to the perfect engine before we can do something about polluting the air, and I think there are a lot of elements that can be studied in order that we can diminish it, even if it is only a gradual thing. The fact still remains that we ought to get going.

This concentration on building a new engine, I think that is a wonderful thing, but as I look at that, this is quite away off. I think we are talking about years here and not weeks.

I would hope that in the meantime there are a lot of other elements that could be looked into to see if we cannot minimize it even under existing conditions.

Secretary VOLPE. Senator, if I did not know you as well as I do, I would not say this, but because I know you as well as I do, I would think you had a wiretap to my office. Only this past week I spoke to some of my people upstairs in research and technology, and I said if I were to wait for some of the studies that they want to make it would be about 1980 before we could begin to solve some of the problems.

As far as I am concerned I want to put my finger on some of the solutions now and achieve them while I am still alive and while I am still here. So I agree with you wholeheartedly.

Senator PASTORE. I do not have a wiretap to your office, but I read the gleam in your eyes.

Senator SPONG. Mr. Chairman.

Senator CANNON. Senator Spong.

Senator SPONG. I just want to return briefly to our earlier exchange. You mentioned the airplane pollution, and I was talking in terms of the buses and the automobiles and where the responsibility ultimately is going to be.

In anything you said to me do you contemplate in any way that the

responsibility for enforcement of pollution from moving vehicles is going to be placed in the Department of Transportation?

Secretary VOLPE. I cannot foresee exactly what the line of demarcation will be between our responsibilities and HEW's. It certainly would appear that HEW is the proper agency to develop the standards.

Senator SPONG. I think in the Air Quality Act that the Congress made it clear that HEW was the prime agency for all of this. I suppose what I am asking you is do you foresee some division of responsibility whereby this will be diverted, some of this will be diverted to your Department insofar as moving vehicles is concerned?

Secretary VOLPE. I would hope if that develops, Senator, it will be so clear that there will be no misunderstanding on anybody's part as to which responsibilities are mine and which are HEW's.

Senator SPONG. I certainly hope if it does occur that that will be true, because I am very fearful of something like that.

Thank you.

Senator CANNON. Thank you very much, Mr. Secretary. We appreciate your being here to help us out.

The next witness is Hon. John Francis Foran, chairman, Assembly Transportation Committee, California State Legislature.

STATEMENT OF JOHN FRANCIS FORAN, CHAIRMAN, ASSEMBLY TRANSPORTATION COMMITTEE, CALIFORNIA STATE LEGISLATURE

Mr. FORAN. I am Assemblyman John Foran, chairman of the Assembly Transportation Committee of the California Legislature. I appear here today in support of Senator Warren Magnuson's low-emission vehicle bill, S. 3072.

Because of your time limitations, my prepared testimony will be brief.

In 1968 I authorized the California Pure Air Act, as well as our low-emission vehicle law. This latter law defines a low-emission vehicle as one "which does not have exhaust emissions of more than 0.5 gram per mile of hydrocarbons, 11 grams per mile of carbon monoxide, and 0.75 gram per mile of oxides of nitrogen."

California is required to purchase vehicles of this type in an amount not less than 25 percent of the number of vehicles which the State bought in the previous fiscal year. Our law provides that we can spend up to 100 percent more for these vehicles than was spent for the average State passenger vehicle in the preceding fiscal year. The purpose of this is to provide a financial incentive to potential manufacturers. California purchases about 3,000 vehicles annually.

I will leave a copy of the California low-emission vehicle law with the committee.

When the California law was drafted, automotive experts were of the opinion that many years would elapse before these low-emission vehicles could be made available on even a limited production basis. Fortunately, it appears these experts were unduly pessimistic.

Since that time there has been a public outcry for a smog-free car. In response to this demand California has undertaken a variety of special projects. I would like to briefly describe a few of them.

STEAM CARS

The California Highway Patrol (CHP) has entered into contracts with two steam engine manufacturers. The CHP is expected to have its first steampowered patrol car on the road in mid-1970.

STEAM BUSES

The California Legislature has received a Federal grant for a special steam bus demonstration project. I believe Secretary Volpe alluded to that. We expect to have a steampowered bus carrying commuters sometime next year.

NATURAL GAS

The State has already converted 10 of its fleet cars to natural gas and is in the process of converting another 175.

As you know, California has even considered banning the internal combustion engine. It has become obvious to the automotive industry that it can no longer delay. In response to this pressure the industry has begun to intensify its efforts to reduce vehicle emissions. I think California has played a special role in bringing this about.

On August 2, 1969, I authored an assembly resolution calling upon the recommendations of a blue ribbon technical advisory committee, vehicle emission standards. Pursuant to this mandate and based upon the recommendations of a blue ribbon Technical Advisory Committee, just last week California adopted new-car emission standards for 1975 model automobiles. I will leave a copy of this technical advisory committee's report with you. I will be happy to serve you with the names of the men who appear on this committee.

These new standards are as follows: 0.5 gram per mile of hydrocarbons, 12 grams per mile of carbon monoxide, and 1 gram per mile of oxides of nitrogen. Naturally we will have to receive a waiver from the Health, Education, and Welfare Department in order to put those in effect.

Thus, in late 1974 Californians will be purchasing mass produced vehicles with relatively low emissions. However, the American consumer wants and should have even lower emission vehicles.

I urge this committee to include in S. 3072 a statement of legislative intent establishing a mandate for the Federal administrative board charged with establishing low-emission vehicle standards. This mandate should direct the board to set the low emission vehicle standards at levels which will sufficiently challenge the innovative capabilities of industry.

Industry has demonstrated its ability to reduce vehicle emissions when called upon to do so. The public interest and welfare demand that Government establish the smog-free car as its ultimate objective. Senator Magnuson's bill provides one of the means by which this can be accomplished.

As the largest single buyer of vehicles in the United States the Federal Government is in a unique position to use its vehicle purchasing power to bring about the innovative changes needed to produce the smog-free automobile. You purchase over 60,000 vehicles a year. Needless to say, this purchasing power can be a potent factor in creat-

ing the competitive conditions needed to spur the automobile industry to develop a truly low-emission automobile.

I believe S. 3072 will help to do this and urge your committee to enact it into law quickly.

Thank you.

Senator PASTORE (presiding). I am sorry I did not hear the entire statement, but I followed you very closely on your first few paragraphs.

On this matter of the California Pure Air Act, when you set these standards, was the industry able to meet them?

Mr. FORAN. The standards that we have set apply starting in 1970 and while they have not produced the 1970 cars that differ from the Federal standards, the standards in the California law become progressively tougher as the years go by from 1970 to 1974.

We do include in our standards oxides of nitrogen which you do not include in the Federal Pure Air Act. We start in 1971 with a standard for oxides of nitrogen of 4.0 and become progressively stricter in 1972, 3.0; in 1974, 1.3.

In addition to this, Senator, while you were out of the room I did mention that our technical advisory committee to our resource board has recommended even tougher standards for the year 1975.

Again I recall your questions that you put to the Secretary. We in California believe that we have to set standards as long as we have our technical experts say they are achievable. We will set the standards and then insist that the manufacturers come up with those standards.

Senator PASTORE. My question was this, though, Mr. Foran. In the past—I realize you have set this for the future as well, but has there been any results thus far in the elimination of pollution because of the standards that you set and was the industry able to meet them? That is my question. Or is this something that happened at a later date?

Mr. FORAN. Our standards for 1970 with respect to hydrocarbons carbon monoxide are the same as your standards. So, in answer to that, yes, your standards and our standards are doing something with respect to new cars.

Going on to the future years, our standards will make a substantial reduction in air pollution in California.

Senator PASTORE. And your technicians feel and your researchers feel that the industry can meet them?

Mr. FORAN. Yes. The technical advisory committee that advises our air resources board is composed of some of the most brilliant people in the university system and the scientific field, headed by Ernest Bracque, who is a professor and head of the engineering department at the University of California at Berkeley and is served by other very prominent men in the field.

Senator PASTORE. Did they consider the elements of economics, technology and feasibility?

Mr. FORAN. Yes, they have to do that because in order to apply for a waiver from HEW we have to meet that criteria.

Again I am sure that it will be the subject of argument and debate before the hearing HEW sets up. We will have our experts back here to make their presentations as to why they believe these are technologically feasible and economically achievable.

Senator PASTORE. Mr. Baker?

Senator BAKER. Mr. Chairman, only this, I would like to express the Committee's and the Federal Government's appreciation to the State of California for the work you have done in this field. I remember when I first came to the Senate and first began my service on the Air and Water Pollution Subcommittee of Public Works there was a great debate on whether or not California ought to be permitted to continue to set its own standards to meet its own circumstances and conditions or whether there should be a uniform set of standards for the country which, of course, was preferred by the automobile industry. It would have obviated the necessity for the so-called California package on an automobile. You prevailed and I am convinced now that you should have prevailed. I was convinced then you should. You have been in the vanguard and the forefront in this field.

I was struck with one bit of testimony at the hearings in Los Angeles, I believe in 1967, as being near the heart of the dilemma as far as you were concerned in the Los Angeles basin. At that time we were measuring pollution as parts per million of unburned hydrocarbons instead of grams per mile. We were then talking about the possibility of urging and encouraging—even coercing—the automobile industry into producing a car that might emit only 200 or 180 parts per million of unburned hydrocarbons. It was pointed out to me then at those hearings, and it is part of that hearing record, that this would help, but that you would have to get down someplace in the range of 20 to 40 parts per million of unburned hydrocarbons in order to substantially improve the situation in the Los Angeles basin.

The question that this longwinded preamble is leading up to is this: Are you now convinced almost 3 years since those hearings were conducted in Los Angeles that with the standards for unburned hydrocarbons and carbon monoxide and the oxides of nitrogen that you continue to set in the State of California by reason of the exception given the State under the Federal legislation, are you convinced that you can obtain those objectives and substantially improve the quality of the air in the Los Angeles basin by modifying internal combustion engines?

Mr. FORAN. With the internal combustion engine, with that latter qualification it makes the question a little bit more difficult to answer. Hotchkiss Smith, who is the chairman of our Resource Board, is of the opinion that we can return the quality of air in Los Angeles to 1940 standards by imposing these extremely strict standards. We do feel that we must go into the area of oxides of nitrogen in order to achieve this.

Senator BAKER. If I may interrupt for a minute, as I recall from those hearings there was testimony to the effect that photochemical smog as a result of oxides of nitrogen was really a substantial factor in the unique case of smog that Los Angeles suffers; is that correct?

Mr. FORAN. That is correct. It is hydrocarbons, oxides of nitrogen, and our beautiful California climate, plus the conversion that contributes to the real problem. We feel if the automobile industry could meet the 1975 standards that we are going to recommend and we are going to ask HEW to grant us a waiver on, I think we can return to 1940 quality air in the Los Angeles Basin.

I think we have to use an approach like Senator Magnuson's bill as well as imposing the very strict standards on the automobile, and one other factor that I think we also are involved in in California, while we have not passed specific legislation on it, we do have three proposals before my committee, that will go into the composition of fuel.

Senator BAKER. Mr. Foran, the objectives that you think can be attained according to these standards may or may not be adopted as Federal standards, nationwide standards by this same time. If they are, would you foresee a continuing requirement for a nonpreemption exception in favor of the State of California in this field or do you visualize a time at which the whole country could indeed have the same set of air quality standards or emission standards?

Mr. FORAN. As I see the situation now, I think I would prefer even under those circumstances to see the State of California retain its ability to have an exception. I say that for this reason: the smog situation in California I think is unique among the States. We have 12 million registered vehicles in the State of California. We have more registered vehicles in Los Angeles County alone than the entire State of Illinois. We have a very serious automotive-caused type of air pollution. I think some other States may have some very serious stationary source problems, probably more serious than ours. However, in the automotive field and because California is a State that perhaps grew up on rubber tires, I think we should be allowed to keep that ability to have a waiver unless we were to develop—unless there were to be developed by Detroit or anybody else a totally smog-free car.

Senator BAKER. Thank you very much.

Mr. FORAN. I have this committee report plus the bill, if I could leave it with the committee.

Senator BAKER. The next witness on the agenda is Mr. Robert R. Aronson, president of Electric Fuel Propulsion, Inc., Ferndale, Mich.

Senator HART. Mr. Aronson, I am delighted to be able to get back in time to welcome you. You are a constituent and someone for whom I have had respect in this area for a long time. If you would proceed with your statement.

STATEMENT OF ROBERT R. ARONSON, PRESIDENT, ELECTRIC FUEL PROPULSION, INC.

Mr. ARONSON. Thank you, Senator Hart.

It is a pleasure to be here again, members of the committee, ladies, and gentlemen.

I appreciate the opportunity to appear before the committee today to express the views of my company on the proposed Federal Low Emission Vehicle Procurement Act, S. 3072, which would authorize Federal procurement of low-emission vehicles at a 25-percent premium based on first cost and taking into account savings in operating costs of these vehicles.

This is the second time I have had the opportunity to present our viewpoint to the Committee on Commerce—the first time being on the occasion of the joint hearings on S. 451 and S. 453, which would have

authorized Federal funds for research, development, and demonstration of electrically powered vehicles. We had been asked by this committee to display our electric car in the Senate garage, along with a number of other electric car prototypes built by others. I don't remember the exact number of vehicles which were displayed at that time—March 1967—but I do distinctly remember that our MARS II electric car was the only vehicle driven to the hearings—driven at highway speeds over interstate highways and turnpikes from Detroit to Washington, D.C., a distance of 756 miles.

I didn't drive an electric down this time, but am happy to say that there are a number of MARS II electric cars in daily operation in this general area as you will note from the list of customers attached to this statement. Forty-four electric vehicles have been produced and sold since then—42 of them highway passenger cars, one a delivery van, and one a multipurpose electric vehicle chassis.

The second production vehicle we manufactured—produced in September 1967—was driven from Detroit to Phoenix, Ariz., a distance of 2,226 miles. It used 1,074 kw.h. of energy at a cost of only \$27.17. An account of this trip can be found in the hearings on "New Technologies and Concentration," (pt. 6) before the Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary of the U.S. Senate in September and October of 1967.

While we were disappointed at the outcome of S. 451 and S. 453, we are now very encouraged at the prospect of S. 3072 being enacted. The passing of this bill would greatly enhance the possibilities of our obtaining sufficient financial support to enable us to produce the volume of vehicles called for. These vehicles, as you will see from the slides I am about to show you, would be built from the ground up and could take many forms in size and shape—from passenger cars to vans to buses.

On the first series of slides you will see what we call a "multipurpose electric vehicle chassis" and various applications of this unit. This is our basic building block—a foundation for what can become a delivery van, passenger car, taxi, or small bus. It is equipped with a sealed, tripolar, lead-cobalt battery like the one I am holding in my hand, a solid state controller, a miniature electronic fast charger, and a series-wound direct current motor. Top speed of this vehicle is 70 mph. Equipped with an aerodynamically designed passenger car body, its maximum range at fixed throttle would be 150 miles at 40 mph. But perhaps the most interesting feature of this vehicle is that it can be recharged to 80 percent of capacity in 45 minutes, utilizing the vehicle's on-board, miniature fast charger. This feature makes it possible for an electric fuel propulsion electric vehicle to travel 600 to 800 miles a day, an unheard of feat several years ago. As a matter of fact, fast charge stations have been set up between Detroit and Chicago at Holiday Inns located at Jackson, Mich., Kalamazoo, Mich., Michigan City, Ind., and Chicago; and in the near future several of our vehicles will be making daily, 600-mile round trips between these two cities.

The second series of slides will illustrate the evolution of a passenger car. Then you will see a typical charging station that might, in the future, be found at any Holiday Inn in the country.

(Showing of slides.)

This is what we call a multipurpose electric vehicle chassis. You see behind the driver a number of these energy cells as I have here on the table. In the front, just ahead of the driver, is the electronic solid state controller which provides for smooth stepless acceleration.

At the head of the solid state controller is the miniature fast charger which as you can see is carried as onboard equipment and makes it possible for the vehicle's batteries to be recharged at 80 percent of capacity in 45 minutes without damage or deterioration to the cells.

This is our basic building block and by rearranging the components you see here in different ways we can make out of this chassis a passenger car, taxi, a small bus or a van or even a pickup truck.

The platform on which the driver is seated and on which the battery cells are resting is an aluminum honeycomb platform which is very light weight, but very rigid and strong. We borrowed from the aircraft industry here. This platform can be lengthened and widened or made more narrow or shorter to accommodate the particular type of vehicle that we are talking about.

So this is truly a multipurpose unit. As I mentioned, it has a top speed of 70 miles an hour and a cruising range of 150 miles at 40 miles an hour.

You might wonder what the range would be at other speeds. Our latest tests on these batteries indicate that at a speed of 55 miles an hour at fixed throttle on a level road the range would be 137 miles.

Now in stop and go traffic in a city, depending on the terrain and the number of starts and stops per mile, the range could be, of course, cut down perhaps to 60 or 70 or 80 miles depending on the conditions.

However, one of the important things to remember is that these battery cells or energy cells are capable of being recharged very rapidly without damage, so that should a delivery van, let's say, travel, oh, let's say 4 or 5 hours of real hard stop-and-go city driving and find the state of charge of the batteries low at noontime, while having lunch the batteries could be then fully recharged and from that point the van could repeat the same thing in the afternoon.

This is the same vehicle with the closeup of the front part of it. You can see the solid state controller a little better there and the miniature fast charger. That picture was taken in Central Park a few weeks ago. The man in the middle is Commissioner Austin Heller, who is the Air Resource Board Commissioner of New York City. He is very interested in electric vehicles.

This is a Fiberglas van body which can be installed on that very chassis that you just saw. So, this is one application of the chassis.

Here are some more of these electric delivery vans in our plant in Ferndale, Mich.

This is a rendering of the multipurpose chassis which could be made into a pickup truck. By putting a cab on the front of it, we could then put a pickup truck body or any other type of commercial body behind the cab.

Here is an application, a rendering, of a taxicab which could be built on the chassis—or a utility truck or a postal van. We are informally working with the U.S. Post Office on the development of a multistop van that would be capable of stopping and starting about 400 times a day over an 8-hour period.

Here we have some bus applications and a rail application. The bus at the top is a 17-passenger bus built the same way with the honeycomb platform widened and lengthened slightly.

This is a module type of construction. The front section where the driver is sitting is identical to the rear section; notice the door in the rear. The two sections over the wheels are identical, and then the two sections between the wheels are identical, so that by adding sections we could make this a 21-passenger or a 26-passenger bus very easily.

This is the evolution of a passenger car, starting with the concept of the car, an artist's rendering. The blue vehicle has a 118-inch wheel base and would seat four passengers or six passengers quite comfortably.

The salmon colored vehicle is a compact version of the first, with the trunklift ending at the rear door of the first vehicle. Notice the way the trunk opens allowing a tremendous amount of space for luggage or cargo.

These small batteries you see—they are only $7\frac{1}{4}$ inches high—would be fitted under the seats and below the floor of the trunk and below the floor in front of the car as well. So actually, if you opened up the trunk and the hood lid and all four doors, you wouldn't see a battery anywhere.

This is the second step in the evolution of this passenger car, which is a fifth scale clay model. You notice to the right of the model is a mirror, and you see a mirror image of the vehicle.

This is the fifth scale model again in fiberglass taken from the clay to give us an idea of the proportions of the vehicle and to allow us to make any changes at that time before scaling it up.

Then comes the building of the chassis. Here you can get a pretty good view of the honeycomb platform which is encased by a steel perimeter all the way around which is partially hollow to accommodate electrical cables, hydraulic and pneumatic cables and other hardware.

Notice the safety cage with two rollbars. This is being designed to be a supersafe vehicle.

Independent four-wheel suspension, heavy duty disc brakes and very low center of gravity.

On the right is the body shell of this vehicle. This isn't the complete vehicle on the chassis. It is what we call a pushmobile, but it is a full-size vehicle.

The car on the left is the MARS II of which we have made 42 vehicles and have them operating, oh, in 20 or 30 States around the country, also in Sweden, Puerto Rico, and Canada. It was a converted Renault. After making 42 converted Renaults, we learned what we needed to learn. We were really testing a propulsion system. We got a lot of feedback, and we were then able to incorporate this knowledge into the design and building of the vehicle on the right.

We haven't named that vehicle yet, so at the present time we just call it MARS II-A. It is a code name.

There is another shot of MARS II-A, with the MARS II in the background. This is a full-size passenger car, as you can see. The trunk lid hinges at the top at the roof line above the back window so that

when it is opened it is horizontal and on the same line with the roof, affording to very large trunk area. It is almost a station wagon concept.

Again this vehicle will travel 70 miles an hour. We could gear it up by simply changing the gear ratio. Then, we could easily obtain speeds for the vehicle of 85 miles an hour or more. But we think that 70 is enough, and, of course, there is a tradeoff. The faster it goes, why, the shorter the range. So we think 70 is sufficient. It will have good passing ability to accelerate at speeds of 40 and 50 miles an hour up to 70.

This is a shot of our propulsion system laboratory at Cornell University. We have two such laboratories; one in our plant at Detroit and the other at Cornell University in Ithaca, N.Y.

This is another shot of some electronic equipment we are building there.

Now for charging stations we have, as I mentioned earlier, four charging stations set up at Holiday Inns. The first in Jackson, Mich., the second at Kalamazoo, Mich., the third in Michigan City, Ind., and the fourth in Chicago, right in town.

We expect to be setting up more charging stations. As a matter of fact, by August of this year we should have charging stations at Holiday Inns from coast to coast to accommodate the various vehicles to be raced across the country in August; vehicles by Caltech and MIT. Cornell will enter a vehicle and several other colleges and universities will enter vehicles. So we are setting up charging stations to accommodate these vehicles so they can travel from Cambridge, Mass., to Pasadena, Calif., via interstate highways and turnpikes and freeways charging at Holiday Inns. They will be permanent charging stations. They won't be temporary setups as we had 2 years ago in the great electric car race at substations provided by utility companies. These will be permanent stations at Holiday Inns, which will make it possible, for example, for someone to buy a passenger car from us in Detroit and drive it to Los Angeles.

This is what a charging station looks like. It is very simple, a 200-amp 3-phase switchbox, providing charging at rates up to 50 kilowatts, and a female receptacle for plugging into. By plugging into this, you can recharge these batteries to 80 percent of capacity in 45 minutes. This is how it is done. This is perhaps a crude way to do it.

Senator LONG. May I interrupt you for a question?

It occurs to me that the average fellow driving across the countryside might not want to stop 45 minutes. He might want to pull in and have a Coca-Cola and charge up for about 15 minutes and take off from there. Is that practical?

Mr. ARONSON. Yes, that is possible.

When you say charging for 45 minutes to 80 percent of capacity, we could compare that with getting 80 percent of a 20-gallon tank of gas, let's say, which is 16 gallons. When you go into a gas station, you don't have to buy 16 gallons, you can buy 8 gallons or 4 gallons. It is the same thing here. You don't have to charge 45 minutes. You can charge 10 minutes, if you want.

Senator LONG. How would your cost of electric fuel compare to the cost of gasoline on a vehicle-mile basis or a ton-mile basis?

Mr. ARONSON. Over a period of 3 years our calculations and those of, oh, dozens and dozens of electric utility companies around the country have indicated a cost of a little less than 1 cent per mile based on the national average of 2 cents per kilowatt-hour. Some of the utilities sell energy at 1 cent per kilowatt-hour.

An example of that is the Pennsylvania Power & Light Co. in Allentown. So, cars being charged in that area, then, could operate at less than one-half cent a mile for electricity.

Here we see again the MARS II-A, the little Fiberglas van in the background and the MARS II.

We expect to have three of these vehicles, one each of each type, running between Chicago and Detroit, making 600-mile roundtrips per day.

Senator LONG. Thank you very much.

I believe we allotted you 10 minutes, and we will try to keep the schedule. If you haven't concluded, I think you ought to summarize your statement.

Mr. ARONSON. Thank you.

Senator LONG. Thank you, Mr. Aronson.

(The attachment to the statement follows:)

COMPANIES PURCHASING MARS II ELECTRIC CARS

Arizona

Arizona Public Service, Post Office Box 2591, Phoenix, Ariz. 85002.

Arkansas

Arkansas Power & Light Co., Post Office Box 6869, Pine Bluff, Ark. 71601.

California

Department of Water and Power, City of Los Angeles, 111 North Hope Street, Los Angeles, Calif. 90054.

San Diego Gas & Electric, Post Office Box 1831, San Diego, California 92112.

Canada

Calgary Power Ltd., Box 1900, Calgary 2, Alberta, Canada.

Colorado

Public Service Co. of Colorado, 550 15th Street, Denver, Colo. 80201.

Delaware

Delmarva Power & Light Co., 630 West Front Street, Wilmington, Del. 19899.

Hawaii

Hawaiian Electric Co., Inc., Box 2750, Honolulu, Hawaii 96803.

Illinois

Central Illinois Light Co., 300 Liberty Street, Peoria, Ill. 61602.

Central Illinois Public Service, 607 E. Adams, Springfield, Ill. 62701.

Indiana

Public Service Co. of Indiana, 1000 East Main Street, Plainfield, Ind. 46168.

Iowa

Iowa Southern Utilities, 300 Sheridan Avenue, Centerville, Iowa 52544.

Kansas

Kansas Power & Light Co., 818 Kansas Avenue, Topeka, Kans. 66603.

Massachusetts

New England Electric Service, 441 Stuart Street, Boston, Mass. 02116.

Michigan

General Motors Engineering Staff, General Motors Technical Center, Warren, Mich. 48090.
Mr. D. S. Gilmore, 1219 Short Road, Kalamazoo, Mich. 49001.

Missouri

Eagle Picher Industries Inc., Post Office Box 47, Joplin, Mo. 64801.

New Jersey

Atlantic City Electric Co., 1600 Pacific Avenue, Atlantic City, N.J. 08404.
Public Service Electric & Gas Co., 80 Park Place, Newark, N.J. 07101.

New York

Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York, N.Y. 10003.
Long Island Lighting Co., 175 East Old Country Road, Hicksville, N.Y. 11801.

North Carolina

Duke Power Co. (Mill-Power Supply Co.), P.O. Box 1339, Charlotte, N.C. 28201.

Ohio

Ohio Edison Co., 47 North Main Street, Akron, Ohio 44308.
Albert W. Hartman, Hartman Electrical Manufacturing Co., Mansfield, Ohio 44907.

Oregon

Eugene Water & Electric Board, 500 East 4th Avenue, Eugene, Oreg. 97401.

Pennsylvania

Pennsylvania Power & Light Co., 901 Hamilton Street, Allentown, Pa. 18101.
Philadelphia Electric Co., 1000 Chestnut Street, Philadelphia, Pa. 19105.

Puerto Rico

Puerto Rico Water Resources Authority, San Juan, P.R. 00936.

Sweden

Swedish State Power Board, Fack Vallingby 1, Stockholm, Sweden.

Texas

Texas Power & Light Co., Fidelity Union Life Building, Post Office Box 6331, Dallas, Tex. 75222.

West Virginia

Monongahela Power Co., 1310 Fairmont Avenue, Fairmont, W. Va. 26555.

Wisconsin

Wisconsin Electric Power Co., 231 West Michigan Street, Milwaukee, Wis. 53201.

Wisconsin Power & Light Co., Post Office Box 192, Madison, Wis. 53701.

Senator LONG. Mr. Victor Wouk, director of electronics research, Gulton Industries.

STATEMENT OF DR. VICTOR WOUK, DIRECTOR OF ELECTRONICS RESEARCH, GULTON INDUSTRIES, INC., NEW YORK, N.Y.

Dr. WOUK. Thank you, Mr. Long.

I am Victor Wouk, director of electronics research of Gulton Industries, Inc., a manufacturer of nickel-cadmium batteries and high-powered, sophisticated electronic equipment, among many other electronics oriented devices.

We do not manufacture automobiles of any type.

I appreciate the opportunity to testify before this committee, as I believe the bill under discussion should be passed. I wish to present the facts that make a hybrid electric vehicle worthy of serious con-

sideration for application today, with no new technology needed, to meet the present emission and cost level specifications of the bill.

I will not burden this hearing and members of the committee with verbal repetition of material well known to you from either previous testimony at this or other hearings, hearings on the subject of air pollution from motor vehicles or the reduction of emissions therefrom. Further, much technical detail is omitted from my verbal presentation, but is incorporated in the extended testimony submitted herewith for the record.

I will try to avoid repeating some of the items discussed previously, and, therefore, I will take only the highlights; so there may be questions after my testimony.

The type of vehicle to be discussed in detail is called the "Hybrid-Electric," in which electric power drives the vehicle through an electric motor. Batteries are used for the main electric power, and a small engine generator set is on the vehicle to recharge the battery as is necessary. This was referred to in yesterday's testimony by Dr. Gouse, and was referred to earlier this morning by Secretary Volpe.

The factors that enable the air pollution level to be so low in the electric-hybrid are, first, when the vehicle is operating on batteries alone, there are no vehicle emissions. An electric vehicle is a "no-emission" vehicle, rather than a "low-emission" vehicle.

Second, when the engine generator set on the vehicle is operating, it operates essentially at only one level, namely, maximum power, and optimum tuning, so that the emissions are at the lowest level possible, consistent with the required vehicle performance.

Therefore, the total pollution includes the average over that length of time when there is zero pollution, and that length of time when the pollution level is low to begin with. The average emission per mile will, therefore, be well within the low levels established for this bill.

I repeat, I am talking about something that can be done today. And we will discuss a demonstration vehicle which is downstairs, later on.

A summary of what we can expect in cost and performance can be reasonably estimated. Costs are projected no further than 2 years, since experience shows that technological advances in many production techniques make cost estimates obsolete rapidly.

Also, it is assumed in these cost estimates that production will be in the tens of thousands of vehicles per year, eventually, first with the price premium which will be allowed by this bill with most of the vehicles going for governmental use, and then, as costs come down, the vehicle being more widely used.

The cost estimates are essentially the following:

A full-size car, with full performance, would cost about 50 percent more than that of a standard "Detroit car," with a pollution level about 25 percent of that car. If we want to have the same price, the vehicle would then be a compact car, but all other performance identical—range, acceleration, speed, accessories—with a pollution level of about 15 percent that of the present day.

Now, I have answered two of the questions which could, in principle, be asked about this bill. The first question is, Can a vehicle be built today, with today's technology, that would meet the emission requirements of the bill? And the answer is "Yes."

There is a second question that can be asked: Can the price specifications be met? And the answer is "Yes."

There is a third question, which is quite important: What about the future of such vehicles? Can substantial reductions in emissions be anticipated as technologies improve, or can the hybrid-electric evolve from the "low-emission" vehicle which this bill calls for at present to the "no-emission" vehicle which we all hope will be available in the future? The answer to this question is also "Yes." One can look to a steady decrease in pollution level so that by the turn of the century the emission level may be close to zero percent from the vehicle.

What can we look for in the timetable that is reasonable? If we consider the emission level of the 1970 car as one, and if these low-emission hybrid-electrics are put into production and are available in the showroom by 1975 in large quantities—and they can be built and available to Government agencies long before that—then in 1975, the emission level of all new vehicles could be 25 percent that of the present levels.

As batteries improve, we can look forward to something in 1985 of less than 15 percent of the present emission levels. By the year 1995 we could be down to 5 percent of the emission levels, and hopefully, at the turn of the century, the year 2000, we would have a "no-emission" vehicle.

If a hybrid-electric has been discussed in the past, why are there no hybrid-electric vehicles being built in quantities presently? The question is one of initial cost. Since the average car owner will not pay a noticeably high initial cost for a low-emission vehicle, Government action, such as proposed in this bill, will encourage development of a practical, low-emission electric hybrid.

I would just like to backtrack one little bit and pose the question as to why the all-electric car is not feasible today. The answer is that gasoline represents a source of energy approximately 100 times as dense as the best reasonably priced battery available today. Gasoline has approximately 1,000 watt-hours per pound. Lead acid and nickel-cadmium batteries have approximately 10 watt-hours per pound. Gasoline is 100 times as energetic as electricity in its present forms. A factor of one or two one way or the other does not vitiate my argument.

This means if one can go 300 miles at 60 miles an hour on a tankful of gasoline, one can only go 3 miles at 60 miles an hour on a "tankful of batteries," if the vehicle is to be identical to the present commercially built model in all respects—weight, comfort, accessories, top speed, acceleration, et cetera.

However, all is not bleak. There are batteries in the laboratory that have promise of 100 watt-hours per pound, which would make an urban use type of vehicle, automobile, truck or bus, practical. Competent electrochemists indicate that in theory batteries of many hundreds of watt-hours per pound can be developed. It is a matter of engineering ingenuity and sufficient work.

If this is so, why do we not have higher-energy batteries at present? I think that on reflection one can realize what the answer is. For over a century now, the electric storage battery has been essentially a device which sits around doing nothing for a long period of time, and then is called upon suddenly to do a lot of energetic work, such as starting the engine of an internal combustion engine vehicle. Then there is plenty

of time for the battery to recharge. This has been the philosophy for over a century.

Now, we are calling on a battery to do something that is just the reverse. We want a battery to be very active for a long period of time, and then sit around for a few minutes at the most, if we are going to have something convenient, and be recharged. This is a new concept, a new requirement, a new philosophy. And this is why work has been done on this comparatively recently.

Now, Secretary Volpe referred earlier this morning to a hybrid-electric vehicle which was a mini-car. The reason why this hybrid-electric vehicle was a mini-car is that the vehicle employed lead acid batteries, or minor variations, thereon. Lead acid batteries cannot provide very much power, and power is what is required for acceleration. And, as Secretary Volpe mentioned, high acceleration is desired by the American public in their cars, and may also be mandatory. Lead acid batteries have approximately 30 watts per pound, if the batteries are to last a long time. On the other hand, nickel-cadmium batteries can be built with almost 300 watts per pound.

That means the following: In order to have, let us say, 200 horsepower for rapid acceleration, one would need approximately 5,000 pounds of lead acid batteries. On the other hand, one needs only 600 pounds of nickel-cadmium batteries to accelerate a full size, full weight vehicle. We have built a vehicle employing these principles. It is full size, has excellent acceleration, and top speed. The vehicle I refer to is outside this Senate building. It is available to any or all members of this committee for demonstration rides, if you so desire. It is not a mini-car. It is almost a maxi-car. Although this vehicle performs very satisfactorily, it is not meant to be an operational device, but rather a test bed, to prove the point of possible performance of an all-electric, or of the intermediate solution to the air pollution problem—the hybrid-electric.

All of the auxiliaries currently associated with this type of car, desired by the American public, could now be incorporated into the vehicle. These include airconditioning, power steering, power brakes, et cetera. As a matter of fact, some of the auxiliaries will perform in a superior manner because they would now be electrically driven from a fixed voltage source, rather than mechanically driven from a variable speed internal combustion engine.

The vehicle and the concept could be adapted to any type of low-emission combustion engine, whether it be a turbine, a gas turbine, whether it be natural gas, whether it be a cleaned-up internal combustion engine—the hybrid concept takes any low-emission device and reduces that low emission to an even lower emission, because the engine is never called upon to provide the peak power necessary for acceleration and climbing hills. The vehicle can be driven from the batteries because of the high power density available from the batteries for hill climbing, rapid acceleration, and the engine itself operates either not at all, or at constant speed, constant load, and therefore, the lowest possible emission from the vehicle.

Heating for the vehicle could be electric. Starting in cold weather—absolutely no problem. What about the cost? The initial cost is impos-

sible to determine exactly at present, because the only vehicles that are available are experimental vehicles. However, if one wishes to have overall costs, over the life of the vehicle, assuming a 5-year life, of 125 percent of that of the equivalent present-day internal combustion vehicle, one can take an initial price of 150 percent of that of the equivalent internal combustion engine vehicle, because of the savings in maintenance and fuel.

Rather than go into the details here, I refer you to the written testimony. But we can show that over the course of 5 years, \$1,000 of a \$4,000 vehicle could be saved. So that means if an initial vehicle, with air conditioning, power brakes, power steering, the works, costs \$4,000, this bill would allow a total cost of \$1,000 more over the period of 5 years. If we have an initial price increment of \$2,000, then, if we save \$1,000 over 5 years, we have met the requirements of the bill.

It is quite feasible to do this, because fuel costs will be cut in about half, and maintenance will be cut in about half. So that the \$1,000 will be readily saved.

This is a conservative figure. What about the future? As I indicated previously, the major problem of the electric vehicle at present is the battery. It does not have enough stored energy in the form of energy density, watt-hours per pound. When the battery goes to 100 watt-hours per pound, then we will have less gasoline in the tank to begin with, and more battery energy. When batteries are improved to 200 watt-hours per pound, we will require even less gasoline in the tank, and when we finally get to 500 watt-hours per pound, the all-electric vehicle, the no-pollution, or no-emission vehicle will be able to perform virtually every function without high-speed recharge, except possibly long, long trips of many, many hundreds of miles. Under those circumstances, there may be enforced rests of several minutes, or possibly the initial batteries that will be developed will have less power density, but more energy density, and other techniques can be employed to insure that the batteries will be available at all times for full performance.

Thank you.

Senator LONG. Thank you very much. I have some questions I am going to submit, and ask you to provide written answers for them.

Let me ask you about your cost estimates. With regard to the cost of operating a gasoline engine, in other words, the cost of operating a filling station and providing the gas at the filling station I think works out to about 6 cents a gallon, and the tax on the product is about 10 cents a gallon—some say as much as 13 cents, Federal plus State. So that about 19 cents of that cost of a gallon of gasoline is represented by cost of operating the filling station plus the taxes.

Do those cost estimates to which you are making reference here include the same factor, that is, the cost of building the highways, in effect, as well as the cost of operation of the filling stations?

Dr. WOUK. What I was referring to, Mr. Long, was the utilization of fuel itself. A properly designed hybrid-electric has been estimated to require on the average half as much gasoline per mile for the same vehicular performance as we have today in a straightforward internal combustion engine vehicle. Does that answer your question?

Senator LONG. So if you are operating on gasoline, it would take half as much?

Dr. Wouk (continuing). Gasoline per mile.

Senator LONG. The hybrid-electric would use half as much gasoline per mile as the present internal combustion engine would use? Where would you get your additional power from? Would you be getting that, then, from an electric power source while the vehicle is standing still recharging the battery?

Dr. Wouk. Overnight the batteries could be charged at a slow rate if desired, but what I did not emphasize in the presentation verbally, but it is in the text, is that the nickel-cadmium batteries can be recharged very rapidly, and discharged very rapidly. These nickel-cadmium batteries that you will see in the vehicle downstairs can be recharged in as short as 5 minutes, not 25 minutes, or 45 minutes. Five minutes. That means that if the batteries were fully charged in the morning, and the vehicle was started up on the batteries and the batteries were then substantially depleted, the excess power available from the internal combustion engine, which is now operating at a very low pollution level, that excess power could recharge the batteries very rapidly, as well as drive the vehicle along. When the batteries have been recharged, the internal combustion engine could be cut off completely.

So, the power will be developed either alternately by the batteries alone, or in combination with the internal combustion engine. The energy to drive the vehicle, most of it in the beginning will come from the fuel in the gas tank. This fuel can be anything. It can be diesel fuel if we have a diesel engine aboard, it can be kerosene if we have a gas turbine. In addition to the fact that the concept is readily adaptable to the existing technologies, I would like to make a point that this approach causes the absolute minimum disturbance to our existing petroleum industry with regard to the distribution of gasoline, and to the automobile industry—because internal combustion engines will still have to be built for the convenience of the automobile driver, because he will still go into the station, the service station, and say “fill ‘er up.”

We are all looking forward to the time when he will be going into the service station and saying “charge her up.” And this vehicle is a transitional vehicle, with virtually no impact on any of the existing industries, no unfavorable impact. This will give the entire economy time, or I might say breathing space, in which to accommodate from the internal combustion engine to the all-electric.

Senator LONG. How do you achieve a greater efficiency of the use of your fuel? I don't understand, logically, how you do it? It seems to me as though you are going to have some loss when you turn an internal combustion engine over, and then you use that to manufacture electricity, and then you use the electricity to drive the shaft. It seems that you would have some loss of power in that intermediate step, compared to what it is when you simply connect the internal combustion engine up directly to a drive shaft.

Do you, by running an engine at constant speed, achieve a sufficiently greater economy so that you can turn the power into electricity

and then put the electricity back into power and gain efficiency in doing that?

Dr. WOUK. Mr. Long, the answer to the latter part of the question is "Yes." But before I go into details, I would like to include an earlier part of your question. You said the internal combustion engine is directly connected to wheels. This isn't quite so, sir. We have, between the engine and the wheels, a clutch and gears. And there are losses in both—substantial losses. The reason for the clutch and the gears is that the internal combustion engine does not like to operate over a wide range of speeds. When it is forced to operate over a wide range of speeds and wide range of loads, the specific fuel consumption varies markedly. At low speeds, the specific fuel consumption is extremely low, and the specific emissions are high. At very high speeds, the specific fuel consumptions are high. The minimum fuel consumption is in a comparatively narrow range of speed.

In our operation, in our design, the engine is always operating under that particular efficient range of speed, and indeed, the fuel consumption per mile is substantially lower.

Senator LONG. In your calculations here, have you taken into account the air pollution that results from electric powerplants that generate power?

Dr. WOUK. Yes, sir.

Senator LONG. And, of course, those do create some pollution themselves?

Dr. WOUK. Yes, sir. I was very careful to say, or I tried to be careful to say, both in the verbal presentation and in the written text, nobody can challenge the fact that in the all-electric there are no emissions from the vehicle, and that in the hybrid the average emissions from the vehicle are lower.

Yesterday, or possibly it was early this morning, someone mentioned—I remember, it was yesterday—it was Senator Muskie—who referred to the fact that some of the vehicles may not be noxious, but they are obnoxious. Certainly this technique reduces the obnoxious level as well as the noxious level. However, with respect to the electricity generation, sir, it is much easier when one considers the overall technical culture, it is much easier to utilize the fossil fuel efficiently at a central station, and to control the emissions at a central station, than it is to control the emissions from a large number of vehicles and the fuel efficiency from a large number of vehicles.

Senator LONG. Thank you very much.

Senator RANDOLPH (presiding). Doctor, there will be written questions that will be forwarded to you so that the answers may be supplied for the record. Is that agreeable?

Dr. WOUK. Certainly.

Senator RANDOLPH. Thank you very much.

(The full statement follows:)

STATEMENT OF DR. VICTOR WOUK, DIRECTOR, ELECTRONICS RESEARCH, GULTON INDUSTRIES, INC.

INTRODUCTION AND SUMMARY OF TECHNICAL AND COMMERCIAL FEASIBILITY

There is no question in any reasonable person's mind as to whether a low emission vehicle is desirable. The air pollution problem, recognized as a nation-

wide threat to the health of Americans, has as a major contribution the emissions from present day automobiles. Therefore, legislation and/or technology that will promote the development of low emission vehicles is highly desirable.

Subject Bill should be enacted, because the three questions that can properly be raised with respect to the Bill can all be answered affirmatively for this legislation. These three questions are the following:

1. Can a vehicle with low emissions be built, with present day technology, which will have the performance of a conventional high polluting vehicle?

Answer: "Yes,"—I will indicate the reasons later on in this testimony.

2. The second question is, "Can the cost be kept within the 125% specification of the Bill?"

Answer: "Yes, when one takes into consideration not only initial vehicle cost, but maintenance costs and operating costs."

3. The third question is, "What about the future of such vehicles; can further substantial reductions in emissions be anticipated as technologies improve?"

Answer: "Yes. One can look to a steady decrease in pollution level, so that by the turn of the century the emission level may be close to zero percent from the vehicle."

The type of vehicle to be discussed in detail is the so-called, "Hybrid-Electric", in which electric power drives the vehicle through an electric motor; batteries are used for the main electric power, and a small engine-generator-set is on the vehicle to recharge the battery as it tends to run down during operation.

The factor that enables the air pollution level to be so low is that when the vehicle is operating on batteries alone, there are no vehicle emissions.

When the engine-generator-set is operating, it operates at only one level, namely maximum power, and optimum tuning, so that the emissions are at the lowest level possible.

Therefore, the average pollution includes the average over that length of time when there is zero pollution, and that length of time when the pollution level is low to begin with. The average of emission per mile will therefore be well within the low levels established.

A summary of what we can expect in costs and performance is shown below. Costs are projected no further than 2 years, since experience shows that technological advances and many production techniques make cost estimates obsolete rapidly.

Type car or year	Cost, standard Detroit car=1	Emission (pollution) level, Detroit car=1
Full-size car.....	1.5	0.25
Compact car.....	1.0	.15
1970.....		1
1975.....		.25
1985.....		.15
1995.....		.05
2000.....		0

HYBRID-ELECTRIC DETAILS

As you know, the concept of the hybrid-electric is not new. It has been discussed in the past by many engineers and scientists, and scores of papers have been written on the subject. See, Wouk (1) and Hoffman (2), footnotes below.

Since such extensive literature exists, why are there not vehicles being built at present in the hybrid design? As pointed out (1), the question is one of initial cost. Before the question of costs is discussed in detail, it is best to compare the basic concepts of a conventional automobile and an all-electric to the hybrid.

To review briefly, Fig. 1 shows the basic operation of a vehicle employing internal combustion engines.

Wouk (1) "Electric or Nuclear Power for Automobiles?" American Association for Advancement of Science, December 28, 1968.

Hoffman (2) "Hybrid Power Systems for Vehicles", Symposium on "Power Systems for Electric Vehicles," April, 1967, Public Health Service Publication # 999-AP-37, pp. 27-42.

The gasoline tank serves as the storage of the energy, in the form of chemical energy which will drive the vehicle.

The internal combustion engine converts the potential chemical energy into mechanical power. Unfortunately, for clean air, the internal combustion engine is inherently a very high emission device, and the problems of reducing the emissions have plagued the automobile industry and, to many people, seem nigh-on insurmountable. Hence the enormous pressure for alternatives to the internal combustion engine, for a vehicle with substantially reduced emissions.

The clutch is mandatory because of the fact that the internal combustion engine (except for extremely minor applications not relevant to vehicles such as automobiles), cannot be started under load. Therefore, the engine must be removed at start from the driving wheels, somehow or other, originally there having been a mechanical clutch, and today the fluid clutch being popular.

The gears are mandatory because the internal combustion engine will not operate properly (except, again, for the very limited, non-relevant conditions) over very wide ranges of speed and load, and therefore, on Fig. 1, the "speed control" is indicated as consisting of the gears, the clutch, and, to some degree the internal combustion engine.

This latter we know is the major "speed control", because the accelerator is used to make the engine turn over faster or slower, and the proper gear is selected either manually or automatically to conform to the terrain, the vehicle load, the desired mode of acceleration, etc.

On the same drawing, at the bottom, is shown the substantially simpler system of the electric vehicle. The stored energy is in the battery, in the form of chemical and electro-chemical processes.

The speed control consists of high power electronics that allow the stored energy of the battery to flow into the motor at the rate corresponding to the requirements depending upon terrain, load, acceleration, desired speed, etc. When properly designed, no clutch or gears are necessary.

The electrical energy is converted to mechanical power in the electric motor, which, in turn, drives the wheels.

The attractive simplicity of the electric vehicle was effective during the early part of the 20th. century, when electric vehicles were driven in large numbers by "Our Great Aunt Matilda". The vehicle could not go very far, nor very fast, but this was not necessary, because the vehicle was used only for local shopping and visiting other ladies for tea. The time required to recharge, many hours overnight, was not bothersome. In addition, the roads that would have enabled people to go very far and/or very fast, had not as yet been built, so that the electric car was practical.

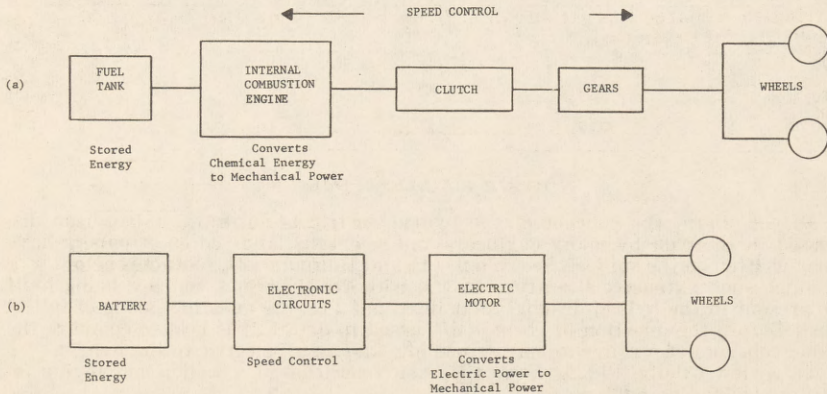


FIG. 1. BASIC SYSTEMS

(a) INTERNAL COMBUSTION ENGINE

(b) ELECTRIC

The invention of the self-starter dealt a death blow to the electric vehicle, because now anybody could use an internal combustion engine automobile (assuming one could learn the coordination of clutch and gears, a requirement which was completely eliminated by the automatic transmission).

Why is the electric car not feasible today? The answer has been reviewed succinctly (1) in that gasoline represents a source of energy approximately 100 times as dense as the best reasonably-priced battery available today. Gasoline has approximately 1000 watt-hours per pound, lead-acid and nickel-cadmium batteries have approximately 10 watt-hours per pound. This means that if one can go 300 miles at 60 miles an hour on a tankful of gasoline, one can travel only 3 miles at 60 miles an hour on a "tankfull of batteries".

There are batteries in the laboratory that have promise of 100 watt-hours per pound, which promise to make an urban use type of automobile, truck, or bus, completely practical (1).

Now examine Fig. 2, the basics of the hybrid. Again, we have a fuel tank with the stored energy in the form of gasoline, diesel fuel, kerosene, etc. Now the device that converts chemical energy to mechanical power can be either the internal combustion engine, with a substantially reduced average emission rate, (for reasons discussed below) or the external combustion, such as a turbine, a steam device, etc. Those problems that prevent the successful development of external combustion engines, such as steam engines and gas or steam turbines, revolving usually around the varying load applied in automotive applications, do not apply here.

The "prime mover", "the combustion engine", then operates a device which will produce direct current power for charging the battery or driving the vehicle, or both. This can be either a dc generator or an alternator and rectifier.

Then we also have the battery, which represents a source of stored energy, and the electrical energy from the generator either flows to the wheels, and/or flows into the battery, or does not flow at all. When the internal combustion engine is not operating, then the battery provides all of the power to the next item, the electronic circuit speed control, and from thence to the motor and to the wheels.

It is the additional complexity of the hybrid which hitherto has prevented it from being looked at as an immediate help to reduction of emissions from vehicles. The motor and electronics of Fig. 2 must be of the same size as that of Fig. 1 in order to have equal vehicle performance. So, no economies can be effected here.

However, the battery of Fig. 2 can be much smaller than that of Fig. 1, and the engine of Fig. 2 can be much smaller than the engine of Fig. 1. Substantial cost savings apply here. The gasoline tank can be as large as desired, and this overcomes completely the objection to the all-electric vehicle, the necessity of having to recharge the batteries too frequently for long distance trips, and possibly even for urban use.

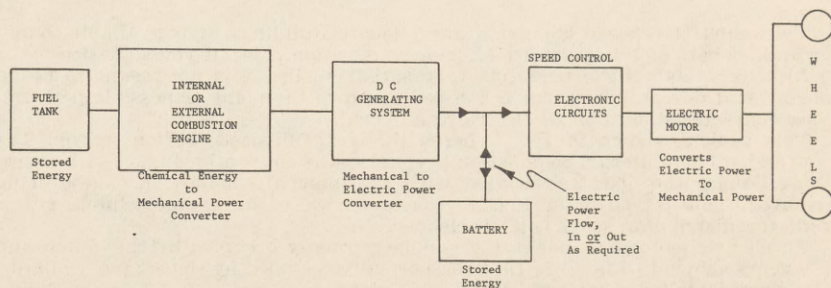


FIG. 2. BASIC SYSTEM, "HYBRID" MECHANICAL ELECTRICAL

Two major factors contribute to the substantially lower average emissions of the "prime mover" *even* when it is operating:

1. The engine of the hybrid can be a substantially smaller engine than that of Fig. 1, because it need not provide the *peak* power required for acceleration, climbing hills, etc. The battery in the hybrid can provide all the peak power necessary. The engine need provide only the *average* power consumed, which, even at 50 miles per hour for a vehicle weighing 4000 pounds, is only 100 horsepower (2).

2. As mentioned above, when the engine is operating, it is operating at its lowest specific emission. It operates at essentially one load level, maximum, for which it can be properly adjusted.

The above factors, when combined, make conservative estimates of the average emissions to be as low as $\frac{1}{8}$ that of present day vehicles, or as high as $\frac{1}{4}$ (2). But, because of the complexity, the initial cost of the hybrid vehicle for equal performance, tended to be, on analysis, noticeably higher than the equivalent "pure internal combustion engine", which is quite "impure" with regard to emissions.

Another reason delaying the development and production of the hybrid was that of performance. In order to keep the cost of the vehicle "within reason", low cost batteries were employed, i.e., lead-acid batteries. This has represented a fundamental error in thinking practiced all over the world. The low cost battery, usually the lead acid battery of the type available in ordinary automobiles for auxiliary power and engine starting, is indeed surprisingly cheap, considering its complexity. Mass production accounts for the low cost.

However, the *power density*, i.e., the amount of power available per pound is so low that the vehicle is inevitably sluggish in acceleration. In order to overcome the sluggishness, the vehicle has been made as small and as light as possible, i.e., a "mini-car", something which just does not appeal to the American public, per (George, et al. (3)). The energy density of lead-acid is 10-14 watt-hours per pound (page 40), but the *power density* is only 35 watts per pound, if a reasonable life is wanted from the battery.

On page 41, it is indicated that the corresponding figures for nickel-cadmium are 12-14 watt-hours per pound, but 300 watts per pound power density. Employing a figure of approximately one kilowatt per horsepower (close enough for this presentation), in order to have, let us say, 200 horsepower for rapid acceleration, or 200 kilowatts, one would need approximately 5000 pounds of lead-acid batteries.

On the other hand, one needs only 600 pounds of nickel-cadmium batteries.

Since the cost of nickel-cadmium batteries is approximately 10 times that of lead-acid, previous designers have been reluctant to use nickel-cadmium, and therefore the vehicle acceleration has been sluggish and unacceptable, and/or the vehicle has of necessity been a mini-car.

However, using nickel-cadmium batteries, a vehicle can be, and *has been built*, (Wouk & Seiger (4)), which is full size and has excellent acceleration and top speed.

The vehicle I refer to is outside these Senate Buildings. It is available to any or all members of this Committee for demonstration rides, if you so desire.

Although this vehicle performs very satisfactorily, it is not meant to be an operational device, but rather a test-bed to prove the point of possible performance characteristics of an all electric or a hybrid.

This vehicle, shown in Fig. 3 herewith, is a full-sized station wagon. The conversion from internal combustion to electric was eminently simple, with everything "under the hood" associated with the internal combustion engine being removed. This is shown in Fig. 4. Taken out were the engine, clutch, gears, radiator, distributor, spark coil, air cleaner, etc.

An electric motor was put in the volume normally occupied by the clutch and the gears shown in Fig. 5. In the area normally occupied by the engine, radiator, etc., were installed a bank of batteries, 80 nickel-cadmium cells, 75 ampere-hours rating. This is shown in Fig. 6.

The vehicle will perform completely satisfactorily on this bank of cells, with respect to acceleration, top speed, etc., since the 75 ampere-hour cells can supply several thousand amperes for a short period of time for acceleration, and steep hill climbing.

George, et al. (3) "Prospects for Electric Vehicles," Arthur D. Little Report. C-69260, March, 1968.

Wouk & Seiger (4) "Design of an Electronic Automobile Employing Nickel-Cadmium Batteries."

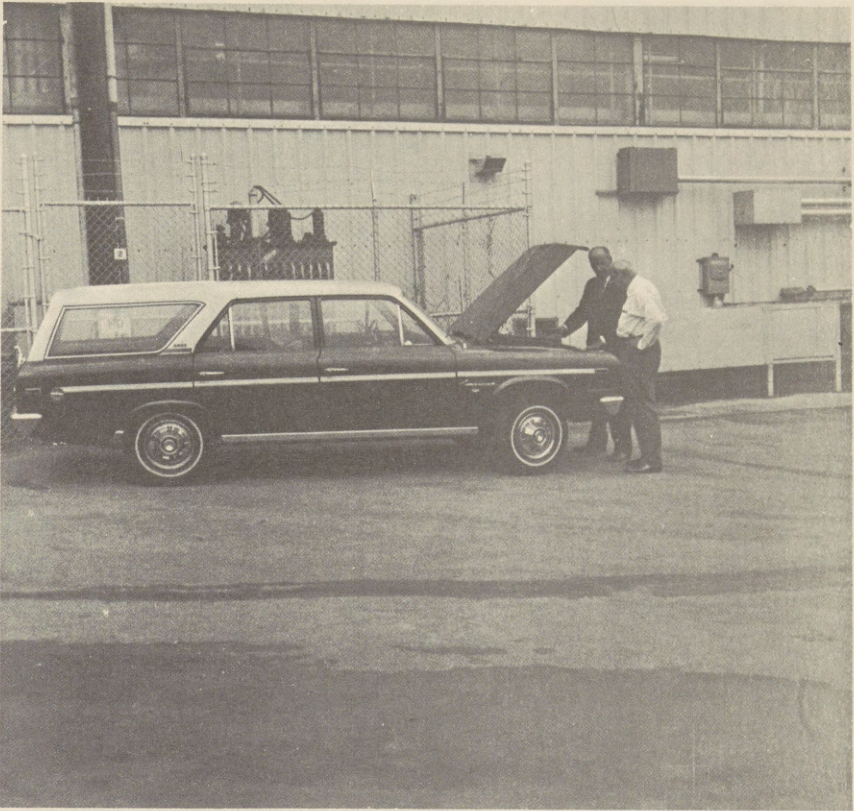


Fig. 3 Station wagon converted to electronic automobile.

The vehicle has an equal bank of cells in the rear, in the station wagon baggage compartment, in order to extend the range for demonstration purposes.

If this were a hybrid, the rear bank of batteries could be eliminated completely.

Further, the front bank of cells could be reduced to one-half, or even less, with the internal combustion engine-generator being mounted in the volume thus released.

Since the engine could be comparatively small, it might well be air-cooled, per the successful air-cooled engines in foreign vehicles of today.

This hybrid would then have all of the characteristics of the original station wagon, except for the substantially lower average emission, and the substantially lower noise level.

All of the auxiliaries currently associated with the type of car desired by the American public, could now be incorporated into the vehicle. These include air-conditioning, power steering, power brakes, etc. As a matter of fact, some of these auxiliaries would perform in a superior manner, because they would now be electrically driven from a fixed voltage source of power. The air conditioning, for example, now requires an over-sized internal combustion engine because,

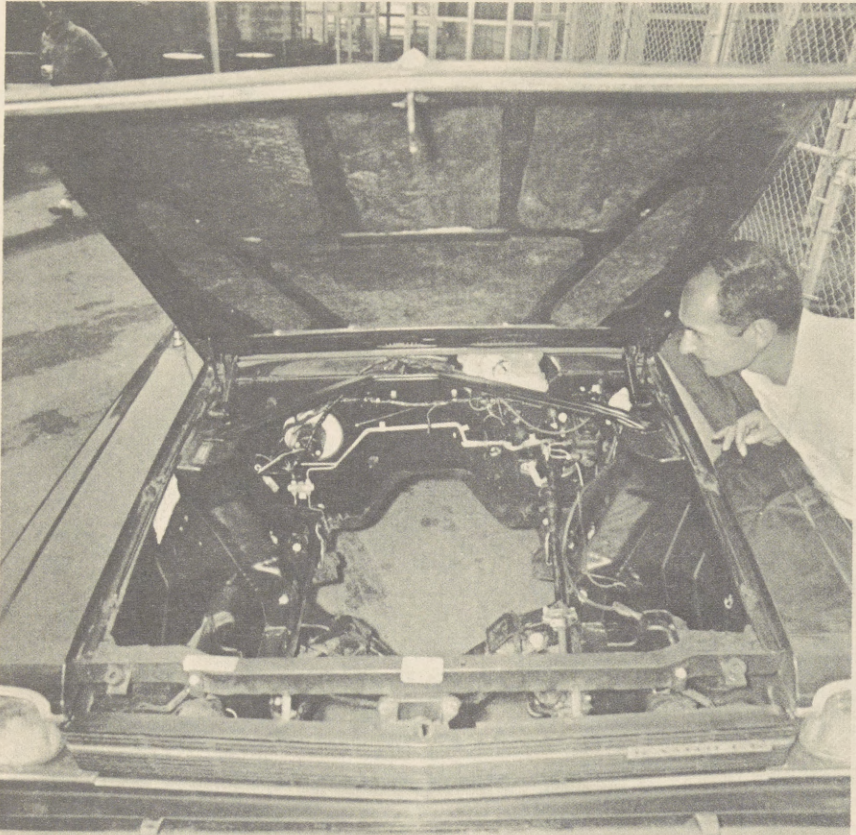


Fig. 4 Empty region under hood, with internal combustion engine and related items removed.

among other reasons, the fact that the compressor of the air-conditioner must operate over such a wide range of speeds, car occupants want air-conditioning when the engine is idling, as well as when the car is moving. With the hybrid, the compressor could be driven by a comparatively small electric motor which would be high-frequency, operating from electronic equipment that would convert the dc from the battery to high-frequency ac.

Similarly, heating for the vehicle could be electric and operate instantaneously. Even in the coldest weather, the car could be warmed up as soon as the switch is turned on, by power from the battery.

Starting in cold weather would be absolutely no problem, because the vehicle would start up as an electric, and while it was moving, the full power of the batteries would be available for operating the self-starter. Also, heat would be available from the batteries to warm the engine prior to starting, thus making it simpler to start.

The hosts of other advantages of the hybrid are too great to list here. Many of them have been covered by Hoffman (2).

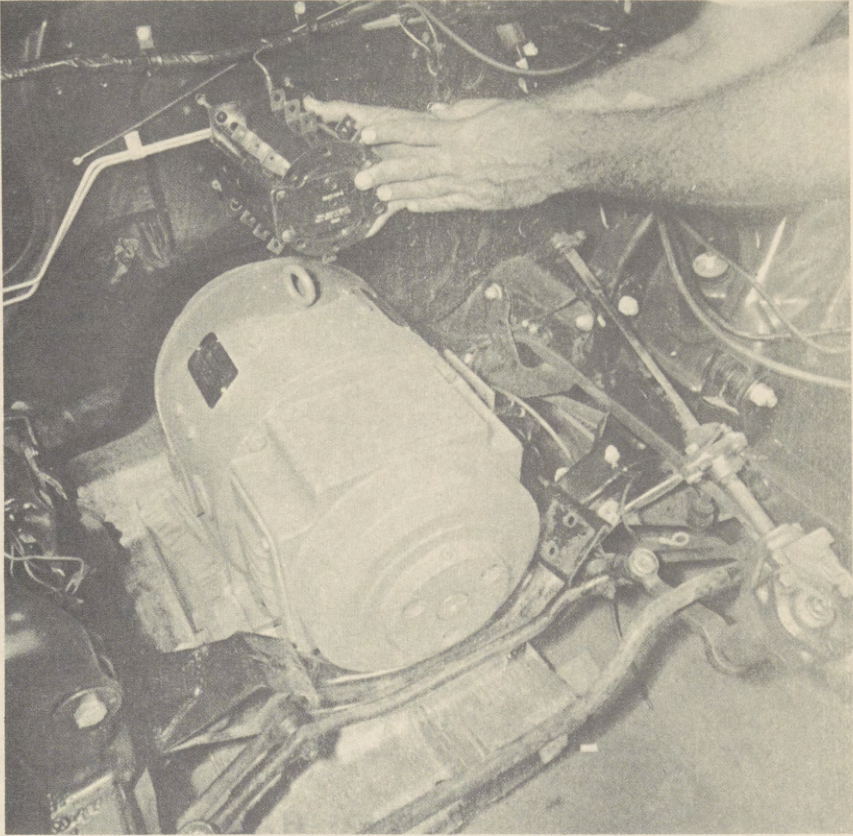


Fig. 5 Electric motor in place. Direct connection to drive shaft not visible.

COST ANALYSIS

What about cost?

The *initial* cost is impossible to determine at present, because the only vehicles available are experimental models. However, if one wishes to have overall cost, over the life of the vehicle (assuming a 5-year life) of 125% that of the equivalent present day internal combustion, one can accept an initial price of 150% of that of the equivalent internal combustion engine. This can be achieved with mass production.

As has been shown by the Northwestern University transportation center (5), the maintenance costs of an electric vehicle versus an internal combustion engine is approximately $\frac{1}{6}$ th.

As indicated by Hoffman (2), the fuel consumption would be approximately 50% that of the equivalent internal combustion engine automobile, because the engine is always operating in its most efficient range.

We can therefore make a commercial case for a hybrid-electric vehicle that would cost as much as 50% greater on an equivalent performance basis, relative to a conventional automobile.

(5) (Proceedings IEE, Vol. 112, # 12, December 1965.

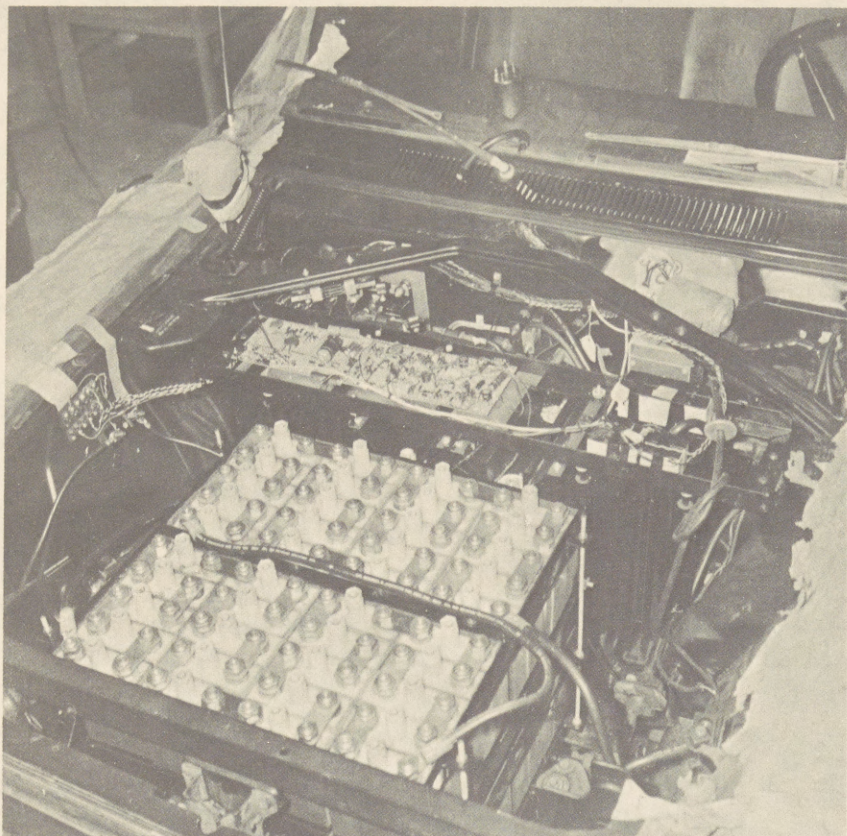


Fig. 6 Front bank of nickel cadmium cells.

Let us assume that we are comparing a \$4,000 car, complete with air-conditioning, power steering, etc. Since there *are savings* in the internal combustion engine system (smaller engine, no clutch, no gears) in large volume production, we could estimate an initial cost of about 1.5 times \$4,000 or \$6,000.

In accordance with the proposed Bill, the vehicle could be purchased by Federal Government Agencies if the initial cost were 125% that of the equivalent internal combustion vehicle, in this case $1.25 \times \$4,000.00$ or \$5,000.00.

The question then remains: "Can the \$1,000 difference between the proposed allowed initial cost of \$5,000 and the actual initial cost of \$6,000 be saved in fuel and maintenance over the life of the car? The answer is a very strong "YES"!

Fuel costs for the average car are about \$200 per year.

Repair costs for the average car are about \$200 per year.

According to Hoffman (2), the fuel savings of a hybrid should be about 50%, which is \$100 per year, or \$500 for 5 years.

According to (5), the maintenance of an electric vehicle is $\frac{1}{6}$ that of an internal combustion engine. In the hybrid, since there IS an internal combustion engine, the savings will not be as dramatic as a pure electric. However, because of the much greater simplicity of design (no gears, no clutch, no overloading problems, no "racing" during idling, no idling wear, etc., the maintenance can be conservatively estimated as $\frac{1}{2}$ that of the normal car. The savings are thus \$100 per year in maintenance, or \$500 in 5 years.

The savings of \$500 per item for the two above items, fuel and maintenance, is \$1000 over the life of the vehicle, exactly what is necessary to meet ALL the requirements of the Bill.

The hybrid-electric is therefore acceptable from a total cost point of view, over the life of the vehicle.

THE FUTURE OUTLOOK

What about the future?

If what is proposed herein is the best that is ever to be hoped for, then there might be questions about proceeding too far with the program, because eventually, the increase in the motor vehicle population would "catch up with the present automobile pollution levels". However, the hybrid-electric is an IDEAL transition vehicle for the next decades, until the all-electric is made viable first with a battery energy density of 100 watt-hours per pound, then 200 and then 500. A level of 1000 watt-hours per pound will eliminate even the requirement of rapid charge capability for any application except the occasional long distance trip of over 200 miles, since 1000 watt-hours per pound will take a car over 300 miles between recharges.

Hoffman (2) has indicated how the reliance on the fuel tank will decrease, and how the "no emission" electric drive will take over more and more of the hybrid function. Fig. 7, an updating of Fig. 5 of (2) shows how, by the year 2000, as battery technology improves, we can eventually move into the realm of all-electric, and zero emissions from the urban vehicles.

SUMMARY AND CONCLUSION

It has now been shown that with TODAY's technology, we can build low emission vehicles that will meet the requirements of the Bill, i.e., (1) a pollution level less than 25% of average emission levels of current design vehicles, and (2) a total cost over the life of the vehicle, including initial cost, maintenance and fuel, no more than 125% that of conventional emission level vehicles. These would be hybrid electric, employing nickel-cadmium batteries and electronic speed control.

In the future, as batteries are improved by advanced technologies, the average emission levels will be reduced to the vanishing point.

No sacrifice of size, comfort or vehicle performance would be necessary with the hybrid-electric. Routine maintenance will be less frequent than with conventional vehicles.

The hybrid electric can be the ideal low-emission vehicle.

ABSTRACT

This testimony presents information concerning a practical low emission vehicle, the hybrid electric. The data are the results of extensive experience during the past 4 years, with high power electronics for controls of an electric car, and the actual construction and operation of a full-sized electric station wagon.

Included are technical references, and examples of practical applications of theoretical considerations.

Costs of the hybrid electric are discussed, along with performance characteristics, and these are compared with present day high-emission internal combustion engine vehicles.

Timetables are presented as to how we can anticipate continuous reductions in emissions as improvements in electric storage batteries occur over the next decades.






		YEAR				
		1960-1970	1975	1985	1995	2000
						
		NON-ELECTRIC	HYBRIDS			ALL-ELECTRIC
ENGINE POWER	= 1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	0	
BATTERY POWER	= 0	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{7}{8}$	1	
RANGE FRACTION FROM BATT'Y ENERGY	= 0	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	
EMISSION LEVEL	= 1	0.25	0.15	0.05	0	

FIG. 7

Senator RANDOLPH. Mr. Lear, please.

Mr. Lear, would you proceed to identify yourself, sir.

**STATEMENT OF WILLIAM P. LEAR, CHAIRMAN OF THE BOARD,
LEAR MOTORS CORP.**

Mr. LEAR. As probably most of you know, I am chairman of the board of Lear Motors Corp. I would like to say, Mr. Chairman and members of the Energy, Natural Resources, and the Environment Subcommittee, being Bill Lear, the chairman of the board of Lear Motors Corp., I appreciate this opportunity to testify before this subcommittee on behalf and in support of the Federal Low-Emission Vehicles Procurement Act, S. 3072, proposed by Senators Magnuson, Jackson, and Muskie, and compliment them and other cosponsors of this bill for their initiative, foresight, and dedication toward solving the problem of air pollution coming from automobiles.

I have read the proposed bill and agree with its intent to encourage the development of low-emission vehicles. But will the bill as drafted accomplish this purpose on which we all agree? Let me discuss this question with you and speak, first of all, of the detailed provisions of the bill before discussing the wider problems.

Let me outline for this subcommittee the problems which an innovative developer faces—problems which show the need to waive the statutory price limitation:

1. Propulsion units developed or manufactured by independents would have to be sold to one or more major automobile manufacturers for installation in their vehicles. This is quite unlikely as large production organizations naturally prefer to use their own engines, et cetera. Also they would be concerned with split liability and warranty problems.

2. To compete, the independent powerplant producer would necessarily have to procure vehicles from automobile manufacturers which also poses problems such as the difficulty of being able to buy such vehicles at wholesale prices. Automobile companies dislike incomplete vehicles (without engines, transmissions, et cetera) because of the obvious unbalanced production, procurement, and inventory problems plus, again, the split warranty and liability problems.

3. There is little possibility of smaller, independent manufacturers being able to produce vehicles at statutory price costs plus 25 percent in the relatively small quantities procured by the General Services Administration. Obviously, it is a lot easier to take them out of the production lines than it is to make these relatively small quantities.

For the above reasons, this bill should not limit procurement costs to statutory costs plus 25 percent. A much more flexible pricing structure should be adopted. Otherwise the legislation would assist and encourage only the existing automotive industry; it would not help the independent developer. And I know that this is not the subcommittee's intent.

In the past, brilliant innovations and breakthroughs in an industry have come from outside that industry—Xerox and Polaroid are such examples.

Because it is the intent of this bill to seek basic solutions to low-emission powerplants from all and any source, we urge you to clarify the bill so that the participation of independents is assured. The bill must not merely provide financial assistance and encouragement to large automobile manufacturers.

Support of the existing industry might lead only to a more patched-up internal combustion engine. But society needs more than that. By 1975 this country must have on the road and available to consumers a new, innovative powerplant that is inherently low polluting and does not require periodic maintenance.

Because of this need, we must have 1975 standards of California imposed now. There is an urgency in our work—there must be if we are to protect our most valuable resource; the very air we breathe.

In this connection, I would direct several other questions to the proposed bill:

1. Is 2 years too long a time between vehicle certification renewal?
2. Who maintains the vehicles after they leave the inventory of the General Services Administration if the vehicles purchased are not inherently low polluting?
3. Does the bill take proper account of increased cost to the vehicle purchaser for maintaining low-emission control devices? Lear Motors estimates the recurring costs for maintaining existing control devices

and those proposed to be about \$6 billion annually throughout the Nation. These estimates were made in a proprietary study based on published reports by acknowledged experts in Government testing agencies. We would be pleased to make these reports available to this subcommittee.

Now, \$6 billion a year is a tremendous cost for the Nation to bear, particularly when we know that there are technological alternatives available—alternatives which will provide an engine which is inherently low polluting.

Since there is no real guarantee that the internal combustion engine can meet required emission standards, I question the real benefit of low-emission, "patch-on-patch" control devices that will cost the general public \$6 billion per year. Incidentally, the total national cost for medical care comes to just over \$6 billion per year—and that includes everything: hospitals, doctors, medicines, research. Are we, as a nation, prepared to waste the same amount which protects and maintains our health?

I recognize that existing legislation allows for the funding of innovative propulsion systems development. I also realize that members of the Senate Commerce Committee and the Air and Water Pollution Subcommittee were instrumental in allocating \$45 million to such research and development. Such support of the innovative, independent developer is absolutely necessary.

Such important civil developments as rail and air transportation, the supersonic transport, nuclear powerplants, communications satellites, irrigation and hydroelectric projects; all of these would never have been possible without Federal initiative in support of private enterprise. These projects are now contributing substantially to the economy of our country.

As you are all aware, I have been involved in the development of low-emission powerplants for some 18 months now and, after an expenditure of my own funds to the extent of \$6 million, Lear Motors has now produced a low-emission powerplant which we believe to be a logical and feasible solution to the problem. We will have prototype vehicles in operation this spring and, with the aid of development support, we could be in a position to seek certification under this bill by the end of the year.

A study by Lear Motors indicates that to do the real job it will take:

1. A \$25 million investment is required to develop prototype gas turbine vehicles;
2. An additional \$75 million investment is required for facilities and tooling to put the gas turbine vehicles into production; and
3. Working capital in the amount of \$200 million is required to get into production.

In closing, I would like to thank you again, Mr. Chairman, for this opportunity to present my views on this most important matter of air pollution. You and your Subcommittee on Energy, Natural Resources, and the Environment are to be complimented on your quick attention to the urgency of this matter and your adroit grasp of the problem.

We must all realize that this is only the beginning of the fight against pollution, but it is a beginning. Thank you.

That concludes my formal statement. If you would prefer to ask any questions, you may ask them now, but I have some additional things to say.

Senator RANDOLPH. I think we might begin with the \$6 million. That is an interesting question. Is this your own money or the corporation's?

Mr. LEAR. It is a corporation in which I own 100 percent of the stock.

Senator RANDOLPH. I have had this question asked of me personally. Did Bill Lear actually spend \$6 million of his own money?

Mr. LEAR. I always say it is my wife's money.

Senator RANDOLPH. The \$6 million, not facetiously now, in a sense it was not a gamble. You were hoping it would be an investment, it would pay a dividend and, let us say, help the country and our people. I know the profit motive was included.

Now, have you forgotten the steam car and gas turbine development?

Mr. LEAR. Our expenditures right now on steam run \$150,000 a month at the present time.

I have also allocated a \$2 million budget to take a look see at a gas turbine, and I believe that after having seen all of the problems, not the problems of designing, not the problems of, we will say, creating or putting together a steam car or a steam bus, but the problems that the users of such a thing would have in getting the kind of service and maintenance that would be required for what I call a six-element system versus a single-element system, that it would be uneconomic to only look at that way to do the job.

There is, in my opinion, a simpler way to do the job from the standpoint that the end result will be an engine that will be a single-element engine.

May I just elaborate to this extent, that a steam engine consists of not an engine per se, but is divided up into what we call an expander, and that is what the normal person would call an engine.

But that does not do you any good at all until you have the fluid. That does not do you any good until you have the boilers, and that does not help you until you have the combustion and for the combustion you need the blower. On top of that, you need condensers, you need fans for the condensers, and you need a feed water pipe.

To give you an idea of the problem, there were no feed water pumps in the world that would handle a 300-horsepower steam engine in a car or a bus and still able to fit it inside the bus. The pressures and the temperatures were such that there was not anything like that.

So at a cost of about \$160,000 to \$170,000 we designed one. But it is still a complicated piece of equipment, and it is something in my opinion that obviously one of these days is going to require maintenance of some kind.

Now, as against that, here we had a six-element system, including a fluid that at the present time freezes, but that can be handled.

Looking at fluids, we have looked at 101 different fluids. We are having a briefing of about six people from HEW and two observers from HEW; we are having some people from the Department of Transportation and some other officials come in on Monday to give

them a full day's briefing of what we are doing, and this committee is invited to send any representatives you want to to that briefing, which will be a very thorough and a very complete briefing, and I will be willing to submit to the committee copies of the information that we do hand out to that group.

But the major problem I see between the steam engine and the gas turbine is that the gas turbine fundamentally should not be a greater emitter for a given amount of horsepower, horsepower per hour, than the steam engine. Fundamentally, it is the same kind of a device.

The only major difference between the two devices is one operates at a pressure of four times the atmosphere or about 60 p.s.i. and the other operates at slightly above atmosphere.

But as far as nitrous oxides are concerned, and that is the only thing that is involved, whether there would be any difference, we believe from the information that we very graciously got from the people out in Bartlesville—Phillips Petroleum—they opened up their laboratory and said come in and see what we have done for 20 years in combustion, and after seeing what they did we believe it is possible to make a turbine, a gas turbine, and when I say gas turbine this does not mean natural gas, it means the hot gas produced by the burning of kerosene, but from what they showed us it looks to us like it is completely reasonable to expect that the emissions would be comparable to, if not the same as, the best steam system that you could make.

On top of that, let us look at the record.

About 8 years ago Chrysler put on the market—they did not put on the market, but they built 50 cars which they let a number of people drive, and those cars were driven for the purpose of getting the observations of the people that drove those cars. The major observations they get is everybody that drove them wanted one as far as they know, at least I did, and I talked to a number of other people and they did, too.

Strange as it may seem, without any intent or without any effort on the part of the Chrysler Corp. to make a low-emission car, they turned out to be a low-emission car as measured by HEW last year and now published in the report on seeking the low-emission car, that they meet the 1973 standards of California and come within a smidgen of meeting the 1974 standards, and a conversation that I had just yesterday with Chrysler in Detroit indicated that although they made no effort at that time, they were not concerned with emission 8 years ago but if they had, they think that possibly they could have gotten it much lower than they are now. I am sure they can.

I think possibly we know a little bit more about how to get the nitrous oxides than they do, but that remains to be seen.

But the point is this: That here is a single-element engine. You put that engine in the car and that is all there is. You say, well, if Chrysler has been working on this for 18 years, why did they not put it in production? That is a question I cannot answer.

But it seems to me that the automotive industry is totally committed to the status quo. They don't want a new engine if they can avoid it.

This is a speech that I made before the SAE about 2 months ago. I said the automotive industry has more inertia in it than any other industry because inertia is a human quality and they have more humans than anyone else.

So they do have a large amount of inertia and their reluctance to change is very great. They are going to save the internal combustion engine which has taken them 65 years to develop no matter the cost. In my opinion I do not believe that they will ever be able to meet the requirements of 1980.

You say there are no requirements of 1980. In order to meet the situations that we are coming smack up against of having to materially reduce these emissions, we are going to have to take a total look at the total problem, and when you take a total look at the total problem, you are going to have to reduce the emissions considerably below those of the California limitations of 1974.

I think at the present time HEW is right now considering stiffer regulations in that respect, and in order to meet those I am sure the internal combustion engine is going to have a terrible problem.

Now, suppose they can meet them. The question that must be asked by this committee of the automotive companies is at what penalty, what sacrifice in power, what sacrifice in the necessity for additional servicing, what is it going to cost in the way of less miles per gallon? These are the problems that will pop up when you try to take an engine as old as the internal combustion engine and make it work.

If you look at the aviation industry, you will see when they went from the internal combustion engine to the turbine engine the reliability went up from 100 to 200 times.

The statement I made to them recently at that meeting at the SAE was the only problem that possibly the automobile industry would have would be building a gas turbine that would only last 100,000 miles.

Senator RANDOLPH. Mr. Lear, I am gratified that you have mentioned the aircraft industry because of your association and knowledge of it for a long period of time.

Pollution, of course, is the basis for whatever we discuss here today or during these hearings. Would you comment on the matter of pollution from jet aircraft.

Mr. LEAR. There are two forms of pollution that come from jet aircraft. One is visible and one is invisible. There is some thinking that possibly the invisible emissions may be as high as the visible emissions; in other words, the unburned hydrocarbons and so forth, the carbon monoxides, and especially the nitrous oxides may be as high.

I cannot answer that because I am not technically equipped to do that. But there has been conversation of that kind.

I talked to one of the presidents of one of the leading airlines recently and he was complaining about the fact that he had to take the smoke out of one engine when the other engines he had in his other airplanes are really equally or more of a polluter.

So there is the possibility that aviation gas turbines should be looked at not only from the standpoint is there a visible emanation out of that engine but how much nitric oxides are they pouring into the air.

I am sure if you get rid of the visible emanations, then the unburned hydrocarbons and the carbon monoxides are minimal, because this is the characteristic of a gas turbine engine, you do not have to worry about that. They just do not have substantial amounts of unburned hydrocarbon; they do not have substantial amounts of carbon monoxide. You can stand in back of one of those engines and breathe the air in your lungs and you do not die. You do not do that back of your exhaust pipe in your automobile.

You say steam, is it dead? No, it is not dead. We have a market probably for between 25,000 and 75,000 engines a year for marine purposes alone.

In the marine field the steam engine is ideal because you can get 40 percent more power out of it because of the fact you can use the river or the lake or the ocean to cool the condenser. The basic problem of a steam system in an automobile is that the condenser has to be cooled by air. If a vehicle could have a portable river go along with it, they would be an ideal system.

But not having that, you have to cook it by air. Air is one-fifth as efficient in the cooling process as water to water or water to steam. Therefore, there is a big advantage for a marine application whereas there is a margin of advantage for a vehicle.

One other thing, for trucks and buses as an interim this may be the answer.

In conversations that I had with some automotive manufacturers recently, they said, well, we could develop a gas turbine for automobiles but it would take 10 years and it would cost a billion dollars. My question to them was this. My query was, all right, suppose that someone handed you a billion dollars and said go ahead and develop a gas turbine engine, would you do it?

They said, oh, no.

Why not?

Because think what would happen to our balance sheet with having to obsolete all that equipment we have got for making internal combustion engines.

This is a real problem, because after all this is an economic/financial business problem. Therefore, they are not readily going to do that.

I was asked a question by a Government man here in Washington yesterday, a high-ranking man, who said what would be your suggestion to bring the automobile industry around to the point of where they would be willing to make a new and better engine? Let us say that the only benefit to the public would be an engine that required less maintenance, less repairs, had more reliability, which started in the wintertime, did not have any radiator, no fluid in the thing except the fuel that you were burning, how would you get the automotive industry to make such a thing?

In my opinion, I think they can only be induced to do it by competition. The one thing they understand better than anything else is competition and not a one of them can afford to lose 1 percent of the market they now have.

Senator RANDOLPH. Thank you, Mr. Lear.

Senator Baker.

Senator BAKER. Thank you very much, and thank you, Mr. Lear, for a most exciting and I think illuminating piece of testimony on this subject.

Senator RANDOLPH. May I interrupt at that point? He is a young man at 68, isn't he?

Senator BAKER. I wouldn't dream he is 68.

Senator RANDOLPH. I know his age, and he is courageous, and I want the record to show it.

Senator BAKER. Mr. Lear, I am intrigued with the general nature of your testimony as well as the obvious vitality that you bring to the subject and the history of accomplishment that you have in the general transportation field. Your Lear jet brings out my very worst tendencies because I get mad when I see someone who has one when I don't.

That being beside the point, let me ask you one question that I hope may summarize your views as I understand them. If you assume that the United States must have a different propulsion system to meet the requirements of the seventies and eightie's, if you assume that the United States will continue to prosper and that people will continue to demand mobility, you as an industrialist and a leader in the field of transportation, what will you bet on as the method of transportation on the surface?

Mr. LEAR. I am glad you asked that question, Senator Baker. The thing I would bet on is the necessity that I started to talk about before of looking at the total problem. The total problem is not going to be met by just bringing the emissions down in any particular kind of a propulsion system. It is going to be met by meeting headon the problem and the ridiculousness of a 185 pound man driving 20 miles to work in a 5,000 pound automobile. This is just out of proportion to what it should be when that same man could be taken to work just as fast and just as safely in a 2,200 pound automobile.

Strange as it may seem, you can definitely relate the amount of emissions that you are going to get from any given system to the amount of horsepower that you are going to need, and a 2,200 pound car will use less than half the fuel of a 5,000 pound car.

But the tendency on the part of the automotive industry is to sell large cars, fundamentally I believe because it doesn't cost them much more to make a large car than a small one, so they make a little more profit on that.

But you can see that there are some smart people in the world by virtue of the foreign cars that they are buying that are light cars because actually what they want is they want transportation, they want to get from point A to point B at the most economical way.

At one time all we had to think about is what they would cost. Today we have to think about what does it cost all of us in the form of additional air pollution to let me go to work in my Cadillac while you go to work in your Volkswagen.

Senator BAKER. If you had to choose between two alternative methods of transportation as the probable dominant factor of the seventies and eighties, which ones would you choose: first, extensive increases in our mass transportation facilities such as rapid rail transit and air, or a great proliferation of privately owned individual automobiles?

Which do you think is most likely to be the dominant transportation scheme in the eighties?

Mr. LEAR. I think you can't alter the way of life that the American has become used to, and that is driving his own car.

Senator BAKER. You think that is the way we will still do it?

Mr. LEAR. I think you have got to look that squarely in the face as it will be the basic method of transportation of the majority of the people, especially in the huge urban complexes.

Senator BAKER. Let me ask you this question, then. If we assume that is the case, that we are going to continue to depend primarily on the private automobile for our transportation in the eighties, at our present pace of progress in developing ways to suppress smog from automobiles, do you think we will make it by 1980 with our present methods and with the internal combustion engine?

Mr. LEAR. Not with the internal combustion engine and not without some restrictive measures that will make it, let's say, costly to drive large cars or make it attractive, let's say, to drive lighter cars. There has been very little exploration of how much could be done to make a lightweight car. I think a lightweight car with a 100-horsepower engine would be the maximum that would be required under any circumstances unless you want to get into the LeMans race.

Senator BAKER. Some of the modern economists in their published works speak of the external diseconomies. They speak of the requirement of something other than the marketplace to produce a given result, that is to say the idea in the field of pollution, for example, the profit incentive may not be enough to urge private industry to do the job. Do you visualize that to be the case or do you visualize a profit incentive and some other method of compulsion that might do away with these external diseconomies?

Mr. LEAR. I think both are included. However, one of the things that sort of points up that some external force is required is this: suppose we look upon the automobile industry as being run by the owners. It is not run by the owners. It is run by managers who are hired by the company, and they are really nothing but menials when you get down to it because if they don't do the job the shareholders like they will be fired because the average—

Senator BAKER. Unless you happen to own 100 percent of the stock like Bill Lear.

Mr. LEAR. That is a little different story. But they have that problem.

Let me just give you one example. Suppose that one of the major companies decided that they were going to junk their internal combustion engine and they were going to now go all out for an engine that I believe is a better engine, which would be the gas turbine because 10 years from now I believe gas turbines will be the rule rather than the exception.

Senator BAKER. Do you think the private automobile industry as we know it will produce a gas turbine for us in 10 years?

Mr. LEAR. I think within 10 years the average car coming on the market will be a gas turbine car in spite of their present position.

Senator BAKER. What do you think is going to change them?

Mr. LEAR. The suggestion that I made yesterday is give someone, some organization, such as ours, it doesn't have to be ours, that can

develop a gas turbine, a satisfactory gas turbine, work with the weakest of the automobile companies who have nothing to lose and combine those two in such a way or give them some funds so that they can develop a car. Once a gas turbine car is on the market, every one of them will try to beat American Motors to the market with a gas turbine.

Senator BAKER. Does Bill Lear plan to try to go into the gas turbine car business?

Mr. LEAR. I am going to be in the gas turbine car business.

Senator CANNON (presiding). Thank you, Mr. Lear. I am happy to have the opportunity to welcome you here. I am sorry that I was not here to introduce you as one of my constituents to the members of this committee.

I am sure it has been pointed out that you are one of the outstanding inventors of our country today, having produced a very, very fine airplane, the Lear jet, and also the Lear autopilot, the Lear radios and many, many other things that bear your name.

I have had the opportunity, I might say to the members of the committee, to visit with you at your plant and see what you have been doing in the way of development of the steam engine, and I am a little confused, however, by an article that I read in the "Automotive News" of November 17, 1969, and I would like to read part of it to you because I don't think it is consistent with what I know about your activities and with what your statement indicates today.

William P. Lear, who has been labeled America's greatest living inventor, has thrown in the sponge on his widely ballyhooed plan to build a smog-free steam car. He now calls the idea "utterly ridiculous." Lear demonstrated his honesty and courage by describing his failure on the steam project to over 800 engineers last Monday evening, November 10, at a packed meeting of the Detroit section of the Society of Automotive Engineers. Because of his fine track record over the years for inventing things that establishment engineers said couldn't be done, Lear led thousands of newsmen, government officials, and just plain citizens into believing that practical emission-free steam cars could be developed if only enough engineering manpower was applied to the problem. No one can say Lear's steam project failed for lack of effort, enthusiasm, public support or finances. He appropriated \$10 million of his own money for the program and has spent \$5.5 million of this sum at Lear Motor Company, Reno, Nevada, where up to 200 people have been employed.

Now the 67 year old Lear has repudiated the whole idea of a steam auto, strongly insinuating that it will never be practical. Belatedly, he is agreeing with most of the auto engineers.

There are a number of items in that article, and I am sure you read the article very carefully, and I would like to have you comment with respect to that.

Mr. LEAR. I am afraid they put some words into my mouth. Actually what I was trying to do, I was trying to point out that I didn't think the industry could tolerate two major changes in propulsion systems, that whereas the steam turbine would in a measure solve the emission problem, that in the long run the ultimate solution would be the gas turbine, and I was trying to encourage them to look toward the immediate development of that rather than to come out first of all with a steam automobile and then secondly come out with a gas turbine.

I think I quoted at that time that the hiatus between the time that you could put a steam automobile on the market and a gas turbine car

on the market would only be a matter of 2 years. I didn't say, as I was quoted I said, that the only decent thing to do was to bury it, which never came out of my mouth. Actually I said I was continuing with my steam project, and I said I am continuing it for more than one reason, but if for no other reason that I can't have somebody in the future say I couldn't do it. We have made major, major contributions to the art of vehicle steam propulsion.

Senator CANNON. Are you presently working on steam propulsion as well as the gas turbine development, or are you working only on gas turbine?

Mr. LEAR. We are not working on gas turbines at all. We have just appropriated \$2 million to take a look-see at the problem. The Flexible Bus Co. in Loudonville, Ohio, very generously loaned us a bus. We had hoped that we would be the successful bidder on the \$460,000 that was promised to the State of California for a bus, and we were told that we were one of the ones selected to receive the bid, but there was no money. However, we went ahead with our own bus. We have spent on that particular bus up to the present time about \$1.3 million, and we will finish that sometime in the next 60 or 90 days.

At the same time we did not bid on the car, the highway patrol car, for the State. But rather we said we will build the highway patrol car and we will loan it to you for your tests, and observations, so you don't have to buy it. Actually, the first offer was for such a trivial amount of money, and the amount of money that has been put in has been so large, it would be better for us to loan them the car than to get the trivial amount of money that was available. The other party that did get it is, I think, out of business now.

But the problems are these. Steam will fit large vehicles, will fit small cars. There is reason that you could go away with it if it were more amenable to, let's say, servicing. But if you go into a repair shop, an automobile repair shop, today, with a broken fan belt, and if the mechanic can't find that, how is he going to determine which of the five elements in the steam system are not working? I believe the major problem is you must give the American people something that not only runs, but that continues to run, uninterruptedly, with a minimum of service and also one that has what I call an inherently low emission characteristic, so that emission characteristic does not change with use or with time.

So far, we have not seen anything like that on the internal combustion engine.

Senator CANNON. With respect to the Government's effort in R. & D. funds, do you think that those should be divided up among a number of competing independents—let's say, pursuing different theories? What is your idea on that?

Mr. LEAR. I think if we want to throw the money away, it would be better to throw it down the sewer. You wouldn't have to administer it, that way. This is not going to get the job done any more than giving somebody \$169,000 to develop the steam car.

We were spending \$250,000 a month, and only making small progress. And I don't think we are exactly stupid. The problems are so great, it would be just like handing four or five NASA contracts out to four or five different NASA contractors to build a spaceship to go to the moon.

Also, as far as these small, paltry sums—I call them nickel and dime R. & D. efforts—handing that to somebody to design a steam car, it would be like saying to NASA, “We want you to put a man on the moon. We will give you a million dollars.” It would be just as ridiculous.

This is a costly development, but it is not costly in terms of what the benefits will be. The benefits on the one side are \$6 billion a year to the people of this country; on the other hand, you have got an investment of possibly between \$300 to \$900 million. And if you don't look at that, you are just looking at the world through rose colored glasses, because that is what it is going to cost to get the first real practical proven gas turbine, light weight, efficient automobile on the market.

Now, whether the Government puts that up or whether, through some method of encouragement, it has to be done. The first step Government could do would be to authorize one company, pick a company that can do it for the money—\$25 million to build that gas turbine. And then when that thing has been built in sufficient quantities and put in enough cars, now you say we're ready for production.

Perhaps you can find someone to put up the other \$275 million to tool it and produce it. But you will never get anyplace until that first step is done.

We think we can do it for \$25 million, and when we say that to the automobile companies they just laugh us out of their offices, because they are talking about much more substantial sums than that. They say it is ridiculous. They said the Learjet couldn't be done for \$10 million. They said \$100 million. And we did it for \$10 million.

Senator CANNON. The Congress recognizes this problem and certainly they are going to take some money and provide it, which we had in the appropriation bill up until yesterday—really, the day before yesterday, and yesterday—

Mr. LEAR. You'll get it back.

Senator CANNON (continuing). Which would have been at least a start along that direction. You are saying that really this development can be done for \$25 million?

Mr. LEAR. Yes; the development of the gas turbine. I feel the gas turbine is a fundamental necessity for the inherently low-emission car of the future. As a matter of fact, Senator Cannon, I believe that 15 years from today that an internal combustion car will be an oddity.

Senator CANNON. I don't know. There are some that are 15 years old that are driving around now that don't appear to be oddities yet. We get that much use out of them, to a degree at least.

Senator Dole, do you have some questions?

Senator DOLE. I have to leave for Kansas, but would like to make some small claim to the products of Mr. Lear's ingenuity. He did go to Nevada from Kansas, and we were sorry to see him leave. But we are happy he's happy in Nevada.

I want to ask one specific question with reference to the bill. You feel that the present statutory cost plus 25 percent would effectively exclude all independents from any piece of the action, is that correct?

Mr. LEAR. There is no way that they could profit or become a part of this for the reasons that I stated. You couldn't possibly build automobiles at twice the price, much less 25 percent more, and I'm talking about the standard car. So that when things are sold to the Government, they are taken out of the production line and slightly modified. It is a modification of their standard production unit. Therefore, they are making those cars for, I would say, 10 percent of what it would cost an independent to supply the same number of cars, starting from scratch. They would be foolhardy to do it.

Senator DOLE. What do you suggest, removal of any limitation at all? Do you have any suggested amendments to the bill?

Mr. LEAR. For it to be operative, I think the most important thing in the evaluation of whether this is a low emission car or not, it should be very carefully evaluated by whoever makes that determination, as to whether it is a low-emission car that will not meet the standards of today, but will meet the standards when that car will still be in service, which is 5 years from today. So, it must meet those standards. Then it must meet the standards of how much will it cost to maintain it in that condition. This is why I quote the figure of \$6 billion, and that is based mostly on the fact that in order to meet the continued low-emission characteristics with these patches that they are putting on internal combustion cars, I feel that a minimal amount of \$25 per vehicle will have to be spent by the users of those vehicles, and if we have in between the years of 1975 and 1990, 175 million vehicles on the road, which is estimated to be the average number for that period, then, you can multiply 175 million times \$25, and that is just the out-of-pocket minimum expense.

But if you took the total expense, it would be probably three times that large, because when you take your car to the garage, it takes a half day to get it there and a half day to get it away, and unless your time is not worth anything, you have got to add that total cost to the total economy.

The cost for doing any kind of repairs has to be added on the side of benefits by doing it another way. In other words, you spend at the most \$900 million over here, but you save \$6 billion a year over here. Isn't it worthwhile? Isn't it worthwhile if you could spend, we will say, \$900 million over here and get the automobile industry to deliver we will say a no better emission car, but a lot better automobile, a lot better engine, one requiring less service to the people that are going to buy automobiles? I think the automobile industry will tell you that gas turbines are more expensive. How can they be more expensive when there is only 20 percent of the parts in the gas turbine?

Senator DOLE. You indicate there is not going to be any change if we wait for the major companies to make the change. And apparently the thrust of this bill in this respect needs to be changed. If we are looking for independent outside sources to make the improvements, then we have to give them the incentives in any legislation we enact.

Apparently we need to make some rather drastic changes in the legislation; otherwise, it is going to be like the fox in the chicken coop, because we would provide the benefit to the companies that are not about to make any change.

Mr. LEAR. That could readily be the case. I firmly approve the intent of the bill, and I am sure it was intended to do the very thing that all of us would like to see done. As a matter of fact, it has been stated by me that I am interested in steam or I am interested in gas turbine. If somebody can clean up the internal combustion engine, I'm in favor of that.

I just don't see it, technically, from the experience that I have had, and my technical sources of information tell me this is a pretty hopeless situation on a long-range basis. But remember that I am not talking about the 1972 requirement. I'm talking about the 1980 requirements.

The automobile industry, almost as a unit, admit that they can't meet the proposed 1980 requirements, but more than that, I think—and it would be one of the things to give consideration to in this bill—is the advisability of considering how many pounds of transportation can you afford to take 185 pounds of humanity around. This is the thing I look at. From that standpoint, you try to in some way limit the size of these cars.

For instance, today, the motor industry has come out with what they call the muscle-powered engines. In the face of our present situation they are coming out with muscle-power. What does that mean? More horsepower than required, 500 cubic-inch engines. What for? Because they get more money. That is the only reason I can see for it. And because somebody wants to hear the tires skid. And when the tires skid, that's another form of pollution.

So here again, I think this is a case where Government can kind of lead the way, and say let's be a little modest about what size engines we put into this. Today those engines you've got aboard, you've got some very smart people aboard in this Government that can tell you how much horsepower will do a certain job.

Now, do you want cars that go 125 miles an hour? I don't think so. Most of your laws limit you to 65 miles an hour. In that case, believe it or not, the original Model-T car was only 18 horsepower, and the gigantic improvement that was made by Ford, the Model-A, was 40 horsepower. That car was a pretty fast car. To put in more than 100 horsepower is ridiculous; 100 horsepower is sufficient for accelerating. It is ridiculous to make the cars bigger and more expensive, and with more acceleration. All they do is hit us harder.

Senator CANNON. To get back to the bill here for a moment, I referred earlier to the \$45 million that we have had appropriated. Now, that could be used for the purpose of developing an engine such as you are talking about. You say it could be done for \$25 million. This bill was directed toward a production incentive, once an engine is developed.

Let me ask you this: In that context, let's say if Congress does see fit in its wisdom and the President sees fit, to let the money be spent in his wisdom for the development of a low-emission engine, then, would the type of an incentive that is in this bill take care of the production problem, where we are saying 125 percent over the statutory allowance, would that provide enough incentive then for the production people to go ahead and produce cars to try to get in the market?

Mr. LEAR. Only mass produced cars could compete. Possibly, the lowest level you could come to in that respect would be the number of cars that are produced by American Motors. They could compete. But anything below that would be out.

Now, then, if an individual developer or manufacturer of an engine were to be in the picture, he would have to sell that engine to one of those four companies, or he would be out of the picture. You can't blame the automobile companies for not buying your engine, because they have got an engine plant and they would rather sell their own. And, furthermore, you cannot blame them for not selling me automobiles, because they do not want an unbalanced inventory.

But maybe one of these days—

Senator CANNON. You mean selling automobiles without engines?

Mr. LEAR. You see, if I made engines and I bought automobiles to put the engines in, I am not saying you can't do it with some people; as a matter of fact, American Motors has offered to do that. But the major thing, I think, the best leverage that the Government has is in getting one gas turbine low-emission, proper size car on the market at the right price, and the right performance, and then the competition being what it is with these companies, and being so important, will lead them into following.

As a matter of fact, they will try to bait us to the market.

Senator CANNON. To do that, don't you have to have some sort of an incentive program such as, for example, that in this bill?

Mr. LEAR. All you have to do is to get someone to loan us \$300 million.

Senator CANNON. Thank you very much, Mr. Lear. We appreciate having you here before the committee.

The next witness is Mr. S. Smith Griswold, president of S. Smith Griswold Associates.

**STATEMENT OF S. SMITH GRISWOLD, AIR POLLUTION CONSULTANT,
S. SMITH GRISWOLD ASSOCIATES, WASHINGTON, D.C.**

Mr. GRISWOLD. Mr. Chairman and members of the Subcommittee on Energy, Natural Resources, and the Environment, my name is S. Smith Griswold. I am appearing before your subcommittee to provide information on the reduction of air pollution possible in urban areas of the United States today through the utilization of natural gas as a fuel for the internal combustion engine. My statement is very brief, but I shall be pleased to augment it at any time with supplemental material.

I am a consultant in the air pollution control field both to industrial clients and State governments, and am currently advising the State of Maine and the Commonwealth of Puerto Rico on the development of expanded air and water pollution control programs to cope with increased industrialization of those areas.

My qualifications on motor vehicle emissions date from my service as Air Pollution Control Officer of Los Angeles County from 1954 to 1965 and as the chief abatement and control official of the Federal air pollution control program from 1965 to 1968. In those positions I organized and supervised both the Los Angeles County and Federal motor vehicle emissions control programs.

I was, of course, administratively and technically involved in defining the contribution of the automobile to air pollution and my interest in this problem has not diminished.

I am sure, Mr. Chairman, that you and the other members of the subcommittee are very conversant with, and have available to you, past and current data on motor vehicle emissions, so I shall not review the record here.

I do wish to note, however, that gasoline-powered combustion engines are presently responsible for 50 to 90 percent of all air pollution in urban areas in spite of the emission control devices on new vehicles which have been mandatory in California beginning with the 1966 model year and nationwide since the 1968 model year.

Obviously these devices have not provided the solution to the problem and, in my judgment, the addition of even more sophisticated hardware will not reduce automotive emissions to acceptable levels in the foreseeable future.

The use of natural gas to power an appreciable number of internal combustion engines used in urban areas will provide a dramatic reduction in air pollution from this source now. It is not necessary to wait, as some have suggested, for more exotic forms of propulsion to come out of the laboratory to abate air pollution.

Some 3 years ago Pacific Lighting Corp., recognizing the air pollution problem of its market area of Greater Los Angeles, undertook to develop a refined methodology for utilizing its product in a manner which would suit all of the characteristics and exacting modes of operation of the motor vehicle.

Pacific Lighting, as you know, is one of the largest natural gas distributing firms in the world. In this development the company was not doing something entirely new since natural gas has powered stationary engines in the United States and elsewhere and motor vehicles in foreign countries during periods of gasoline shortage. Pacific Lighting was faced with producing a system which would meet the harsh requirements of driver acceptability.

While meeting this challenge they proved that the primary advantage of natural gas as a motor vehicle fuel is air pollution abatement. By air pollution abatement I mean more than 90 percent reduction in carbon monoxide and a reduction in oxides of nitrogen and hydrocarbons which would more than meet any regulations currently under consideration by the Federal Government or the more stringent regulations of the State of California itself.

The data supporting this statement is contained in a technical paper presented recently to the Society of Automotive Engineers entitled "Natural-Gas-Fueled Vehicles Exhaust Emissions and Operational Characteristics." I shall be happy to submit a copy of this paper for the record.

The Pacific Lighting system is a dual-fuel system. A vehicle is equipped with tanks for its supply of compressed natural gas but at the same time retains its capabilities to utilize gasoline if for any reason unusual mileage demands exceed its supply of natural gas. The switch from natural gas to gasoline, or vice versa, is made easily even under driving conditions.

The dual-fuel system is currently in operation on an increasing number of motor vehicles in fleet operations throughout the country including test vehicles of the General Services Administration whose Administrator has presented testimony at these hearings.

While the major purpose of the system is air pollution abatement from this major source, it is important to note that, in the case of fleet vehicles, it is possible, through its adoption, to achieve a very real economic gain, which can be said of almost no other air pollution control equipment. A hundred cubic feet of natural gas will power a vehicle from 15 to 20 percent further than a gallon of premium gasoline and costs far less.

There are no natural gas refueling stations today for the individual auto owner, and few could afford their own, but is it not reasonable to control the 10 percent of vehicles which contribute 30 percent of the air pollution from motor vehicles in urban areas, while awaiting technological developments which will make natural gas an acceptable fuel, costwise, to the owner of the family car? And may I add that the present difficulty for the individual car owner is development of a low-cost small compressor which can be utilized in the home, very similar to the type a scubba diver uses to fill his oxygen tanks.

In discussing the dual fuel system with interested Members of the Congress, some have suggested that tax incentives might be considered in order to realize a maximum reduction in air pollution in a minimum period of time. Rapid amortization of the cost of basic equipment or a favorable consideration of natural gas in the highway user-gasoline tax structure were mentioned.

Realizing that there is a possibility for confusion among various types of fuels, I want to make it clear that in proposing the use of natural gas I am referring to the fuel that is piped into nearly every urban building for space heating, cooking, water heating, or industrial operations. I am not referring to liquified petroleum gas or liquified natural gas, although both of these fuels have definite air pollution control potential. The technology for their adaptation to motor vehicles is on the way, but is not currently as far advanced as that for natural gas.

To compare the air pollution advantages of natural gas-powered fleet vehicles over the electric auto it is necessary to consider refueling methods. Plugging into a natural gas line is not comparable to plugging into an electric powerline. With the former you utilize only a natural gas and an electric-powered or natural gas compressor to fill fuel tanks. The power to fuel electric cars would constitute a demand on steam power facilities which would increase the use of fuels which in themselves may increase pollution from a major source in urban areas.

Further, the methodology for utilizing natural gas in the internal combustion engines is here today. It is immediately available to all automobile operators, from the owner of an individual car or truck to the Post Office Department which operates 65,000 start-idle-stop vehicles. For the fleet operator, it is available at a price that will very nearly pay out in savings on operation and maintenance during the first year of operation.

The individual owner would purchase his equipment to adapt to natural gas usage at a comparatively high initial outlay. However, this equipment can be removed from one vehicle, installed on another, and used through a succession of vehicles.

In summary, reduction of air pollution from motor vehicles is critical. Fleet operators of short-range vehicles are the greatest contributors on an individual basis in the pollution-ridden urban areas. When it can be shown that these operators can make a major contribution to the solution of this problem while reducing the cost of their operations, there appears to be no reason why such a program should not be furthered in every way possible.

May I, for your official record, state that not only does Pacific Lighting Corp. support S. 3072, but that I personally, based on experience in Los Angeles County, firmly endorse the bill and its concept as an effective means of notifying the automobile industry of the Government's intent to find a workable solution to a civic problem.

Thank you, Mr. Chairman.

Senator CANNON. Thank you, Mr. Griswold, for a very fine statement.

We heard some testimony on this the other day, and it seemed that perhaps the existing supply would be a problem. Would that be any problem at the present time in your suggestions here for fleet operations?

Mr. GRISWOLD. The supply of the equipment?

Senator CANNON. No, of the fuel itself.

Mr. GRISWOLD. I cannot possibly see how there could be a shortage of this fuel for this purpose. While there is, of course, increasing demand for natural gas to provide industry a clean fuel, as compared to oil or coal, in order to meet air pollution regulations, yet there is availability of this fuel for this purpose. As I say, it is an excellent fuel from an air pollution standpoint and I am sure it is available in quantities for this purpose wherever there is a real demand.

Senator CANNON. But in your suggestion here that this be applied to the fleet operators, for example, you are suggesting a situation there where they would need their own refueling facilities? You wouldn't have to have any open-to-the-public-type facilities for that type of an operation?

Mr. GRISWOLD. Actually, in Phoenix, Ariz., which, as you know, Senator, doesn't have the cleanest, highest, driest, healthiest air in the West any more, Arizona Public Service is trying this program out, and intends to install two service stations, one downtown for use by State, county and city vehicles with dual fuel systems, and one out at their own plant to service their own vehicles. But the one they are making available downtown is going to be for individuals who want to come by and have their natural gas tanks repressurized.

Senator CANNON. Have they actually gone to this system at the State level now?

Mr. GRISWOLD. In Arizona?

Senator CANNON. Yes.

Mr. GRISWOLD. I was discussing this with Governor Williams last week. The State, through the cooperation of the Arizona Public

Service, is going to make installations on several of its vehicles. The city and the county also intend to participate in this program.

Senator CANNON. Sort of a test program? Is it in the nature of a test program as such?

Mr. GRISWOLD. They are going to learn its adaptability to their particular type of fleet operations.

Senator CANNON. Thank you very much for your very fine statement. We appreciate your fine work in this field.

(The attachments to the oral statement follow:)

NATURAL GAS VEHICLES, INC.

FACT SHEET—COMPRESSED NATURAL GAS FUEL SYSTEM FOR MOTOR VEHICLES

General Accomplishment

The development of a simple inexpensive system that can be applied to presently operating motor vehicles, reduce contaminant emissions drastically, and decrease operating costs while maintaining acceptable performance.

Use of Natural Gas in Internal Combustion Engines

The use of natural gas as a fuel for internal combustion engines is not a new concept. Pipeline compressor engines have operated for years on natural gas. This fuel is also used by oil field operators, farmers, and water districts to power engines. It is equally feasible to use natural gas as a fuel for motor vehicles. Natural gas has an octane rating of 130 as compared to 100 for premium grade gasoline.

Description of the Dual Fuel System

Compressed natural gas for the system is stored in pressurized tanks approved by the government (I.C.C.). The tanks are located in or on the vehicle. A fuel line connects the tanks to regulators installed in the engine compartment of the vehicle. The regulators reduce the pressure of the natural gas before it enters a specially designed gas-air mixer which replaces the conventional air cleaner of the carburetor. This gas-air mixer is the "heart" of the system and includes an air filter. The control cable on the dash panel changes the setting in the gas-air mixer to allow either natural gas or gasoline operation interchangeably.

Safety Features

Throughout the test program, safety has been the prime consideration in the development of the compressed natural gas fuel system. Several characteristics of natural gas make it an inherently safe fuel. Natural gas is lighter than air. In case of a leak, it will rise and dissipate harmlessly into the atmosphere. Heavier-than-air fuels will "puddle" on the ground and present a potential fire hazard. The ignition temperature of natural gas is higher than that of many other fuels—1,300 degrees Fahrenheit—which means that it takes a hot spark to ignite the gas. Finally, the ratio of natural gas mixed with air must be within narrow limits in order for combustion to take place.

Starting with these inherent safety qualities of natural gas, a system has been designed that is safe and practical for motor vehicle operation. All affected components of the system have been tested to 10,000 p.s.i. Only I.C.C. approved tanks are used and are rated at 2,650 p.s.i. These tanks are fueled to 2,250 p.s.i. Insurance underwriters and fire protection officials have inspected the system and have said that it is as safe or safer than conventional gasoline or LPG powered vehicles.

Dual Fuel Capability

In a vehicle equipped with the CNG system, clean-burning natural gas is normally used instead of gasoline where conventional motor vehicles are apt to be pollution offenders—at "stop-and-go" speeds in heavy traffic and congested urban areas.

If operation of the motor vehicle beyond the range of the stored natural gas fuel is desired, the pull of a choke-like cable located on the dashboard converts operation of the vehicle to gasoline. This simple switch can be made while the vehicle is operating. The dual-fuel system does not require engine modification and is not expensive.

Reduced Air Pollution

The dual-fuel system has produced dramatic results in the reduction of air pollution emissions. Some of the vehicles converted in the original test project have been driven nearly 40,000 miles. Subsequently, an additional 50 vehicles were converted for fleet evaluation of emissions from various engines. There was no deterioration in vehicle emission performance with mileage accumulation. The following results of certification tests performed by the California Air Resources Board illustrate typical emission reductions achieved by using natural gas as a fuel for both an old vehicle without air pollution control equipment and a new vehicle equipped to meet Federal emission standards for new motor vehicles and motor vehicle engines. The 1974 California emission standards are much more stringent than any now proposed by the Federal government.

1968 FORD RANCHERO, 289 CUBIC INCH V-8 ENGINE

[Fuel emissions in grams per mile]

Pollutant	Gasoline	Natural gas	California 1974 standards
Carbon monoxide.....	28.20	2.11	23.0
Hydrocarbons.....	2.56	1.41 ¹	1.5
Oxides of nitrogen.....	3.82	.51	1.3

1965 RAMBLER AMBASSADOR, 327 CUBIC INCH V-8 ENGINE

Carbon monoxide.....	33.0	3.07	23.0
Hydrocarbon.....	3.2	1.8	1.5
Oxides of nitrogen.....	4.0	1.29	1.3

¹ Hydrocarbons, other than methane, amount to approximately 0.3 grams per mile.

Maintenance of Motor Vehicle Emission Controls

Adequate maintenance of existing motor vehicle emission control equipment is a critical factor in its effective performance. There is a definite tendency for deterioration in the performance of exhaust control systems when fueled with gasoline even with expensive maintenance and surveillance.

Natural gas is a clean fuel and exhaust emissions resulting from its use will not only comply with but exceed the requirements of all current state and Federal regulations without any deterioration in performance whatsoever.

Since there is no engine oil deterioration or sludging the positive crankcase ventilation valve will not require maintenance or replacement.

The compressed natural gas fueling system is a closed system and there are no evaporation losses from the carburetor and intake manifold.

Adaptability

The compressed natural gas fuel system is adaptable to all types of internal combustion engines. There are only two simple tuning adjustments to be made. One is made to suit the fuel demands of the vehicle on installation; the other is the idle adjustment. This idle adjustment is easier to accomplish than on the conventional carburetor. There are very few moving parts and the potential maintenance of this system is practically nil. Vehicles have been operating over one year without need for a single adjustment.

Installation of Compressed Natural Gas Fueling System

In most cars this system requires only four hours to install by a trained mechanic. Successive or multiple installations on the same type and model vehicle can be accomplished more quickly.

The kit is shipped complete with instructions for installation. The I.C.C. approved storage tanks can be shipped together with the conversion kit or the buyer may arrange to purchase them directly. The average fleet vehicle travels less than 100 miles per day. The characteristics and use of the vehicle will determine the number and size of these commercially available tanks.

Transferability from One Vehicle to Another

The system is easily and inexpensively transferable from one vehicle to another. The necessity might exist for the replacement of pressurized fuel line and possibly minor alteration of the mounting brackets for some components. The converted vehicle can be returned to full gasoline operation by replacing only the gasoline line from the fuel pump to the carburetor and reinstalling the original air cleaner.

Natural Gas Vehicles, Inc., will provide qualified assistance in the training of fleet mechanics and maintenance men at a minimum cost.

Vehicle Fuel Range

Depending on the size and number of storage tanks installed on the vehicle and fuel consumption characteristics of the engine the range of vehicles presently in service on compressed natural gas varies from 40 to 120 miles.

Compressed Natural Gas Storage Tanks

There are several sizes and weights of I.C.C. approved compressed gas storage tanks commercially available and suitable for use with the natural gas fuel system.

The size and number of tanks depend entirely on the type of vehicle, useable space and amount of fuel required for operations during any day-shift or convenient fueling period.

The dual fuel capability permits switching to gasoline if the supply of natural gas is insufficient to meet unusual operating needs.

The steel tank commonly used in commercial vehicles is 9' in diameter, 54' in length, and weighs about 100 lbs. A single tank will provide fuel for about 50 miles of normal operation.

The steel tanks now used in passenger vehicles are 9' in diameter, 27' long, and weigh about 15 lbs. Each tank will provide sufficient natural gas to fuel a large engine more than 15 miles. Current installations consist of manifolding eight of these tanks together in the luggage compartment which provide the vehicle with a range of approximately 120 miles.

Heat Potential of Natural Gas Compared to Gasoline

One hundred cubic feet of natural gas has an energy content of about 108,000 BTU. Gasoline of premium grade has a BTU value of 125,000 per gallon. Natural gas burns more completely and at a cooler temperature.

Natural Gas Refueling System

In the compressed natural gas system, it is more practical to refuel the tanks in place than to change tanks. At the present time, several compressor refueling systems with existing off-the-shelf components are being used for fleet operations. This compressor will be installed on the residential or commercial natural gas supply line and be powered by a 110 volt electric motor.

When fleet vehicles remain at a garage or another central location overnight, a repressurization cycle lasting several hours is satisfactory. But there are times when it might be necessary to refuel a fleet vehicle more rapidly. Several "tanker" vehicles have been developed to make a rapid refueling system possible. These carry a number of high pressure natural gas tanks. The fuel is transferred from these tanks to the vehicle being fueled by simply connecting a hose through a quick-disconnect fitting located on the vehicle.

Comparative Fuel Costs Less Road Taxes

Natural gas is available in every city in the U.S. and its price is regulated by FPC and State Commissions.

The average price per therm (100 cu. ft.) has varied only from 6¢ to 6.2¢ over the last nine years. An average vehicle will achieve about 15 percent more mileage on a therm of natural gas than on a gallon of gasoline.

Compression costs are estimated to approximate 4¢ per therm and road taxes 7¢ per therm. (This is the equivalent of the per gallon gasoline tax in California.) The total average cost per therm (equivalent gallon) would be only about 14¢ excluding road taxes.

The 130 octane fuel is ideally suited for today's high compression, high performance engines.

Oil and Oil Filter

When vehicles are operated on CNG it is not necessary to change the engine oil more than once each year regardless of mileage accumulated.

There is no crankcase oil dilution and it does not deteriorate as in an engine fueled with gasoline. In colder areas of the country an SAE 20 oil is used in October. The oil gradually thickens to the viscosity of SAE 30 by the warm season. Since there is no sludging the filter need not be changed more than once each year.

Spark Plugs

Natural gas contains no additives such as lead or purges such as TCP. Spark plugs do not foul or deteriorate and do not require gapping or cleaning. Experience with stationary engines indicates longevity to exceed 50,000 miles.

Positive Crankcase Ventilation System

Since there is no crankcase oil dilution, fouling, or sludging the PCV valve does not require periodic cleaning as when operating on gasoline. In fact, this system is not necessary if the *dual-fuel* capability is not used and the vehicle is operated continuously on CNG.

Exhaust System

Natural gas contains no additives, purges, or impurities. There are little or no corrosive compounds or gases flowing through the exhaust and tail pipes and muffler system. To date, more than 40,000 miles have been accumulated on vehicles fueled with CNG without evidence of exhaust system corrosion.

Engine Starting in Cold Weather

Since natural gas is always in the vapor state when *introduced* into the combustion chamber and since spark plugs are always clean, starting is nearly instantaneous regardless of cold weather conditions.

Vapor Lock

The CNG fueling system is a "closed" system and there is no possibility of vapor-lock. Additionally, an engine fueled with CNG runs cooler and does not have an equal tendency with gasoline-powered engines to overheat during normal operation.

Senator CANNON. The next witness is Mr. Edward Svoboda, Borg-Warner, in Illinois.

You are accompanied by Mr. Robert Stone; is that correct?

STATEMENT OF EDWARD SVOBODA, BORG-WARNER, DECATUR, ILL., REPRESENTING THE NATIONAL LP-GAS ASSOCIATION, ACCOMPANIED BY ROBERT STONE

Mr. SVOBODA. Yes, sir. That is correct. Mr. Stone is the attorney for the National LP-Gas Association. He is a former staff member of that organization. He will answer any questions regarding the association.

Mr. Chairman, members of the committee, my name is Edward J. Svoboda. I am a project engineer on emission control products for the Marvel-Schebler Division of Borg-Warner Corp., and am appearing on behalf of the National LP-Gas Association.

The National LP-Gas Association is the trade association for the nationwide LP-gas industry representing 4,400 members and 41 affiliated States. Its members account for 85 percent of the industry's volume of business and they participate on every level of commerce. They are producers of liquefied petroleum gas, manufacturers of equipment and appliances, and retailers of these related products. The LP-gas industry serves over 12 million installations, families and businesses,

it brings LP-gas to over 40 million people. Liquefied petroleum is the generic name for propane, butane, and their mixes. It is used in the household, on the farm and in a variety of commercial and industrial usages as a source of heat, power or refrigeration. LP-gas is a clean burning fuel. It is also used as a source of power or fuel for internal-combustion engines. It is in this latter respect that I appear before this committee with the considered opinion of the LP-gas industry that we have something to offer to this committee in its search for a motor fuel that will minimize air pollution.

We heartily endorse the objectives of bill S. 3072 introduced by Senator Magnuson. The encouragement of the development and use of a low-emission fuel or vehicle is unquestionably in the public interest and we feel that we can serve the public in providing such a low-emission fuel.

Use of LP-gas as a motor fuel is not necessarily new, but growth in its use as related to minimizing exhaust emission is comparatively new. It has a long history of use in automotive vehicles, going back nearly 50 years. However, recent concern with air pollution provides reasons and need for expanding its use in this respect. In August of 1961 the University of California in Los Angeles published a report on "Merits of Liquefied Petroleum Gas Fuel for Automotive Air Pollution Abatement," in which they concluded a significant reduction in smog would be possible with the use of LPG as a motor fuel. In 1964 we at Marvel-Schebler instigated tests on this fuel as a possible low-emission source fuel.

Research demonstrations and actual experience using existing equipment has shown that LP-gas when used as an engine fuel can contribute greatly toward the abatement of air pollution. Tests have shown that the noxious emission from LP-gas engines are considerably less than gasoline fuel engines with emission devices. Tests conducted to date indicate that LP-gas engines can meet the target set for low-emission vehicles as expressed by Senator Magnuson in introducing S. 3072. Test data relative to this is submitted with this statement, and I request that it be made part of the record.

Part of the test data is contained in two letters from the State of California Air Resources Board approving Century LPG fuel systems for use on engines used inside buildings and permitting after market conversions on vehicles originally equipped with approved gasoline emission control devices.

The data shows that in most cases the hydrocarbon and CO emissions fall within the 0.5 g.p.m. and 11 g.p.m. target specifications proposed by Senator Magnuson.

Further data on NO_x —or nitrogen oxide—emissions is contained in an attached memorandum listing test results obtained by an independent laboratory in Los Angeles, Calif. Of the 10 vehicles tested, nine were equipped with LPG fuel systems. The results indicate a substantial reduction in NO_x values as compared to known values for gasoline powered vehicles without special NO_x controlling features. While at this point the test data does not show full compliance with the target specification of 0.75 g.p.m. for oxides of nitrogen, it must be made clear that these target specifications were not used as criteria

when the tests were conducted. It appears that with minor adjustments, a goal of 1 g.p.m. could be achieved with LPG used as fuel in existing engines without waiting for an advance in the state of the art. In addition, we feel that as NO_x controls become available as original equipment, the goal of 0.75 g.p.m. will become realistic.

Bill S. 3072 sets up certain criteria for consideration in determining the values of the low-emission fuels. These criteria are: (1) The safety of the vehicle; (2) its performance characteristics; (3) its reliability potential; (4) its service ability; and (5) its fuel availability.

How does LP-gas meet these criteria? It is our opinion that it affords the best and present opportunity with respect to safety. Safety specifications covering LP-gas as a motor fuel exists in standards now published by the American National Standards Institute and the National Fire Protection Association. They are in State laws and regulations in substantially all States. The record is excellent.

As a demonstration of experience in safety, one user, the Chicago Transit Authority has an outstanding safety record after 716 million miles and 316 million gallons of LP-gas consumed.

Current performance characteristics of LP-gas fueled engines, with reduced noxious emissions, are equal to or exceed characteristics of gasoline fueled engines. It is not expected that the performance or power of LP-gas fueled engines will be significantly effected in the low-emission criteria.

As a demonstration of the hardware, the Chicago Transit Authority reports 416 of the original 500 LP-gas buses have averaged 530,000 miles per bus. As to serviceability any auto or truck mechanic can be instructed on the characteristics of LP-gas engine fuel in a matter of hours.

LP-gas is readily available at locations throughout the United States. There are nearly 100 petroleum companies engaged in the production and marketing of LP-gas. There are over 8,000 locations throughout the United States where LP-gas is received and stored in bulk by dealers, for ultimate distribution to consumers. These locations provide availability in quantity at these distribution points. In addition there are thousands of other smaller dealers who could become a point of supply.

We hasten to add that at this point in time we cannot pretend to serve the entire automotive market, but can contribute significantly, particularly in providing fleet maintenance where the economics are also favorable to LP-gas. Products and fuel will be available to supply this market as it develops. We can sum it up with the statement that anything any motor fuel can do, LP-gas can do better.

I thank you.

Senator CANNON. Thank you for a fine statement.

Do you have to do anything to the engine before you can use the LP-gas?

Mr. SVOBODA. No, not really. It is an option. You can intall better valves if you wish; you can raise the compression ratio. But these are all options that the user can either do or not do.

Senator CANNON. But is it not necessary to do so?

Mr. SVOBODA. No, sir, it is not.

Senator CANNON. In other words, you do not have to have any modifications, substantial modifications of the engine.

Mr. SVOBODA. No.

Senator CANNON. How do you store the gas? Do you store it in the existing tank or in an extra tank?

Mr. SVOBODA. The tank would have to be a standard high pressure tank approved by the American Testing Society. It is the standard bubble tank, round configuration.

Senator CANNON. Do you use the existing fuel lines? Does it flow through the conventional fuel lines?

Mr. SVOBODA. No, it does not. We have to have high pressure fuel lines.

Senator CANNON. On these buses do they have a dual system? You mentioned Chicago. Do they have a dual system or a single system?

Mr. SVOBODA. No, they just have the LP.

Senator CANNON. Some trucks I know do have a dual system.

Mr. SVOBODA. Yes, there is available on the market now a dual fuel system that can utilize the LP-gas or gasoline by merely a selection knob on the control panel.

Senator CANNON. What type of engines are in the buses that use those in Chicago, for example?

Mr. SVOBODA. I am not sure as to the make of the engine. I think they are made by Waukesha.

Senator CANNON. Are they a Diesel engine?

Mr. SVOBODA. No. They are a gasoline engine.

Senator CANNON. Are the odors that are normally associated with bus exhaust or bus fuels, are they evident around the Chicago buses?

Mr. SVOBODA. No, there is practically no odor from an LP-gas vehicle.

Senator CANNON. How do the fuel costs compare?

Mr. SVOBODA. Well, the fuel costs are substantially the same as gasoline. You are required to use a little more fuel per mile because of the lower B.t.u. content. However, when you consider the extended maintenance program and so forth that you are allowed to get by with on these vehicles, it actually saves money.

Senator CANNON. But you get lower mileage but your fuel itself costs about the same as gasoline?

Mr. SVOBODA. No, the fuel without taxes, regular fuel on a quantity basis such as a fleet operator would buy is about 16½ cents a gallon in the State of Illinois. LP is about 14 cents a gallon.

Senator CANNON. What is the average life of a conventionally fueled bus compared to these buses in Chicago now that you say you are getting about 350,000 miles?

Mr. SVOBODA. Well, actually, this is a hard question really. I would guess that the average vehicle of that type would be about 300,000 miles. This is what most fleet operators consider a lifespan for a truck.

Senator CANNON. Are all of the buses in Chicago converted to operating in this fashion?

Mr. SVOBODA. No, sir. It is sort of a pilot program where they converted 500 buses.

Senator CANNON. What is their total number of buses operating?

Mr. SVOBODA. Oh, gee, I do not have any idea.

Mr. STONE. I believe it is about 50 percent on LP-gas; in that neighborhood.

(The attachments to the oral statement follow :)

STATE OF CALIFORNIA—RESOURCES AGENCY,
AIR RESOURCES BOARD,
Sacramento, Calif., December 19, 1968.

Mr. E. J. SVOBODA,
Project Engineer, Marvel Schebler Division, Borg-Warner Corp.,
Decatur, Ill.

DEAR MR. SVOBODA: This letter is to confirm the approval of your exhaust emission control system for portable and mobile internal combustion engines (fork lifts) used inside buildings, as described in the enclosed copy of Air Resources Board report and resolution 68-97, adopted by the Board on December 19, 1968.

JOHN A. MAGA, Executive Officer.

STATE OF CALIFORNIA, AIR RESOURCES BOARD, RESOLUTION 68-97

Whereas, Marvel Schebler Division of Borg-Warner Corporation on December 12, 1968, submitted an application and all test data for California certification of an exhaust emission control system for portable and mobile internal combustion engines (fork lifts) used inside buildings; and

Whereas, the applicant's exhaust control system is described as an LPG (liquefied propane gas) fuel system under the Century trade name with major elements:

- (1) carburetor and regulator using liquefied propane gas
- (2) recommended maintenance

Whereas, the Board finds that the systems comply with the California Administrative Code, Title 13, Chapter 3, Sub-Chapter 1 and Sub-Chapter 2, Article 5: Now, therefore, be it

Resolved, That this Board under the powers and authority granted in Chapter 4, commencing at Section 39080, Division 26 of the Health and Safety Code, Issue a certificate of approval to Borg-Warner Corporation with respect to its exhaust control system for new and used portable and mobile internal combustion engines of size classifications (a3), (b) and (c) of the referenced Administrative Code Article.

STATE OF CALIFORNIA, AIR RESOURCES BOARD, STAFF REPORT, EXHAUST EMISSION CONTROL SYSTEM, MARVEL-SCHEBLER PRODUCTS DIVISION, BORG-WARNER CORPORATION, DECEMBER 12, 1968

Marvel-Schebler Division of Borg-Warner Corporation has submitted an application containing all of the test data for new and used engines required by the California Exhaust Emission Test Procedure for Portable and Mobile Internal Combustion Engines (fork lifts) Used Inside Buildings.

The applicant's exhaust control system comprises an LPG (liquefied propane gas) regulator model G-85 or H and the carburetor models listed below.

EMISSION DATA OF EACH TEST ENGINE PROJECTED TO 1,500 HOURS

Engine make	Engine			Carburetor		Emissions CO percent	
	Model	Class	Cubic inches	Make	Model	Test	Standard
Continental.....	Y112	A3	112	Century.....	3C-704LE	0.2	2.0
Do.....	Y112	A3	112	do.....	3C-704LE	.3	2.0
Do.....	Y112	A3	112	do.....	3C-704LE	.3	2.0
Do.....	F163	B	162	do.....	3C-705LE	.2	1.5
Do.....	F163	B	162	do.....	3C-705LE	.5	1.5
Waukeshaw.....	D1556	B	155	do.....	3C-705LE	.2	1.5
Continental.....	F163	B	162	do.....	3C-705LE	.7	1.5
Chrysler.....	30	C	230	do.....	3C-705LE	.4	1.5
Continental.....	F227	C	227	do.....	3C-705LE	.3	1.5
Do.....	F6209	C	209	do.....	3C-705LE	.4	1.5
Do.....	F227	C	227	do.....	3C-705LE	.1	1.5

Based on the test data and other information submitted by the applicant, the staff finds that the Borg-Warner Corporation exhaust control system meets California requirements. The staff, therefore, recommends adoption of Resolution 68-97.

STATE OF CALIFORNIA—RESOURCES AGENCY,
AIR RESOURCES BOARD,
Sacramento, March 21, 1969.

Mr. E. J. SVOBODA,
Project Engineer,
Marvel-Schebler, Division of Borg-Warner Corp.,
Decatur, Ill.

DEAR MR. SVOBODA: We are pleased to inform you that the enclosed resolution and report were adopted by the Air Resources Board on March 19, 1969.

JOHN A. MAGA, Executive Officer.

STATE OF CALIFORNIA AIR RESOURCES BOARD, RESOLUTION 69-14

Whereas, in 1968 the California Legislature amended Section 27156 of the Vehicle Code to provide for operation of vehicles on fuel other than gasoline where the emissions are at levels which comply with existing emission standards, and

Whereas, in August 1968, the Air Resources Board staff, on instructions from the Board, published a demonstration program for systems operating on fuel other than gasoline to show compliance with emission standards, and

Whereas, on February 10, 1969, Marvel-Schebler Division of Borg-Warner Corporation submitted test data from such a demonstration program on two models of Century carburetors utilizing liquified petroleum gas (LPG); Now, Therefore, be it

Resolved, that this Board finds that the emissions of engines equipped with Century carburetors listed below comply with existing standards, making these carburetors legal for use in California on both light and heavy-duty vehicles of 1966 through 1969 model year for those engine sizes listed below:

Carburetor model	Engine sizes
3CG-706-LE-----	200-300 cubic inches.
3CG-705-DTLE-----	over 300 cubic inches.

STATE OF CALIFORNIA, AIR RESOURCES BOARD, STAFF REPORT, EXHAUST EMISSION CONTROL DEMONSTRATION FOR LIQUIFIED PETROLEUM GAS CARBURETORS, MARVEL-SCHEBLER DIVISION OF BORG-WARNER CORP., MARCH 19, 1969

Marvel-Schebler Division of Borg-Warner Corporation has submitted test data in accordance with the attached program to demonstrate that two models of Century LPG carburetors comply with existing emission standards. These data are shown below:

Carburetor model	Applicable displacement class	Engine size (cubic inches)	Test vehicle	Projected emissions at 50,000 miles		Test type
				HC (parts per million)	CO (percent)	
3C-706-LE-----	C	240	1969 Ford, 1/2 ton-----	230	0.3	Light duty.
	D	292	1968 Chevrolet, 3/4 ton---	79	1.3	Heavy duty.
3CC-705-DTLE-----	E	327	-----do-----	30	.2	Do.
	F	390	1969 Ford, 3/4 ton-----	36	.4	Do.

Each test vehicle in the fleet met the emission standard.

Based on the test data submitted by the applicant, the staff finds that the Century carburetor models listed comply with existing emission standards. The staff, therefore, recommends adoption of Resolution 69-14.

[Inter-office Correspondence]

MARVEL-SCHEBLER,
Decatur, Ill., January 13, 1970.

To: R. N. Little.
From: E. J. Svoboda.
Subject: NOx Values on LPG Vehicles.

On January 8, 1970 the Western Liquid Gas Association sponsored a test for the purpose of determining the NOx reducing potential of LPG fuel. A total of ten vehicles, converted from gasoline to LPG fuel at sometime in their history, were picked to represent the majority of engines operating in the Los Angeles area.

The tests were conducted by Olsen Labs, Inc., 5037 Telegraph Road, Los Angeles, California, using the official 7 mode cold start.

The results were as follows on the attached page.

E. J. SVOBODA.

Test No.	Vehicle	CID	Mileage	Fuel system	Special engine alterations	Test results ¹						
						HC p.p.m.	CO (percent)	NOx p.p.m.	HC p.p.m.	CO (percent)	NOx p.p.m.	
1	1969 Chevrolet 3/4-ton pickup.	350	3,723	Century		94	0.13	349	180	1.00	0	1,06
2	1969 Chrysler	440	31,291	Impco.	Vacuum advance disconnected; deceleration device installed in at 18 m.p.h.; out at 15 m.p.h.	54	.26	469	150	.85	870	
3	1968 Ford 1/2-ton pickup.	240	18,252	Dual fuel Impco LNG	Vacuum advance disconnected.	67	.18	777	200	1.10	1,170	
3A	do.	240	18,252	Gasoline	do.	162	.51	1,611	200	1.10	1,170	
4	1970 Ford 1/2-ton pickup.	351	441	Century	Vacuum advance disconnected.	143	.42	741	180	1.00	1,060	
5	1969 Plymouth	383	29,121	Impco.	do.	160	.11	420	180	1.00	1,060	
6	1970 Chevrolet 1/2-ton pickup.	350	825	do.	do.	148	.05	676	180	1.00	1,060	
6A	do.	350	825	do.	Rework distributor advance so weights would not advance until 1,350 r.p.m. or 35 m.p.h.	136	.07	242	180	1.00	1,060	
7	1970 Chrysler	440	4,542	Century	Vacuum advance disconnected; idle distributor solenoid disconnected.	32	.17	450	150	.85	870	
8	1969 Pontiac	400	18,313	Impco.	do.	99	.17	602	180	1.00	1,060	
9	1968 Chevrolet	350	70,946	Century	Vacuum advance disconnected; idle distributor solenoid disconnected. 5,000 miles on engine.	76	.37	598	180	1.00	1,060	
10	1965 Oldsmobile	425	128,452	Impco.	Personal car of Petrolane employee; has many engine changes not revealed. Certain to have NOx controls.	61	.05	333	180	1.00	1,060	

¹ Corrected to the 13 carbon ration and 0.75 reactivity factor.

Senator CANNON. Thanks very much. We appreciate your appearing here and giving us your views.

We have two statements to submit for the record, one from Mr. Arthur M. Mackwell, Public Relations Officer, Engelhard Minerals and Chemicals Corp., which will be made a part of the record and another one from Mr. Edward Knapp, Anti-Pollutant Controls, Inc., both of which will be submitted for the record.

(The statements follow:)

STATEMENT OF ARTHUR M. MACKWELL, ENGELHARD MINERALS & CHEMICALS CORP.

Mr. Chairman and members of the committee, it is the conviction of many, if not most experts on automotive air pollution that we will have to deal with this source of pollution within the broad parameters of the internal combustion engine as it is now in use. No other power source either has or gives promise of having the performance characteristics presently provided by the internal combustion engine. And the traveling public has given no indication that it will accept significant changes in the performance it presently obtains from the products of Detroit.

It is our purpose here, as briefly and with as little technical obfuscation as is consistent with clarity, to suggest that a catalytic exhaust purifier will provide the foundation for an emission control system which will meet the most stringent standards which can reasonably be set. The catalytic exhaust purifier and the emission control system which can be structured upon it, using presently existing technology, are wholly compatible with the gasoline powered internal combustion engine and will not significantly affect its performance.

To put that another way, in principle we can clean up the exhaust on current model automobiles using existing technical development. And we can do it for far less than the 25 percent premium cost that the bill presently under consideration allows.

There are presently several catalytic exhaust purifiers on the commercial market. Without question, the best catalytic agent for these purifiers is a platinum group metal. This statement will deal with the performance and potential of the PTX and PTX-D Purifiers made by Engelhard Minerals & Chemicals Corporation, which has a platinum group metal catalyst deposited on a ceramic carrier.

The PTX Purifier is designed for internal combustion engines powered by liquid propane gas or unleaded gasoline. The PTX-D Purifier is designed for engines powered by diesel fuel. The primary uses of the PTX and PTX-D Purifiers to date have been on fork lift trucks and on stationary installations in confined spaces or in other circumstances where purity of air is especially important. For example, thousands of purifiers are in use on equipment used in warehouses, ship holds, mines and food storage or handling depots. Another example, one major industry has asked its supplier of emergency generators to design this equipment so that a PTX purifier can be installed without modification of the exhaust system. In this industry, the emergency generator exhaust often is located near the air conditioning intake.

The State of California is the only state to have a certification program for vehicles designed for use in confined spaces. The PTX Purifier has been certified for use in conjunction with liquid propane gas fueled vehicles following exhaustive test procedures conducted under the supervision of the California Air Resources Board. The reductions in carbon monoxide and hydrocarbons which are obtained by use of the PTX Purifier with unleaded gasoline can be readily ascertained by perusing these test results on a fork lift truck in use in a major brewery.

	Idle		Governed speed	
	In	Out	In	Out
CO percent.....	3.54	<0.006	1.34	<0.006
CH ₄ p.p.m.....	320	<50	90	<50
C ₂ H ₄ p.p.m.....	260	<50	250	<50
Hydrocarbons ¹ p.p.m.....	590	<50	110	<50

¹ Calculated as n-hexane.

Smoke in exhaust: None at steady speed, slight on acceleration. Odor in exhaust: None.

These examples are cited to show that, outside the automotive field, the catalytic purifier has had wide acceptance and has been in use in industrial equipment and installations since 1964.

Except for testing purposes, the PTX purifier has not been used on passenger automobiles. Why? Because the lead in most gasoline poisons the platinum catalyst and limits its efficiency. There has been no technical solution to this problem in sight for the makers of catalytic mufflers and for that reason they have not concentrated their efforts on the passenger car field. There is, of course, a solution to the problem which lies beyond the power of the makers of catalytic mufflers to implement or even to influence to any substantial degree. That is to take the lead out of all gasoline. Until recent months, there has been little evidence that this will be done. Now, however, it is becoming apparent from the statements of members of Congress, from persons high in the Administration and from people in the automotive field that a gradual reduction of the lead in gasoline, leading to its eventual elimination, is seriously contemplated. This would be done, primarily, because lead is a poison and, as William Megonnell, Assistant Commissioner of NAPCA said recently, "the combustion of gasoline in automobiles is the major source of lead in the atmosphere." But it also would clear the path for use of a catalytic purifier on passenger automobiles.

There have been some tests conducted with a catalytic purifier on passenger autos, using both leaded and unleaded gasoline in the laboratory and over the road. These test results indicate that the catalytic purifier has every bit as much potential for cutting pollution from passenger cars as it does for fork life trucks and other industrial equipment. For example, as far back as 1963 road tests using unleaded gasoline in a high mileage 1954 popular model auto indicated an average reduction in carbon monoxide of approximately 90% and reduction in hydrocarbons exceeding 70%.

The results of these very limited road tests may very well be modified when fleets of modern cars are equipped with the PTX muffler or some similar catalytic device and driven under widely varying conditions. Obviously, wider experience with a catalytic purifier on passenger cars ought to lead to improvements in the purifier and ways of using it which, eventually, will give better results. The City of New York is contemplating equipping a number of cars with catalytic purifiers in order to test their efficacy and longevity. If test results are as anticipated, they will equip the city fleet with catalytic mufflers and use unleaded gasoline. We ought to learn something from that.

There is one other problem which has defied solution in the past. That is the abatement of oxides of nitrogen, one of the major pollutants from auto exhaust. The major auto companies have been working on a device to greatly reduce or eliminate the oxides of nitrogen. And, while there has been no specific public announcement yet, statements of various industry leaders, including Henry Ford II, clearly indicate that they have been successful in this endeavor and that such a device is wholly compatible with a catalytic purifier.

Detroit already has developed modifications to the carburetion and ignition systems which have aided in cutting down pollutants. And the NAPCA has indicated it will have recommendations on altering the composition of gasoline to further cut emissions.

To summarize: the heart of an effective pollution abatement system for the passenger auto as we know it now is a catalytic purifier, in tandem or combined with a device to reduce or eliminate oxides of nitrogen; these to be used with an engine powered with unleaded gasoline.

If this committee and The Congress, through the legislation before you now, can stimulate the further development, production and use of this existing technical knowledge in the automobiles used by the Federal Government, it will have made a giant contribution to the war on air pollution.

STATEMENT OF EDWARD M. KNAPP, VICE PRESIDENT OF ANTI POLLUTANT CONTROLS, INC.

Reference is made to a conversation with Mr. Sutcliff of the staff on January 16 wherein he stated that the Subcommittee would not have time to hear us but that he suggested that a statement of what would have been said by us be submitted in writing. This statement follows:

I am Edward M. Knapp, Vice President of Anti Pollutant Controls, Inc., a corporation of the State of Maryland, located at 4501 Upshur St., Bladensburg, Maryland. May I introduce the other officers of the corporation, Mr. Leslie J. Kinney, President, and Mr. Stephen J. Nesbitt, Treasurer.

Anti Pollutant Controls, Inc. was organized by a group of inventors to hold, protect, and introduce into commerce a group of patents and patent rights dealing with anti pollution devices and systems. All of these rights were created by the inventors who are stockholders in this corporation, and all of the rights are pledged to the corporation. We appear here to support the pending bill S-3072 because, as one of the inventions in the pool, we own a group of devices which when added to the present internal combustion engine as used on automotive equipment make of the present internal combustion engine a "low emission vehicle" within the definitions of this legislation. Later in this statement we will suggest certain specific amendments to the bill.

Before discussing the group of devices which will make any of the present internal combustion engines "low emission engines", we direct attention to the fact that Anti Pollutant Controls, Inc. has for development devices and systems in other areas of pollution control.

Anti Pollutant Controls, Inc. offers a system which when applied to smoke stack, such as those on incinerators where solid waste is burned, power plants where fossil fuels are burned, and chemical plants of various kinds, reduces the sulphur dioxide and smoke particles emitted to zero. The system also handles the emission of other pollutants. It uses a chemical reaction which operates only under certain specified conditions, and the invention deals with a method of creating those conditions and initiating the reaction.

We also own the patent rights on a system using a microwave energy for the desalination and/or purification of water. This is a system which can be built in small modules of 12,000 gallons a day or it can be built into large plants of several million gallons a day. The system will handle saline water, sewage, or industrial waste water and turn any of these into potable water, with a few possible exceptions. The system uses a minimum of equipment and expense, and its projected costs are lower than those of the present art.

Anti Pollutant Controls, Inc. has developed a system whereby any car, truck, or bus driven by an internal combustion engine can be economically turned into a low emission vehicle operating on a regular gasoline obtained at any service station. The system has been in operation on a 1959 Rambler. Its adaptation to propelling that vehicle on the road needs only further development. Application of the system to other makes and models of cars would be rather simple and inexpensive. We have proved the essential point that we are putting gasoline in the car, changing the gasoline under the hood to a gas similar to natural gas, and immediately burning that gas in the engine with no more pollution being emitted from the exhaust that you would get from the gas stove in your home.

The system includes two elements, (1) a steel chamber set into the exhaust line leaving the engine, gasoline fed to that steel chamber and changed into gas by the heat of the exhaust, this gas being fed to (2) a carburetor suitable for natural gas, and replacing the present day gasoline carburetor. The engine starts on gas, not gasoline, and thus this is not a dual fuel arrangement. In a year of operation we have not had to change the spark plugs or the timing. Putting our system on any car, old or new, can be done at any service station and does not require a skilled mechanic.

The results of the operation of this engine in conjunction with our patented system are shown by the attached copies of reports of two independent analytical

chemical laboratories. The analytical reports are made part of this presentation by reference. We quote the following salient report paragraphs:

First, from the covering referral sheet prepared by Anti Pollutant Controls, Inc. "The internal combustion engine used is that of a 1959 Classic Rambler, modified only by the replacement of the standard carburetor by a carburetor designed for the use of natural gas, and the installation of our system. A regular grade gasoline bought at the nearby service station is placed in the gasoline tank of the car. It is fed from there to our device imbedded in the exhaust line. It should be noted that in a car of this age the fuel pump, a subsidiary unit, was found to be inoperable and was removed entirely, being replaced by a simple gravity feed system. The device is a steel chamber where the heat of the exhaust alters the chemical nature of the liquid gasoline and turns it into a gas. The gas fuel is fed directly to the natural gas carburetor mounted in place of the normal carburetor through a 5/8" copper tube. Flow of gas is regulated by a manually operated needle valve. The sampling system for the gaseous fuel is described in the reports of the analytical chemists."

Second, from the report of the Washington Reference Laboratories, signed by Howard Willner, Chief Chemist and Deputy Director. "Sample collection tubes had been prepared in advance under negative pressure in anticipation. Two samples were collected and were labeled as A & B. Sample A was collected by attach-a-length of Tygon tubing to the nipple of the gas sampling tube and inserting this tube into the exhaust pipe of the automobile engine. The stopcock was then opened and exhaust gases entered the gas sampling tube until equilibrium was achieved. The gas sampling tube stopcock was closed to seal, and the sample labeled A and shipped to Sadtler Research Laboratories for IR analysis." The procedure for the collection of Sample B from the gaseous fuel going to the engine was similar to that described.

The reference to IR analysis means Infrared Analysis. Infrared Analysis of chemical compounds is a method under which infrared light is passed through the compound. Each separate chemical compound, and they are numbered in the thousands, has a distinctive pattern of frequencies at which it absorbs infrared light. There is a complementary pattern of frequencies at which the compound is transparent to infrared light. By scanning across the entire spectrum of infrared light, in order, the analyzing machine produces a distinctive trace on a graph, defining precisely the pattern of frequencies at which infrared light is absorbed, as unique an identification as a finger print, and easily matched with well known spectra of compounds as recorded in the library of spectra.

Returning to the report of the Washington Reference Laboratories, we quote as follows:

"Discussion of Results:

"1. *Sample A.* This sample was submitted to IR analysis according to the protocol as described in the letter from Mr. Young (copy attached). The attached spectrogram (78430-1) is a perfect match for carbon dioxide (reference scan #3).

"The meaning and impact of this statement lies in the fact that by the route of complete combustion and *only* by this route can one achieve combustion products which do not include unburned hydrocarbons.

"Further, in a phone conversation with Mr. Young of Sadtler we were informed by him that the level of CO (carbon monoxide) detectable by this instrument is in the range of one part per billion, so that we may safely assume a level of carbon monoxide in the exhaust of this engine approximately 0.001% of the usual internal combustion engine fueled by gasoline.

"2. *Sample B.* This sample was examined in two parts, part 1 being the condensed liquid in the sampling tube, part 2 being that material which remained in gaseous state after temperature decrease. The liquid portion was subjected to IR analysis and MMR. Analysis indicated that there were a series of straight chain and branched hydrocarbons varying in length, with the average length being C₆ and an average molecular weight of less than 100. Included in this group were 5% aromatic compounds, which were identified as xylene and toluene.

"The gaseous portion of the sample was subjected to IR analysis and the spectrogram (78430-5) thus derived was almost identical to a reference spectrogram (#113) for N-butane. It may be stated with certainty that the gaseous material present is all in the range of C to C₆.

"The meaning of these two statements is in effect that all of the material identified as Sample B is material with chemical and physical properties such that it would be a gas at engine operating temperatures. Commercial gasoline is not such a compound."

The final quote is from the report of Sadtler Research Laboratories, this sent to Washington Reference Laboratories, signed by Mr. Elien Young, Research Chemist.

"*Sample A.* An infrared spectrogram of the submitted sample was prepared on a Bausch and Lomb/Shimadzu Spectronic 270 IR infrared spectrophotometer. The resulting spectrogram No. 78430, when compared to the Sadtler Standard Infrared Spectra of Pure and Commercial Materials yield a perfect match for carbon dioxide. A reference spectrum of carbon dioxide is included for your records." The paragraph in the Sadtler report dealing with Sample B is long and technical and therefore we quote only the last sentence, as follows: "It can be concluded that the gases present in the sample are straight chain hydrocarbons in the C to C₆ range".

What we have described here is a system to make the present internal combustion engine a low emission engine. The conversion is inexpensive, and there is no need to outlaw the gasoline engine. There is no need to create a distribution system for an exotic and dangerous fuel, including the wholesale changes required in zoning regulations. There is no need to revert to either the steam car or the electric car in order to obtain freedom from pollution. The present engine, modified according to our system has essentially the same performance as the present engine, unmodified. It drives about the same, it is fueled at its regular gasoline service station, it is no less safe or reliable than the present engine, and it can be repaired in any service station.

The system we have just described has applications far beyond the automotive. The system was first conceived of in response to a request from the Maritime Commission for a means, other than an additive, to remove corrosive metallic compounds from the heavy fuel oils used in marine turbines (nominally gas turbines) for ship propulsion. The combustion of these metallic compounds chews up the turbine blades. What better answer than to turn the heavy fuel oil into a gas, removing the metals in the process, and to burn a non corrosive gas in the turbine, with the added inducement that the ship emits no smoke.

With the concept in hand it is obvious to apply it to smaller turbines, used in industry for power. The problem of corrosion is hardly present here because of the use of more refined fuel oils, but the principle of turning a liquid fuel into a gas and turning the turbine into a true gas turbine is valid.

The system would also apply to the jet engine used in aircraft. By turning jet fuel into a gas and burning that gas, the long dark plume of unburned carbon would be eliminated, along with the oxides of nitrogen. One airline has been discussing this application with an agent of the corporation.

While the present legislation excludes military vehicles, the system we propose has military applications. Huge sums have been spent to develop a multi-fuel engine, a mover for the military services which would adapt to the variety of fuels available. We suggest that proven efficient engines be turned into multifuel engines by converting the variety of fuels into a single efficient fuel, a combustible gas.

Another adaptation of the system and device is suitable for insertion in the home oil burner. The effect is to turn an oil furnace into a gas furnace. Air conditioning with an oil furnace appears to be difficult—at least there appears to be no system for it on the market. Air conditioning with a gas furnace is reported to be easy. The system can also be adapted to a large power plant.

A staff report to the Federal Power Commission recently pointed out that by 1975 a sizable portion of the United States will suffer from a shortage of natural gas. Present gas reserves and transmission lines will handle the present loads for the indefinite future. However, the known reserves will not support the building of the new transmission lines required to enable gas companies to take on the new projected loads, particularly the big industrial loads. The system we propose could be used by gas companies to manufacture gas on the spot from residual fuel oil for which no shortage is forecast.

In supporting S-3072 wholeheartedly, we do suggest some changes in the language of Section 4, subsections (a), (b), and (d). Each of these subsections uses a phrase "models or classes of motor vehicles" or a variant of the phrase.

We suggest that in each case where the phrase cited is used, there be inserted immediately following it the words "including modifications of present models or classes of vehicles." The places for the insertion are: subsection (a) page 3 of the bill, line 19; subsection (b) page 3, line 22; subsection (b) page 4, line 7; subsection (d) parentheses (1), page 4 of the bill, line 19; subsection (d) parentheses (5), page 5, line 10; and subsection (d) parentheses (6), page 5, line 13. We further suggest a change in the language of Section 4, subsection (d) parentheses (6), page 5 of the bill, line 15. We suggest the deletion of two words as follows: *presently being*. We further suggest the insertion of the following words after the word "purchased"—"in the past, at present, and in the future".

We are not about to offer any new models, makes, or classes of vehicles. With our system of modification included, any make, model, or class of vehicle remains that same make, model, or class, but it becomes a low emission vehicle within the definition stated in this bill. Under the present language it would not be eligible for certification under this bill, regardless of its performance as a low emission vehicle. What we are proposing is that a maker of any standard automotive vehicle can apply to that vehicle our modification and apply for that vehicle to be certified under this bill.

Anti Pollutant Controls, Inc. is by nature a research and management corporation dealing with a variety of patentable art. We do not look forward to becoming a manufacturing organization for the production of any of the hardware involved in the technologies covered in this statement. This covers not only the applications derived from the automotive art, each of which is a separate business, but also the technologies in desalination of water, and in the elimination of polluting emissions from any smokestack.

We are prepared to license interested parties in any of the fields we have mentioned, either established industrial organizations now in those fields, or investors who wish to set up new organizations to produce and/or market the hardware. Our own efforts are being directed at present to the development of further ideas in any of these fields.

ANTI POLLUTANT CONTROLS, INC.,
EDWARD M. KNAPP,
Executive Vice President.

ANTI-POLLUTANT CONTROLS, INC.,
Washington, D.C.

REFERRAL

Attached are copies of two reports by independent analytical chemists as to the composition of (1) the gaseous fuel used in an internal combustion engine and produced by and in a device inserted in the exhaust system of that engine, and (2) the engine exhaust produced by the combustion of that gaseous fuel.

The internal combustion engine used is that of a 1959 Classic Rambler, modified only by the replacement of the standard carburetor by a carburetor designed for the use of natural gas. A regular grade gasoline bought at a nearby service station is placed in the gasoline tank of the car used. It is fed from there to the device imbedded in the exhaust line. It should be noted that in a car of this age the fuel pump, an auxiliary unit was found to be inoperable and was removed and entirely replaced by a simple gravity feed system. The device is a steel chamber where the heat of the exhaust alters the chemical nature of the liquid gasoline and turns it into a gas. The gas fuel is fed directly to the carburetor designed for natural gas and mounted on the engine through a $\frac{5}{8}$ " copper tube. Flow of gas is regulated by a manually operated needle valve. The sampling system for the gaseous fuel is described in the reports of the analytical chemists.

This device for the production of gaseous fuel under the hood of an internal combustion engine is covered by patents issued and pending, all assigned to Anti Pollutant Controls, Inc.

ANTI-POLLUTANT CONTROLS, INC.,
EDWARD M. KNAPP.

SUPPLEMENTAL STATEMENT

Anti-Pollutant Controls, Inc. comments upon a number of matters brought out by testimony before the Sub-committee in hearings on S-3072, January 27, 28, and 29, 1970.

1. Senator Goodell was asking various witnesses about measures being taken to control the emission of lead compounds through the exhaust. Such poisonous compounds are derived from the addition of tetraethyl lead to the gasoline to improve its octane rating. He was told by all the witnesses who spoke that nothing could be done to control the emission of lead compounds, except by a complete ban on the use of leaded gasoline, replacing it with the use of an unleaded gasoline at an added cost of about 4¢ per gallon, plus a lag of a number of years while the gasoline producers installed the equipment to produce an unleaded gasoline in large quantities.

Anti-Pollutant Controls, Inc. responds quite differently to Senator Goodell's question, saying that there is a way to control the emission of lead and that we have it. We put a leaded gasoline in the tank of our apparatus, and the reports of the chemists indicate that (1) none of the lead is showing up in the gaseous fuel fed to the engine, and (2) no lead shows up in the exhaust.

2. As was clear in our original presentation to the committee we are certain that the only route to a pollution free engine is through the use of a gaseous fuel and perfect combustion. We produce a gaseous fuel under the hood of the automobile, in contrast to the methods for using a gaseous fuel on which the Sub-committee heard considerable testimony. These other methods involve the use of LPG (liquified petroleum gases—propane and butane), CNG (compressed natural gas), and LNG (liquified natural gas). Both LPG and CNG involve the transport in the automobile of heavy steel tanks, holding the fuels and fuel gases under high pressure. To contain enough fuel for normal usage in an automobile the tank would have to be bulky, unwieldy, and expensive. LPG for automotive use is a different thing from the small tanks carried on camping trailers to supply fuel for a camp stove used a few minutes a day. Because of the inherent hazard, such tanks cannot be carried legally through tunnels, and the larger LPG tank for automotive use and the still larger tank for CNG would also be forbidden. This restriction makes both systems impractical for general use.

LNG, on the other hand requires first a cryogenic tank to hold the liquid natural gas at a temperature of 258 degrees below zero, Fahrenheit, (pressure alone, within any tolerable value won't suffice) and second a complicated and fragile system for vaporizing the gas and feeding it to the engine. In order to keep the cryogenic tank sufficiently cool, there is required to be an evaporation of the liquified gas at the rate of 10% per day. This lost gas has to be vented to the air all the time, which means that a twenty gallon net capacity tank (the cryogenic tank occupies the space of a forty gallon tank) would lose two gallons a day, even if there were no use of the car. The normal parking of the car in front of the house for the 12 hour period of 6 P.M. to 6 A.M. would result in the loss of a gallon. Anything that might interfere with this evaporation would increase the tank pressure to the danger point. In the case where the car was kept in a garage, the collection of vented gas in the top of the garage would create a fire and explosion danger. LNG does produce a pollution free automobile, but a dangerous one.

3. In contrast to these systems, the Anti-Pollutant Controls, Inc. system creates a gas under the hood of the car from ordinary gasoline. It involves no different storage tank than that now in use. It creates this gas at a low pressure which has no opportunity to create a hazard. It creates no dangers not now present with the gasoline engine. We provide all of the advantages of the LPG, CNG, and LNG systems but none of the disadvantages. We do not call for the modification of the present engine, we do not call for a modification of the present gasoline production or distribution system, we do not call for a ban on the use of leaded gasoline, although we could do without the use of leaded gas. But there is a difference, we don't call for a higher octane unleaded gasoline—we could use the lower octane straight run gasoline just as well. Gas fuel has an octane rating higher than anything now in use.

4. The creation of a system to provide nationwide distribution of LNG requires major modifications in the distribution system now in effect for gasoline. Something like 30,000 new cryogenic tank trucks would be required to replace the present fleet which delivers gasoline to service stations. Each service station would require new cryogenic tanks to store LNG, plus new pumps, and new fittings through the entire system it has to fill the customer's automobile tank. All the gasoline pipe lines would have to be made cryogenic or a totally new bulk system created. Last but not least is the wholesale reworking of zoning regulations in all communities to provide for the storage of fuels much more exotic and dangerous in residential communities. This is a nightmare.

5. The steam car, investigated by Mr. William P. Lear to the extent of five and one half million dollars and then dropped by Mr. Lear for good and sufficient reasons would be less complicated than the problem posed by the systems for LPG, CNG, and LNG.

6. As was pointed out in testimony before the Subcommittee, none of the systems proposed by the automobile companies removes more than 80% of the pollutants now emitted. The planning of the automobile companies does not propose to reduce the level of pollution markedly before 1980, and they testified that the level of pollution would again be rising by 1990.

The system proposed by Anti-Pollutant Controls, Inc., as stated in the original presentation to the committee, and as again stated here, creates a gas fuel under the hood of the car, and eliminates the pollution given off by any one car to the extent of 99.9999999% (this is the equivalent of one part per billion—the figure given in the reports of the analytical chemists). This is better than the results achieved today by a factor of 100,000.

This result can be accomplished by 1972 or as soon as 60,000,000 units can be produced and installed on the used cars of the country, and as soon as our system can be made standard factory installed equipment on new cars to the tune of about 8,000,000 units a year.

7. In the hearings it was brought out that the use of gas as a fuel is about 25% more economical than the use of gasoline. This economy is obtained using the two systems with extremely high initial cost, CNG and LNG. It is probable that the economies are slightly less with LPG where the initial cost can be assumed to be lower. We make the gas under the hood and we can count upon at least 25% savings. The preliminary estimates of the cost of our system, including the hardware and the installation, to the consumer is about \$75 for a used car where two pieces of equipment now on the car must be replaced. For a new car where the two units involved would be in the assembly line, the cost of installation would be less than that for a used car. It might be pointed out in this connection that the reason the automobile manufacturers do not plan on a reduction of pollution before 1980 is that they have no unit for used cars.

Figures from the American Automobile Association indicate that the average driver puts about 12,000 miles on a car per year. Estimates from car dealers indicate that overall drivers get about 15 miles per gallon. Price data from the Bureau of Labor Statistics indicates that the average price paid is in the neighborhood of 33¢ per gallon. When one multiplies this out and figures what the 25% economy would mean, there is grounds for a general inference that the buyer of our system would recover his extra initial cost on a used car in about one year, and that after that time he would be making a profit. With a lower initial cost on a new car, recovery of that cost would come quicker and the profit would begin earlier. None of this takes into account the economies such as fewer oil changes, less spark plug trouble, and less maintenance in other ways with a gas fueled car. We feel that if the buyer of an anti-pollution system can save money he is going to be amenable to putting the unit on his car, almost without the need for compulsory laws.

8. There are available formulae for non corrosive high test alloys suitable for more adaptable turbines which would be gas turbines in fact, not merely in name.

Respectfully,

Anti-Pollutant Controls, Inc.,
EDWARD M. KNAPP,
Vice President.

WASHINGTON REFERENCE LABORATORIES,
Washington, D.C., July 3, 1969.

A REPORT OF THE COLLECTION OF SPECIMENS FROM AN AUTOMOBILE ENGINE

Attached you will find reports which were sent to my attention from Sadtler Research Laboratories in response to specimens sent by me to their laboratory for analysis by IR Spectroscopy and NMR analysis as we do not in our laboratories have instrumentation of this nature.

Sequence of Events

Arrangements were made between Messrs. Knapp, Nesbitt and myself to collect samples of the fuel being utilized by the engine of an automobile, and the exhaust of this same automobile on the premises of the Chillum Sheet Metal Works in Bladensburg, Maryland. On the afternoon of May 28, 1969, I went to the above described location in the company of my associate, Mr. Steven A. Silverman, to collect samples.

Sample collection tubes had been prepared in advance under negative pressure in anticipation. Two samples were collected and were labeled A and B. Sample A was collected by attaching a length of Tygon tubing to the nipple of the gas sampling tube and inserting this tube into the exhaust pipe of the automobile engine. The stopcock was then opened and exhaust gasses entered the gas sampling tube until equilibrium was achieved. The gas sampling tube stopcock was closed to seal and the sample labeled "A" and shipped to Sadtler Research Laboratories for IR analysis.

Immediately following, a sample was collected of the fuel being fed to the engine carburetor. A system very similar to that used for collection of Sample A was used. At this point a description of the fuel feed arrangement is necessary to understanding the sampling procedure. A length of $\frac{7}{8}$ inch copper tubing arises from the left rear and below the engine where it is coupled to the "evolver". At the upper end of the copper tube it is joined to a "T" coupling. One arm of the "T" feeds into the engine carburetor, through a needle valve. The third arm of the "T" is attached and has mounted upon it a spring-held stopcock with nipple. The arrangement is thus that the spring-held stopcock, when opened, is continuous with the $\frac{5}{8}$ inch copper tube, and when negative pressure is applied the formed fuel present in the copper tube flows toward the negative pressure, in this case, the gas sampling tube. A sample was collected in the manner described above and identified as sample "B".

Both samples were then shipped to Sadtler Research Laboratories in Philadelphia for analysis, the specific results of these studies will be explained in detail under "Discussion of Results". On May 28, 1969 I received a telephone call from Mr. Young of Sadtler Laboratories indicating that he had completed analysis of Sample A but he found only atmospheric air in sample B, which indicated that the gas sampling tube had leaked, and that it would be necessary to collect a second sample B and submit it for analysis.

A second sample B was collected on Saturday, June 7, 1969 at the same location and it should be pointed out that some difficulty was experienced in the collection of this specimen. The difficulty was experienced for the following reason: Insofar as we had experienced leakage on the previous specimen, we subjected the gas sampling tubes to a substantially greater negative pressure than we had used previously, mainly as a check on the integrity of the gas sampling tube. We attempted to sample the fuel with the engine running as described previously and discovered that the engine as set up with no fuel pump and utilizing gravity feed of gasoline. Unfortunately the negative pressure was so great that raw gasoline* was sucked directly into the gas sampling tube. This was obviously an inappropriate sample so that some modification of collection procedure was required. The collection procedure was modified in such a manner so as to preclude introduction of raw gasoline into the system. A valve in the line from the gasoline tank to the evolver was closed, followed by closure of the needle valve leading from the "T" joint previously described so as to stop the flow of fuel to the engine. This series of actions effectively trapped the fuel in the $\frac{5}{8}$ inch

*Previous IR analysis conducted by the undersigned indicated that this material was indeed commercial gasoline.

copper tube so that it could be sampled. The gas sampling tube was then filled with fuel with the aid of a hand pump. The fuel entered the cell as a visible gas, a portion of which condensed quite rapidly to a pale yellow liquid with the balance remaining in the gaseous state. This sample identified as "B" was then shipped to Sadtler Laboratories for analysis.

Discussion of Results

1. *Sample A.* This sample was submitted to IR analysis according to the protocol as described in the letter from Mr. Young (copy attached). The attached spectrogram (#78430-1) is a perfect match for carbon dioxide (reference scan #3).

The meaning and impact of this statement lies in the fact that by the route of complete combustion and *only* by this route may one achieve combustion products which do not include unburned hydrocarbons.

Further, in a phone conversation with Mr. Young and Sadtler we were informed by him that the level of CO (carbon monoxide) detectable by this instrument is in the range of one part per billion, so that we may safely assume a level of carbon monoxide in the exhaust of this engine approximately .001% of the usual internal combustion engine fueled by gasoline.

2. *Sample B.* This sample was examined in two parts, part 1 being the condensed liquid in the sampling tube, part 2 being that material which remained in gaseous state after temperature decrease. The liquid portion was subjected to IR analysis and NMR. Analysis indicated that there were a series of straight chain and branched hydrocarbons varying in length, with the average length being C₆, and an average molecular weight of less than 100. Included in this group was 5% aromatic compounds, which are identified as xylene and toluene.

The gaseous portion of the sample was subjected to IR analysis and the spectrogram (78430-5) thus derived was almost identical to a reference spectrogram (#113) for N-butane. It may be stated with certainty that the gaseous material present is all in the range of C to C₆.

The meaning of these two statements is in effect that all of the material identified as sample B is material with chemical and physical properties such that it would be a gas at engine operating temperatures. Commercial gasoline is not such a compound.

Summary

Definitions for this report:

1. Fuel—defined for this report as that material being fed into the engine which has been converted from gasoline into the gaseous material.

2. Gasoline—commercially available gasoline purchased at a filling station.

Samples were collected which were submitted to Sadtler Laboratories for analysis. The results were that the exhaust gas was pure carbon dioxide and that the fuel was a mixture of straight and branched hydrocarbons with a small percentage of aromatics, all materials in this fuel are gases and will follow Boyle's Gas Law at the engine operating temperature.

HOWARD WILLNER,
Chief Chemist, Deputy Director.

SADTLER RESEARCH LABORATORIES, INC.,
Philadelphia, Pa., June 19, 1969.

REPORT OF ANALYSIS

From: Washington Reference Laboratories, 4380 MacArthur Boulevard, NW.,
Washington, D.C.

Attention: Mr. Howard Willner.

Samples: Two (2)

Received: May 28, 1969

Laboratory No.: 78430

Subject: Two (2) samples identified as A and B.

Request: Infrared analysis and identification.

Results:

*SAMPLE A*¹

¹ The graph is in the committee files.

An infrared spectrogram of the submitted sample was prepared on a Bausch and Lomb/Shimadzu Spectronic 270 IR infrared spectrophotometer. The resulting spectrogram, No. 78430, when compared to the Sadtler Standard Infrared Spectra of Pure and Commercial Materials yielded a perfect match in carbon dioxide. A reference spectra of carbon dioxide, No. 3, is included for your records.

SAMPLE B²

Sample B was found to contain a liquid. An infrared spectrogram of the liquid was prepared using a Perkin-Elmer 137 Infrared Spectrophotometer. The resulting spectrogram, No. 78430-2, is typical of a straight chain Hydrocarbon of C₆ to C₁₂ in length. A heavier spectrogram of the same sample, No. 78430-3, gives indications of the presence of aromatics in the sample. In order to obtain a more positive identification of the sample, an NMR scan was prepared using a Varian A-60A Proton Magnetic Resonance Spectrometer with the following results:

	Percent
CH ₃ on chains-----	49
CH and CH ₂ chains-----	42
CH ² and CH ₃ on-----	5
Aromatic-----	4
Total-----	100

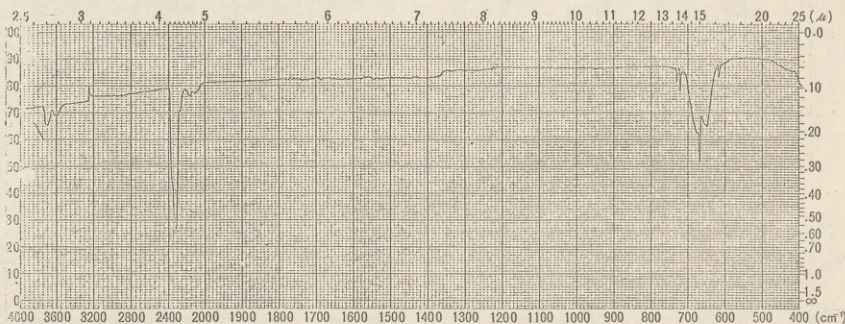
The average chain length is C₆ with a branched methyl group non-adjacent to the terminal methyl groups. The aromatic compounds were identified as toluene and xylene. An infrared spectrogram, No. 78430-4 and a heavier spectrogram of the sample material, No. 78430-5, are typical of straight chain hydrocarbons. A reference spectrogram of n-butane, No. 113, is included for your records. It can be concluded that the gases present in the sample are straight chain hydrocarbons in the C to C₆ range.

Suggestions for Further Work

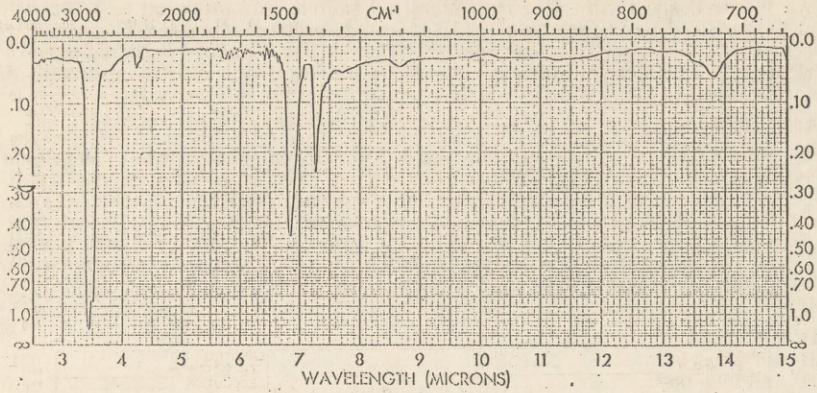
It is felt that a more positive identification of the gases present in sample B can be obtained by Gas Chromatography. An estimated \$200 should be sufficient for this work. May we hear from you on this matter.

ELIEN YOUNG, *Research Chemist.*

² The graph is in the committee files.

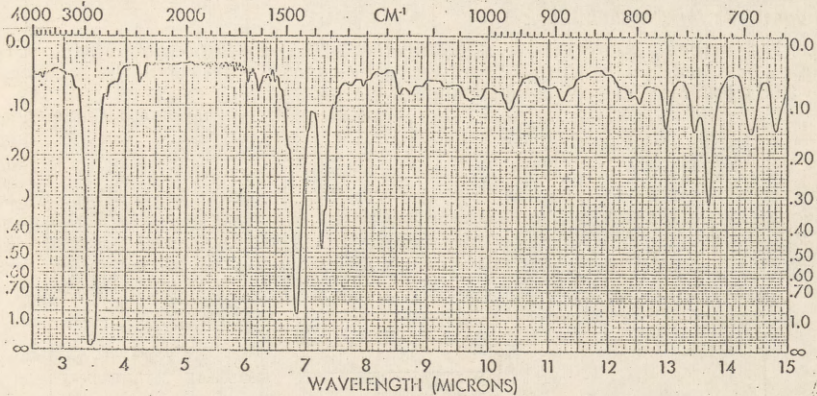


SAMPLE <i>A</i>	M. P.	SPECTRUM NO. <i>78430-1</i>
EMPIRICAL FORM	B. P.	RESOLUTION
STRUCTURAL FORMULA	ORIGIN <i>Washington Reference Labs</i>	DATE <i>3/20/59</i> OPERATOR <i>EY</i>
	PURITY	REMARKS <i>as received</i>
	PHASE	
	THICKNESS	



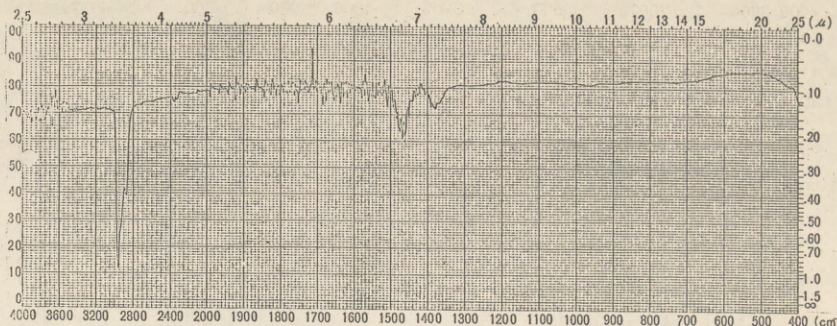
SPECTRUM NO <u>78430-2</u>	ORIGIN <u>Washington</u>	LEGEND	REMARKS <u>as rec'd</u>
SAMPLE <u>B-Liquid</u>	<u>Reference Labs</u>	1.	
	PURITY	2.	
	PHASE <u>B.S.</u>	DATE <u>1/2/49</u>	
	THICKNESS	OPERATOR <u>BY</u>	

SPECTRUM NO. _____
SAMPLE _____



SPECTRUM NO <u>78430-9</u>	ORIGIN <u>Washington</u>	LEGEND	REMARKS <u>as rec'd</u>
SAMPLE <u>B-Liquid</u>	<u>Reference Labs</u>	1.	
	PURITY	2.	
	PHASE <u>B.S.</u>	DATE <u>1/2/49</u>	
	THICKNESS	OPERATOR <u>BY</u>	

SPECTRUM NO. _____
SAMPLE _____

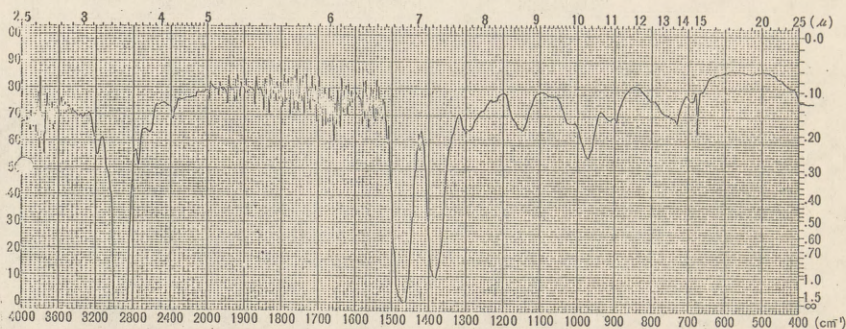


SAMPLE A-Gas	M. P.	SPECTRUM NO. 78430-4
EMPIRICAL FORM	B. P.	RESOLUTION
STRUCTURAL FORMULA	ORIGIN <i>Washington Reference Labs</i>	DATE <i>6/2/49</i>
	PURITY	OPERATOR <i>BY</i>
	PHASE <i>Gas</i>	REMARKS <i>as rec'd</i>
	THICKNESS	

SADTLER RESEARCH LABORATORIES, INC.

Form 69-72

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SAMPLE B-Gas	M. P.	SPECTRUM NO. 78430-5
EMPIRICAL FORM	B. P.	RESOLUTION
STRUCTURAL FORMULA	ORIGIN <i>Washington Reference Labs</i>	DATE <i>6/2/49</i>
	PURITY	OPERATOR <i>BY</i>
	PHASE <i>Gas</i>	REMARKS
	THICKNESS	

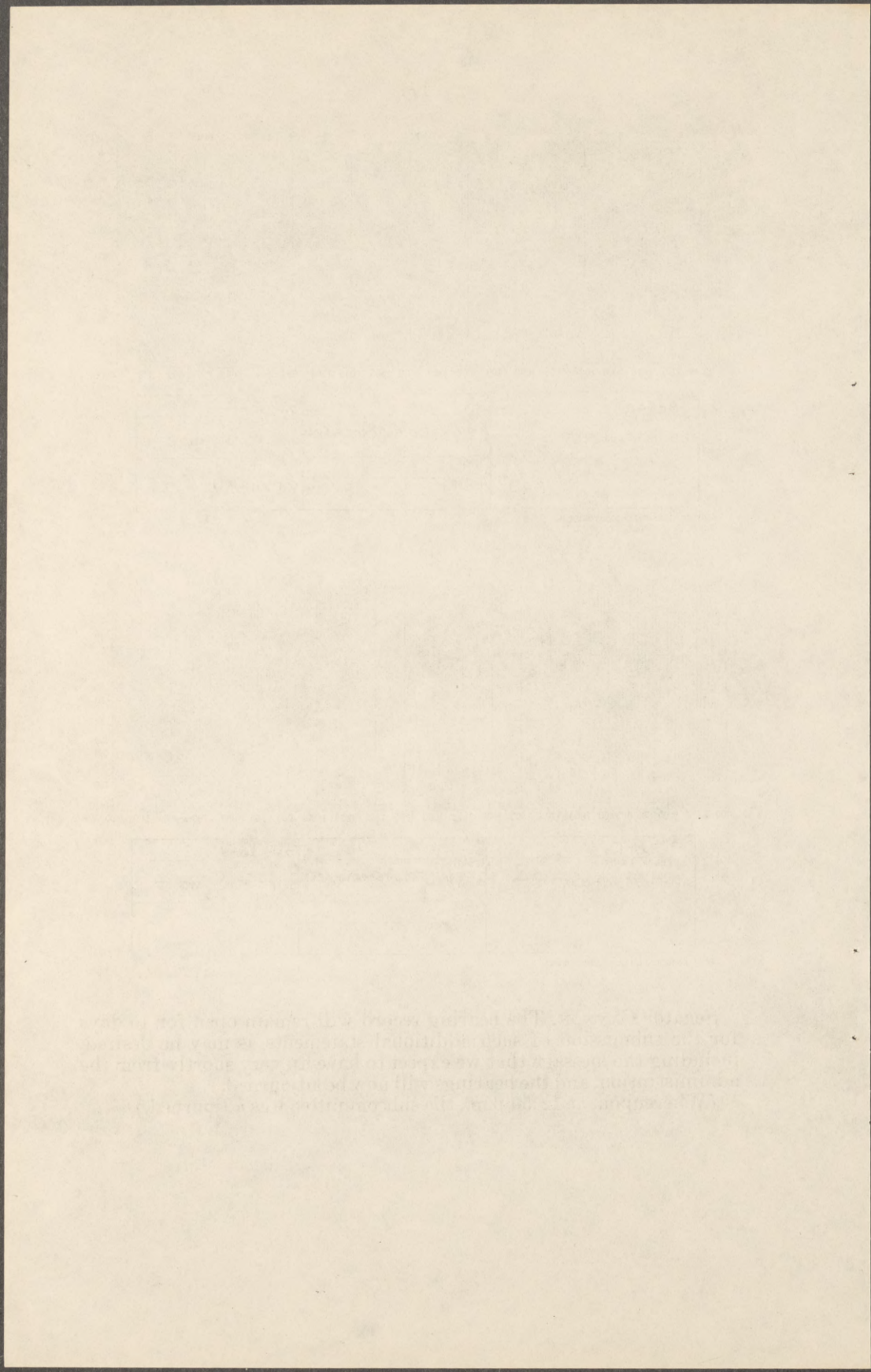
SADTLER RESEARCH LABORATORIES, INC.

Form 69-72

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Senator CANNON. The hearing record will remain open for 15 days for the submission of such additional statements as may be desired, including the message that we expect to have up very shortly from the administration, and the hearings will now be adjourned.

(Whereupon, at 12:50 p.m., the subcommittee was adjourned.)



ADDITIONAL STATEMENTS, LETTERS AND ARTICLES

AMERICAN PUBLIC POWER ASSOCIATION,
Washington, D.C., January 30, 1970.

HON. WARREN MAGNUSON,
*U.S. Senate,
Washington, D.C.*

DEAR SENATOR MAGNUSON: On January 21, the APPA Legislative and Resolutions Committee, meeting in Washington, D.C., considered and endorsed S. 3072, introduced by you, Senator Jackson, and Senator Muskie, to authorize the Federal government to purchase low-emission vehicles, including those powered by electricity, "to stimulate the development, production, and distribution in interstate commerce of low-emission motor vehicles in order to provide the public increased protection against the hazards of vehicular exhaust emission." I am enclosing a copy of the resolution approved by the committee, and would appreciate it if you could insert in the hearing record on S. 3072 this indication of support for the bill by APPA, which represents 1,400 local public power systems in 47 States, Puerto Rico, and the Virgin Islands.

Sincerely,

ALEX RADIN.

ELECTRIC VEHICLE PROCUREMENT

Whereas, air pollution is a matter of national concern and is endangering the lives and well-being of all citizens, and

Whereas, automobiles, powered by internal combustion engines, emit substantial amounts of pollutants into the nation's atmosphere, and

Whereas, there exists the technology necessary to produce low emission passenger and other vehicles, including those powered by electricity, capable of performing many of the tasks now performed by vehicles having internal combustion engines, and

Whereas, Senators Warren G. Magnuson, Henry M. Jackson, and Edmund S. Muskie have introduced S. 3072 of the 91st Congress, which would authorize the Federal government to procure low-emission vehicles as substitutes for vehicles powered by internal combustion engines: Now therefore, be it

Resolved, That the American Public Power Association supports Federal legislation, such as S. 3072 of the 91st Congress, which would authorize the Federal government to procure low-emission vehicles, including those powered by electricity, in order to demonstrate that such vehicles can perform without causing harmful air pollution.

AMERICAN CYANAMID Co.,
ORGANIC CHEMICALS DIVISION,
Bound Brook, N.J.

DEAR SENATOR SPONG: We have read of your interest in the problems of air pollution and feel that you might like to hear about some of the work American Cyanamid Company has done in this field.

Cyanamid's Refinery Chemicals Department has been especially active in the State of California program for the control of smog caused by automobile exhaust. Our anti-smog automobile exhaust system was one of the first systems approved for use on the 1966 model cars. This was a joint development between Walker Manufacturing Company and ourselves. A description of the system and how it works is enclosed as well as a report termed, "The Reactive Hydrocarbons in Motor Vehicle Exhaust".

As an active participant in the fight against smog-forming automotive exhaust emissions, American Cyanamid Company favors control standards that will result in clean air. We continue to carry on research and development programs directed to the solution of this air pollution problem.

We hope that you will not hesitate to contact us if you wish additional information.

Very truly yours,

ROBERT J. PHELAN,
Development—Air Purification.

"THE WALKER-CYANAMID ANTI-SMOG EXHAUST SYSTEM"

The Walker-Cyanamid anti-smog exhaust system consists of four basic elements: (1) the catalytic converter, which replaces the standard muffler; (2) a venturi; (3) a throttle positioner; and (4) an annual engine tune-up or adjustment.

In the catalytic reactor, the exhaust gases pass through a bed of catalyst. Here the unburned smog-forming elements and carbon monoxide in the exhaust gas are "burned" and thereby converted into water and carbon dioxide. Air for this combustion is supplied by a specially designed venturi that sucks air into the exhaust stream.

Both the annual engine tune-up and the throttle positioner contribute to economy and efficient operation. The tune-up reduces the concentration of carbon monoxide and hydrocarbons in exhaust gas to limit the heat load on the reactor. This enables the use of smaller devices, more economical material, and eliminates the need for temperature controls.

During driving, high-speed deceleration generates the greatest amount of hydrocarbons. In the Walker-Cyanamid system, the throttle positioner controls and decreases these emissions.

While providing conventional muffler sound control, the system and tune-up afford increased car performance with an average fuel savings of nearly ten percent.

According to test results, our system qualified well within the state-set standards which permit 275 parts per million of averaged hydrocarbons and 1.5 percent carbon monoxide in exhaust gases.

In an accelerated 12,000-mile test program, the Walker-Cyanamid system reduced the hydrocarbon level to 234 ppm and carbon monoxide to 0.64 percent—well below the standards established by the State of California Motor Vehicle Pollution Control Board and the Department of Health.

More significantly, the system actually does a better job of preventing smog than the test results indicate. The 275 ppm maximum set for hydrocarbons is based on a method that measure all hydrocarbons in exhaust gas collectively. Some hydrocarbons, however, have a negligible effect on smog formation, whereas the reactive hydrocarbons are the principal causes of smog-forming reactions.

The Walker-Cyanamid system is particularly effective in singling out and reducing the reactive hydrocarbons, eliminating about 80% even after 12,000 miles of use.

"THE REACTIVE HYDROCARBONS IN MOTOR VEHICLE EXHAUST"

The exhaust gases emitted from automobiles consist of numerous chemical compounds, many of them do not cause smog and are not health hazards. The trouble-makers are carbon monoxide, and some hydrocarbons and unburned or partially burned gasoline. The worst offenders are the "olefinic" hydrocarbons, which react with nitrogen oxides (in exhaust gases) in the presence of sunlight to form smog. These are the "reactive hydrocarbons."

When the present California hydrocarbon standard was established, it was recognized that these reactive hydrocarbons were the principal cause of smog. However, because a good method for measuring reactive hydrocarbons was not known at the time, the standard was based on a method that measures all hydrocarbons collectively.

Thus, although the present California standard requires a substantial reduction in hydrocarbons, it does not specifically require the reduction of the smog-forming reactive hydrocarbons. It appears, that the contemplated Federal standards will follow California's pattern.

In the last several years, test methods have been developed that distinguish between the various types of hydrocarbons in exhaust gas. Such methods as gas phase chromatography or differential flame ion analysis are quite adequate for

this purpose. We are, incidentally, proud to point out that American Cyanamid Company was instrumental in the development of the latter method. By using these new techniques to analyze treated and untreated exhaust, one can tell if the real offenders are being eliminated.

Cyanamid feels strongly that new hydrocarbon standards should be adopted based on these improved analytical techniques and aimed at reducing the reactive or smog-forming hydrocarbons. By aiming specifically at the cause of the problem, we will have a better chance of reducing the smog formation.

[Telegram]

DETROIT, MICH., *February 10, 1970.*

HON. WARREN MAGNUSON,
*U.S. Senate, Old Senate Office Building,
Washington, D.C.*

Following wire was sent today to Philip A. Hart, United States Senate, Washington, D.C.

American Motors Corporation strongly supports the intent of the legislation embodied in S. 3072 because we believe that environmental quality is of major concern to all.

If enacted into law, the bill will accomplish two things. It will provide a valuable and realistic incentive without regard to the mode employed, for development of lower emission vehicles. It will also provide to the government and industry invaluable field experience with new equipment prior to its introduction to the general market.

The automotive industry has worked diligently to solve the engine emission problem since it was discovered in the 1950's that its product was a major contributor to photo chemical smog.

Like the other manufacturers, American Motors has not limited its efforts to reducing the emissions from the internal combustion engine. Although we do not undertake programs on the same scale as General Motors, Ford or Chrysler, we have been, and are presently individually or jointly with other organizations, conducting research projects in the fields of electronic automobiles and steam propelled vehicles.

Please be assured that we will continue to work for improvement in quality of our environment.

Sincerely,

American Motors Corp.,
ROY D. CHAPIN, Jr., *Chairman.*

STATEMENT OF WALLACE TRIPLETT, DIRECTOR OF MARKETING AND PUBLIC RELATIONS
OF VEGA ASSOCIATES, DETROIT, MICH.

Senator Hart, Vega Associates is a research and development firm concerned with special-vehicle development. We have had success over the past 4 years in developing a new vehicular structural system that offers the advantages of dent resistance, economical repair, increased impact safety, and is easily disposed of at the end of its usefulness without littering the landscape or polluting the air.

We constructed a prototype to prove our theories. The vehicle built was a four-passenger recreational type, and it was selected because it offered the opportunity for offroad as well as highway operation, and thereby more clearly demonstrated the validity of the structural system.

It is our belief, as well as others, that the introduction of zero-pollution transportation can be hastened by the utilization of our vehicular structural system because it readily lends itself to limited production with minimal tooling costs.

According to an article in the *Industrial Design Journal* by a specialist in automotive economics, Dr. Lloyd D. Orr, assistant professor of economics at Indiana University, "to leave the development of the electric car to the major auto firms would be as foolish as it would have been to have put a conservative livery stable operator in charge of the development of the horseless carriage." Dr. Orr's statement continued: "The greater reliability of electric motors will eliminate the need for complex network of dealers, while the use of plastics for structural parts will provide economy of manufacture on a much smaller scale. Finally the longer life and greater durability of electrics will destroy the myth that cars must be replaced every 3 years".

There has been much experimentation to substitute plastics for metals, but very little has been done since the introduction of the first all-plastic car 17 years ago to design structurally with the freedom plastics allow.

As a cooperative venture with Electric Fuel Propulsion, Inc. of Detroit, Mich., a firm whose testimony before this and similar hearings, and study groups is a matter of record,¹ and whose propulsion system has clearly demonstrated its superiority, Vega has undertaken to develop a zero-pollution vehicle.

Vega Associates is requesting of this committee that financial assistance be made available to fund this development program.

The capital requested and a general breakdown of expenditure of it would be:

Facility and equipment.....	\$260,000
Engineering, design, prototype tooling, and prototype vehicle.....	600,000
Test and development.....	100,000
Production engineering	200,000
Total	1,160,000

Facility and equipment, \$260,000

Facility, \$90,000.—Three-year lease of a 30,000-square-foot, single-level, zoned gas-fired heat, air-conditioned, fireproof-construction sprinkler system, with loading dock (truck), parking lot, and direct highway access.

Equipment, \$170,000.—Dual, electric platen, thermoforming machine (10 feet by 20 feet mold area), top stroke 50 inches, bottom stroke 24 inches, mold temperature control unit and vapor cooling spray (\$45,000). Shop tools, power tools, hand tools, and expendables.

Equipment for the following activities.—(\$125,000)

- A. Administrative.
- B. Engineering.
- C. Design.
- D Test and development.
- E. Material handling.
- F. Maintenance

Engineering, design, prototype tooling and construction of prototype vehicle, \$600,000

Engineering, \$200,000.—Chassis development; electrical propulsion system adaptation; integration of subsystems; component selection; establishment of design parameters; body design package drawings; performance circulations.

Design, \$150,000.—Concept; configuration development; scale layout drawings; three-eighth scale clay study model; three-eighths fiberglass wind tunnel model; wind tunnel test program; full-size exterior clay model; full-size interior seating buck.

Prototype tooling, \$48,000.—Forming molds for exterior body shell, interior trim panels, compartment covers and impact sections; rear-window-bending form; chassis welding fixture; tube bending jigs; drilling templates, and trimming patterns.

Prototype build, \$202,000.—Chassis fabrication; fabrication of battery compartments; installation of electrical propulsion system and subsystems; fabrication of compartment covers and exterior body panels; fabrication of body inner structure; assembly of body inner structure, required body framing and body mounts to chassis; assembly of exterior body panels to body inner structure and chassis; installation of instrumentation, wire hookup and connection of controls; installation of seats and interior trim; installation of body lighting and hardware; application of finish and ornamentation.

Test and development, \$100,000

Test.—Complete checkout of components, subsystems and electric propulsion system under controlled condition to verify their function. Short road trips to

¹ Statement of Robert R. Aronson, president of Electric Fuel Propulsion, Inc., before the Senate Antitrust and Monopoly Subcommittee, Oct. 3, 1967.

The Mars 2 electric car, Society of Automotive Engineers (paper on electric fuel propulsion), May 1968.

Testimony before the Subcommittee on Energy, Natural Resources, and the Environment, Commerce Committee, Robert Aronson, Jan. 29, 1970.

establish and record vehicle performance. Long-distance road trips to document component reliability, maximum range, top speed, handling, and ride characteristics.

Development.—Modifications, changes, and alterations to improve reliability and performance as required by analysis of test results. Upgrading of the automobile to comply with the Federal motor vehicle safety standards, and inclusion of as many features as possible from the safety car program of the Department of Transportation and the National Highway Safety Bureau.

Production engineering, \$200,000

Updating engineering and drawings for production. Preparation of vehicle build manual.

Advantages of Vega Associates electric fuel propulsion vehicle can be briefly summarized as: Safe to operate—nonpolluting—economical—comparatively free of maintenance—dent resistant—quiet—impact safety—urban and suburban appeal.

With America devoid of clean air thanks largely to the internal combustion engine, deafening noise becoming a medical problem of high concern, and the sight of junkyards as acceptable monuments to progress, we at Vega Associates have accepted the challenge to stem this abhorrent tide. We think it is very significant that our firm have a part in the salvation of our great Nation.

Thank you for your attention and indulgence.

Natural Gas Fueled Vehicles Exhaust Emissions and Operational Characteristics

R. W. McJONES
Consulting Engineer

R. J. CORBEIL
Pacific Lighting Service Company

ABSTRACT

Natural gas fuel in a lean mixture with 25 % excess air operates satisfactorily in an otherwise normal automotive engine. All exhaust emissions known to contribute to air pollution are reduced to levels meeting or bettering currently proposed standards. Dual-fuel operation with gasoline as a standby fuel permits immediate use of natural gas prior to the establishment of a widespread fueling network.

INTRODUCTION

An experimental study of the exhaust emissions, operating characteristics, and economic aspects of natural gas fueled vehicles was undertaken in early 1968. The use of compressed gas in a dual-fuel arrangement with gasoline as a standby proved surprisingly attractive in all aspects, and the test program was expanded to include several routine service vehicles in late 1968. By late 1969 the number of vehicles in service had climbed to some 70, including city, county, state, and federally operated fleets, as well as several commercial fleets.

The present paper is concerned primarily with the exhaust emissions results, and secondarily with the operational characteristics of these dual-fuel vehicles.

SYSTEM DESCRIPTION

The dual-fuel system is built around a variable venturi mixer, which mounts on the carburetor intake as a replacement for the production air cleaner, (Figure 1). The mixer is supplied with natural gas through a system of regulators and valves, (Figure 2) from either pressure cylinders, (Figure 3) or liquified natural gas tankage, (Figure 4) - in the latter case, a heat exchanger is provided to vaporize the natural gas.

No internal engine modifications are involved in these dual-fuel conversions. Spark timing is usually readjusted slightly to obtain minimum exhaust emissions during both natural gas and gasoline operation.

FUEL-AIR MIXER

The mixer operates on the diaphragm controlled, variable venturi principle and meters the proper quantity of natural gas into the air stream over the full range of engine air flow demands. One mixer model covers the full range of engine sizes and does not require different orifices or venturis to match it to a specific engine.

Adjustment procedure is the same for all engine sizes and consists of two steps:

1. Adjust the final pressure regulator to deliver natural gas to the mixer at a pressure between $-.5$ and $+.5$ inches of water when the engine is operating under a light load.
2. Adjust the mixer idle screw to the lean drop-off point.

At these settings, the mixer will maintain a lean mixture with approximately 25 % excess air, as was employed in the documentation tests reported herein.

Normal function of the gasoline carburetor is unaffected when the mixer is placed in the "gasoline" configuration. This is accomplished by pulling a Bowden wire control on the vehicle dash. Electrical selection of the proper fuel is coordinated with the mixer configuration control so that it is impossible for the vehicle operator to select the wrong fuel.

SPARK TIMING

Minimum emissions of NO_x and hydrocarbons are found with the most retarded timing which is consistent with satisfactory vehicle operation. In general, this optimum timing is reached by using the manufacturers basic setting but with the vacuum advance disconnected. In a few cases, the basic timing must be advanced 5° from the recommended value but never to an idle setting beyond 10° BTC. In the very few cases when centrifugal spark advance is not provided, vacuum advance cannot be abandoned and standard timing must be retained (preferably, a centrifugal advance distributor is retrofitted).

The test data of this report show that exhaust emissions on gasoline are generally improved by the dual-fuel conversion - an improvement entirely attributable to the modified spark timing.

TEST PROGRAM

Following a number of exploratory tests, a documentation program involving one vehicle in each displacement class was carried out according to the following sequence:

- Test 1 - A cold start test as received using "basin mix" gasoline fuel.
- Test 2 - A cold start test after installation of the dual-fuel system using "basin mix" gasoline fuel followed by a hot start test using natural gas.
- Test 3 - Same as Test 2 after 4000 miles.

EMISSION TESTS

A test vehicle was placed on a chassis dynamometer and driven through the California seven-mode cycles in accordance with the standard test procedure. The exhaust gases from each cycle were monitored by an NDIR sampling train for the concentrations of hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2), and oxides of nitrogen (NO_x). At the same time the exhaust gases of each test cycle were collected in Mylar bags and analyzed for HC, CO, and CO_2 by a second NDIR train.

Bag samples of the last two cycles of each test were also analyzed by the subtractive column technique in conjunction with a flame ionization detector to obtain data for reactivity calculations. Syringe samples were also taken from the last two bags for the determination of NO_x concentration by the modified Saltzman method.

The total volume of exhaust gases from each driving cycle as collected in Mylar bags was measured by a standard orifice plate. Fuel consumption for each test was also determined.

The emission comparisons of this report are for composite cold/hot cycles on gasoline vs. hot start cycles on natural gas. The validity of this comparison is illustrated in Table I, where cold start cycles are compared for natural gas and gasoline. Since natural gas is always metered as a gas, there is no need for a choke or other enrichment device to ensure the presence

of enough vaporized fuel to support combustion in a cold engine. The result is that hot start emissions and composite emissions are virtually the same for natural gas. There is no point in going through the extra effort to generate cold start data once this feature has been demonstrated.

Natural gas is a low carbon fuel as compared with gasoline, and cannot be expected to produce 15 % CO₂ at the chemically correct mixture. The California Air Resources Board has adopted 11 % CO₂ as the basis for natural gas exhaust dilution corrections. This value was derived by the ARB staff on the basis of heating values and carbon/hydrogen ratios. Direct measurements of carbon consumption, as reported in Table II, substantiate the 11 % CO₂ value; and all concentration data in this report have been corrected accordingly.

Natural gas is primarily composed of methane, with ethane and other gases appearing as minor constituents. The major portion of the testing reported herein was performed with typical pipeline gas as represented in Table VIII. For comparison, other "natural gas" mixtures ranging from reference methane (99.6%) to LNG liquid (86% methane) were tested and reported wherever applicable - particularly in Tables V and VI.

EMISSIONS DATA

Exhaust emission data are summarized in Tables II through IV for six vehicles, one in each displacement class and three each with manual and automatic transmissions. Discussion of the emission data can best be accomplished on a pollutant by pollutant basis.

Carbon Monoxide

The variable venturi mixer provides uniform mixture distribution and maintains excess air in the mixture at all times; the virtual elimination of carbon monoxide is an expected result.

Hydrocarbons

Direct comparison of exhaust hydrocarbon concentrations show substantial reductions when converting from gasoline to natural gas, but do not reflect the shift in hydrocarbon composition toward non-reactive compounds with natural gas fuel.

Methane is the primary constituent both of natural gas itself and of the exhaust hydrocarbons resulting from natural gas combustion. Methane has been shown to have near zero reactivity in every measurement of photochemical smog production reported to date - a result which is consistent with methane's well-known chemical stability.

Gas chromatographic data in Table V make it clear that the paraffinic component of natural gas exhaust is virtually pure methane; and that in the exceptional case where another paraffin is found, it turns out to be ethane, which is nearly as non-reactive as methane. Accordingly, it is apparent that reactivity units for natural gas exhaust must be calculated with a factor of zero for paraffins to make a valid comparison with gasoline reactivity units where the preponderance of the paraffins are long chain molecules with a

definite photochemical reactivity.

Table IV presents all the hydrocarbon reactivity data from the documentation tests and emphasizes the reductions in olefins and aromatics in the natural gas exhaust. Note that large reductions in reactivity units are achieved with natural gas, even with methane being weighted as unity; and that the use of 0-8-3 weighting results in an approximate 90 % reduction of reactivity units as compared with gasoline.

Hydrocarbon emissions from carburetor and fuel tank evaporation are nearly zero with the dual-fuel system. The gasoline carburetor is dry when operating on natural gas so that gasoline hot soak emissions are zero. Gasoline tank losses are reduced to zero when evaporation controls are used as on 1970 California cars.

The relatively large exhaust hydrocarbon concentrations of the 440 cu. in. engine during its first natural gas test is an interesting result which must be discussed. This high mileage car, when tested, had some marginal components in its ignition system and misfired occasionally on natural gas - leading to large unburned hydrocarbon values. As shown in Table IV, neither olefin nor aromatic values rose, so the misfiring did not result in the release of reactive hydrocarbons to the atmosphere. As ignition tune up corrected the misfiring prior to the second natural gas test. However, this vehicle still does not perform to expectations and further studies of its engine are in progress.

Oxides of Nitrogen

Reduction of NO_x formation by operation with very lean air/fuel mixtures has been predicted from chemical theory and has been frequently demonstrated in the laboratory. Previous attempts to operate vehicles in this mixture range with regular fuels have been thwarted by surging, poor idle, and other common symptoms.

The unique chemical characteristics of natural gas, coupled with the accurate mixture control of the variable venturi mixer have resulted in satisfactory vehicle operation at mixtures which do permit achievement of low NO_x without sacrificing low carbon monoxide and low hydrocarbon levels (see Table VI).

Other Pollutants

In addition to the above pollutants for which standards have been adopted, there are other known air pollutants which are reduced or eliminated by the use of natural gas as a motor vehicle fuel. These are:

1. Lead is totally eliminated; natural gas is 130 octane without lead.
2. Soot is virtually eliminated; dramatic changes are apparent on the filters used in the exhaust sampling train, (see Figure 5).
3. Odor is improved; the natural gas fueled vehicles smells much like any natural gas appliance.

FUTURE EMISSION STANDARDS

From its inception, the dual-fuel program has had as its goal the achievement of "clean car" emissions as defined in California Assembly Bill 356 of 1968. The extent to which this goal has been realized is shown in Table VII. Grams/mile for both gasoline and natural gas have been calculated on the basis of a carbon balance between the exhaust and the measured fuel consumption. (rather than on the basis of arbitrary exhaust volumes as described in the Federal Register, 4 June 1968). For details on carbon balance calculations, see Appendix A.

Both carbon monoxide and reactive hydrocarbons are seen to be well within the prescribed levels. The oxides of nitrogen are marginally within the standards, except for the 440 cu. in. engine. As mentioned earlier, that engine has not yet delivered the emission levels expected of it, and continuing efforts are under way to diagnose the problem. There is no reason to believe that displacement as such is responsible for the relatively higher emissions of this engine, since its fuel consumption and exhaust volume are not appreciably greater than those of the 302 cu. in. engine which has emissions within the target area.

OPERATING CHARACTERISTICS

Maximum Power

Natural gas passes through the intake manifold and into the cylinder as a gas - occupying approximately 10 % of the available volume - whereas gasoline normally exists as droplets during the intake stroke and takes up very little volume. This reduction in air capacity with natural gas results in a loss of maximum horsepower of about 10 %. The slower flame speed of natural gas lowers peak cylinder pressures and further reduces maximum horsepower unless spark timing is advanced from the normal gasoline setting. The dual-fuel system described herein has been optimized for minimum exhaust emissions rather than maximum power, and results in a loss of peak horsepower of about 15 %. Most drivers do not find this loss in power objectionable, and consider it to be a reasonable price to pay for the associated reductions in air pollution.

General Driveability

By virtue of its gaseous state, natural gas offers easy starting (even in cold weather), reliable idling, and stumble-free acceleration. In most vehicles, these advantages offset the disadvantage of lost peak power and result in a distinctly more pleasant overall driving characteristic. It is particularly impressive to be able to accelerate away from a cold start without risk of the engine dying. Part throttle surge is never encountered at the recommended air-fuel ratio. An occasional engine will surge on natural gas at mixtures leaner than about 30 % excess air; however, most vehicles can be driven smoothly at radically leaner mixtures.

Fuel Consumption

The consensus of operational experience with natural gas has been that 100 cubic feet (LHV = 100,000 BTU) are equivalent in average driving to one gallon of gasoline (LHV = 114,000 BTU). This result is generally consistent with the seven-mode fuel consumption data of Table II, where BTU's/mile with natural gas run from 80 % to 100 % of the gasoline values, for a 90 % overall average.

During extended operation at fairly high power - such as freeway driving - the BTU/mile consumption tends to become equal for the two fuels, and 100 cubic feet of natural gas will not equal one gallon of gasoline. During stop-and-go driving, the absence of an accelerator pump and the very lean idle mixture with natural gas result in very favorable BTU/mile figures, and 100 cubic feet will more than equal one gallon of gasoline.

FUEL TANKAGE

Both compressed and liquefied natural gas have been employed during the dual-fuel fleet tests reported herein, with most of the emphasis to date being devoted to pressure storage. For vehicles whose average daily mileage is less than about 80 miles and who return to a fueling station on a daily basis, the use of pressure stored natural gas is an inexpensive and simple procedure. Beyond 80 to 100 miles per day, LNG becomes the more attractive storage mode except in certain special situations when frequent refueling is possible.

The fuel cylinders are mounted on the vehicle with bracket and bolts designed to withstand crash loadings, (Figure 2) and they are not removed and replaced for refueling. Most refueling is currently being performed on a "time loading" basis with manifold systems, (Figure 6). It is, however, entirely feasible to refuel within two or three minutes from a high capacity compressor or from a stored gas supply, (Figure 7). Compression heating of cylinders during a "quick fill" amounts to only about 20° F and is not a deterrent to this loading procedure.

The standard compressed gas container for this program has been the familiar 9" diameter by 51" long DOT 3AA2265 cylinder which is in widespread usage for welding and industrial gases, (Figure 3). This cylinder has an internal volume of 1.54 cubic feet and would contain 234 cubic feet of a perfect gas at its rated filling conditions of 2265 psig and 70° F. Real gases depart from the perfect gas density relationship, and as they approach their critical pressure and temperature, this effect becomes very large. For natural gas at 2265 psig and 70° F., the supercompressibility factor is .75, and the cylinder contains 312 standard cubic feet. This cylinder weighs approximately 125 pounds, and two will fit easily in the trunk of a sedan or in the forward bed area of a pickup truck.

It is interesting to note that so long as the working stress of the steel is held constant - as it is for cylinders made to a given specification such as DOT 3AA - both the size and the working pressure may be varied without significant effect upon the ratio of cylinder weight to gas volume contained. Thus all DOT 3AA specification cylinders will weight approximately 40 pounds per 100 cubic feet of natural gas contained.

Cylinders of higher design pressure offer reduced space requirement for fuel storage and may be attractive in certain applications. Tanks, compressors, and components for operation to 3000 psi are readily available and have been used widely in both aircraft and industrial applications.

The use of higher strength materials for compressed gas storage has long been common practice for aircraft applications. As an example, a spherical steel vessel of 19" diameter rated at 3500 psi contains 500 cubic feet of natural gas. As an aircraft item, this weighs 105 pounds, or 21 pounds per 100 cubic feet. Cost, availability, and various approvals stand in the way of early use of these vessels in ground vehicles.

Most vehicular use of LNG to date has involved vacuum jacketed tanks whose cost has been prohibitive for general application, (Figure 4). Recent work with plastic foam insulation has shown considerable promise and may well be the key to economically justifiable LNG tankage. An interesting new insight into LNG tank heat balance points out that increased pressure capability in the inner tank can be just as effective as better insulation in terms of providing extended "lock-up" time before the tank begins to boil-off gas.

For both compressed and liquefied natural gas fueled vehicles, the ability to switch back to gasoline fuel is a tremendous asset in the present world where gasoline filling stations are close together and natural gas filling stations are widely spaced.

SAFETY

The natural gas fuel system has been developed in cooperation with the various governmental agencies charged with safety and fire prevention responsibilities. The system has been inspected by safety engineers from insurance underwriters and has been judged to be as safe or safer than either gasoline or LPG fuel systems. Application has been made for Underwriter's Laboratory listing for the natural gas dual-fuel system.

Several characteristics of natural gas make it an inherently safe fuel. Natural gas is lighter than air. In case of a leak it will rise and dissipate into the atmosphere. The ignition temperature of natural gas is higher than that of other motor vehicle fuels - - 1300° F as compared to 800 - 900° F.

CONCLUSIONS

Natural gas fuel in otherwise standard internal combustion engines reduces exhaust emissions of all known air pollutants to levels meeting or bettering any standards yet proposed. Dual-fuel operation with gasoline as a standby fuel permits routine operation on compressed natural gas, even though fueling stations are widely spaced and range is restricted by tank size and weight. Liquefied natural gas promises extended range for vehicles traveling more than 80 - 100 miles between refuelings.

APPENDIX A

Calculations of Grams per Mile Emissions Using Fuel Consumption Measurements

This procedure involves determination of the fuel carbon consumption, expressed in grams/mile, and equating this quantity to the total carbon content of the exhaust gases. For engines with low values of exhaust CO and hydrocarbons, it is reasonable to assume that all of the fuel input carbon shows up as exhaust CO₂. This simplifies the arithmetic and results in calculated values for the other exhaust constituents which are always slightly larger than their true values.

The ideal CO₂ value which corresponds to complete combustion of the input carbon is referred to as CO₂. The following values have been used in reducing the data of this paper.

<u>Fuel</u>	<u>Carbon Density</u>	<u>CO₂ (Fuel Basis)</u>
Methane	14.35 gm/cu. ft.	52.7 gm/cu. ft. fuel
Pipeline gas	15.65 gm/cu. ft.	57.4 gm/cu. ft. fuel
Indalene	.864 gm/gm fuel	3.17 gm/gm fuel

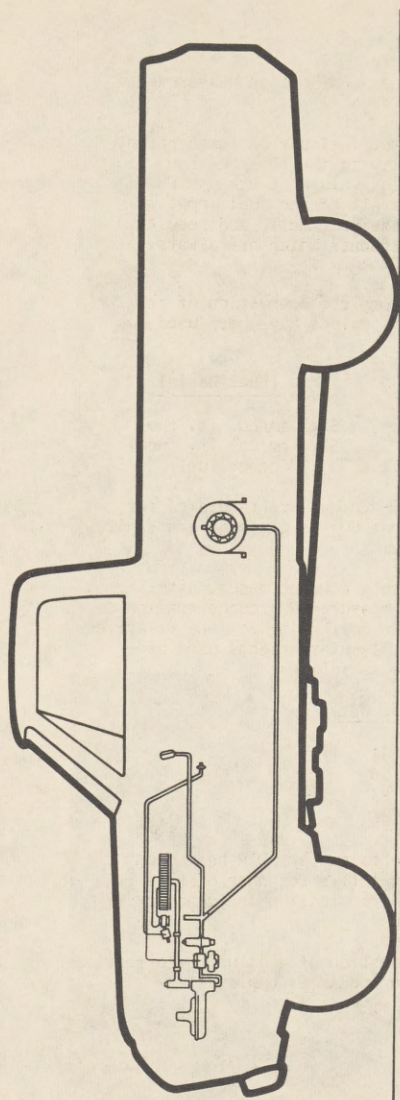
In Table II, fuel consumption and ideal CO₂ values are tabulated for both gasoline and natural gas operation. Note that CO₂ is given in grams/mile, since the fuel consumption has been accounted for.

Calculation of the various exhaust components now becomes a matter of taking the ratio of each concentration to the measured CO₂ concentration and multiplying this ratio by the CO₂ value - then correcting for the relative molecular weight of the component in question. Molecular weights used are taken from the Federal Register procedure and are as follows:

<u>Component</u>	<u>Mol. Wgt.</u>
CO ₂	44
CO	28
HC	83
NO _x	46

In addition, hydrocarbon concentrations obtained by NDIR have been increased by a factor of 1.8 to account for the relative response of this instrument. Hydrocarbon concentrations from flame ionization instruments are taken at face value.

Note that this technique sidesteps the question of a dilution correction for CO₂, since only the ratio of CO₂ to other components is employed.



1. 2nd Stage Regulator
2. Gasoline Solenoid Valve
3. Gasoline Carburetor
4. Gas-Air Mixer
5. Fuel Selector Switch
6. Natural Gas Fuel Gauge
7. Pressure and Temperature Safety Valve
8. Shut-off Valve
9. Conventional 220 Cu. Ft. Gas Cylinder
10. Natural Gas Solenoid Valve
11. 1st Stage Regulator
12. Natural Gas Fill Valve and Pressure Safety Valve

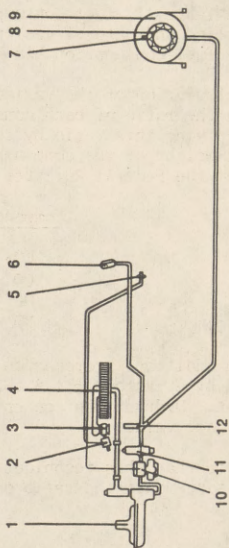


Fig. 1 - Schematic drawing shows equipment involved in the dual-fuel system. Gas moves from pressurized cylinder in bed or trunk of vehicle to standard carburetor, undergoing pressure reduction at two stages

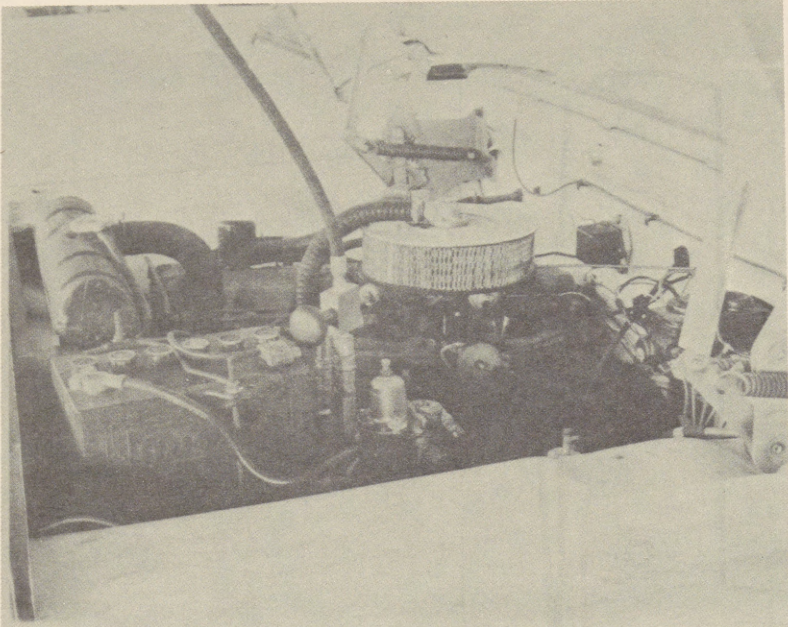


Fig. 2 - Under-hood view showing fill hose in position for refueling.

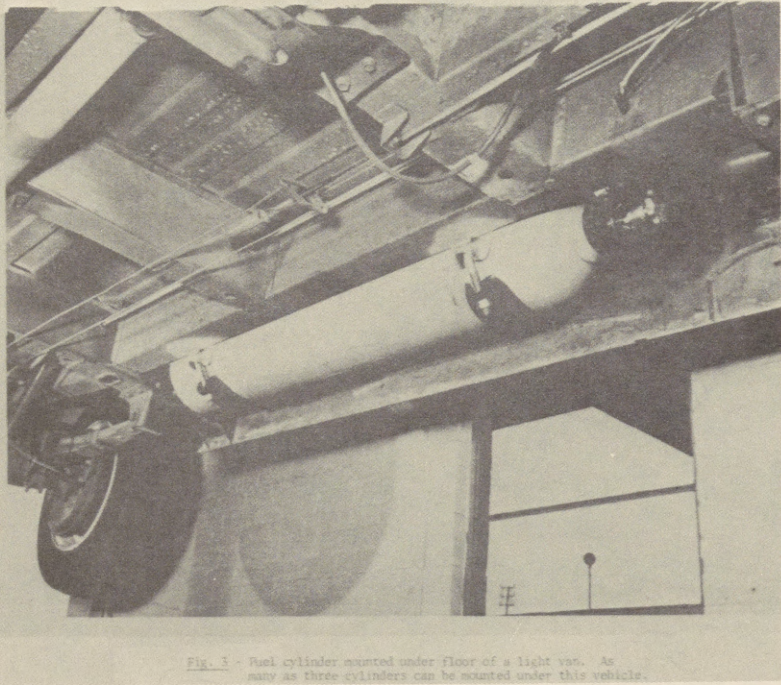


Fig. 3 - Fuel cylinder mounted under floor of a light van. As many as three cylinders can be mounted under this vehicle.

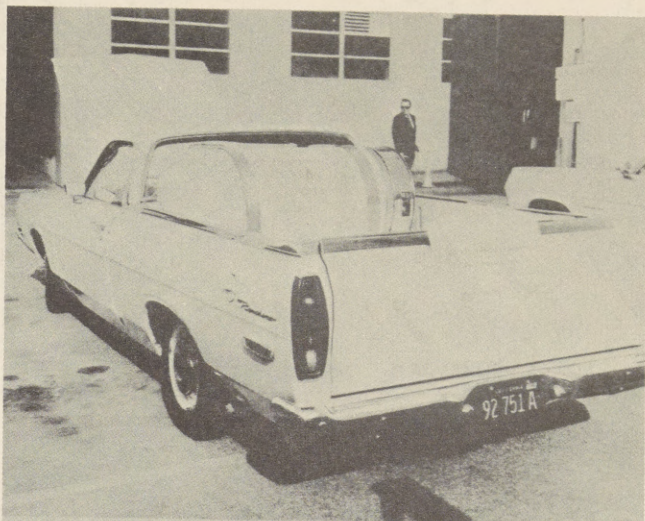


Fig. 1 - Vacuum jacketed 15" tank on light pickup. This 50 gallon tank is much too large for routine use on this size vehicle.

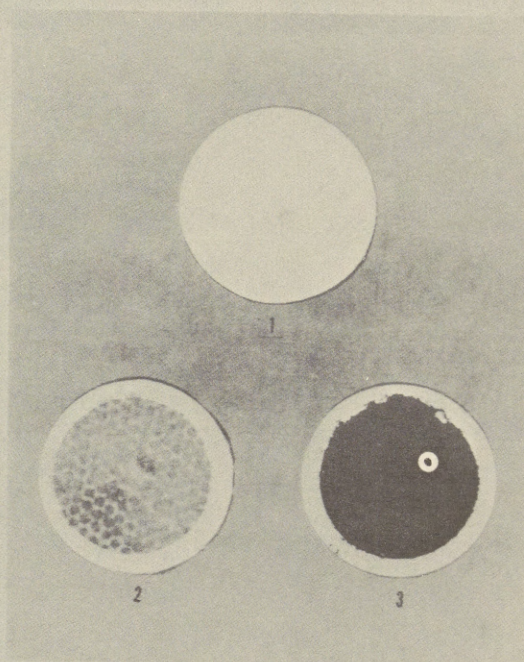


FIGURE 1 - TANK CROSS-SECTIONAL VIEWS FROM EACH TIER OF THE TANKED SAMPLE FOR ONE TYPICAL TEST RUN.

- (1) Natural gas - test vehicle
- (2) Sewage - test vehicle
- (3) Sewage - current vehicle



Fig. 6 - Operational fleet during "time loading" refueling process

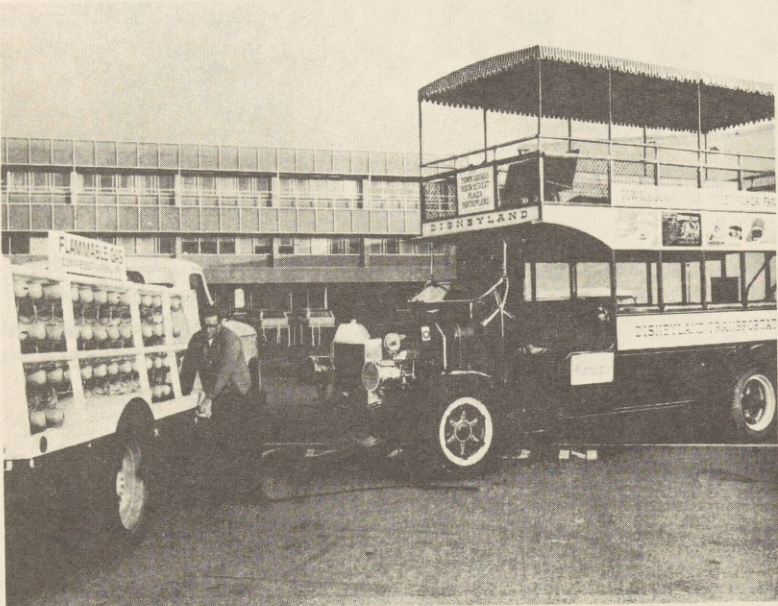


Fig. 7 - Sightseeing bus during "quick loading" refueling. This vehicle carries five standard cylinders under the seats and floor.

TABLE I - SEVEN MODE COLD START COMPARISON

	<u>1966 6 Cyl. (170 cu. in.)</u> (Natural Gas)		<u>Typical Engine</u> (Gasoline)	
	<u>HC (ppm)</u>	<u>CO (%)</u>	<u>HC (ppm)</u>	<u>CO (%)</u>
1st Cycle	93	0.15	452	3.17
2nd Cycle	93	0.15	253	1.63
3rd Cycle	83	0.15	319	1.55
4th Cycle	85	0.15	288	1.36
6th Cycle	85	0.15	280	1.33
7th Cycle	86	0.15	280	1.31
Composite Results	87	0.15	297	1.54

TABLE II - VEHICLE IDENTIFICATION, FUEL CONSUMPTION, AND CARBON DIOXIDE DATA

Engine Class Cubic Inch	Yr/Cy1 Displ. Trans.	Test Conditions	Gasoline		Natural Gas		Natural Gas (1) CO ₂ Reference %	BTU/Mile Nat. Gas/Gasoline
			Fuel Gm/Mi.	CO ₂ Gm/Mi.	Fuel Qt. Ft/Mi.	CO ₂ Gm/Mi.		
a 0-140	1969/4	Baseline	3097	405	-	-	-	-
	134 c.i. Man.	At conversion	3295	415	4.58	263	9.5	.84
		After 4000 mi.	7298	403	4.86	279	10.4	.91
b 140-200	1969/6	Baseline	3081	487	-	-	-	-
	199 c.i. Man.	At conversion	3990	539	5.46	313	8.7	.77
		After 4000 mi.	8402	571	6.08	349	9.2	.81
c 200-250	1968/6	Baseline	9541	558	-	-	-	-
	250 c.i. Man.	At conversion	10559	650	7.84	450	10.4	.92
		After 4000 mi.	14123	620	7.92	454	11.0	.97
d 250-300	1968/8	Baseline	3172	-	-	-	-	-
	289 c.i. Auto.	At conversion	4987	-	-	-	-	-
		After 9000 mi.	14060	548	7.2	413	11.3	1.00
e 300-375	1969/8	Baseline	3097	676	-	-	-	-
	302 c.i. Auto.	At conversion	5443	748	9.62	552	11.0	.98
		After 4000 mi.	9754	704	8.66	497	10.6	.93
f 375 +	1967/8	Baseline	4188	846	-	-	-	-
	440 c.i. Auto.	At conversion	44933	846	9.61	552	9.8	.86
		After 4000 mi.	49097	846	10.26	588	10.4	.92

(1) Natural gas CO₂ reference is calculated as $15\% \times \frac{\text{CO}_2 \text{ nat. gas}}{\text{CO}_2 \text{ gasoline}}$ and is presented as verification of the 11% value adopted by the California ARB for natural gas exhaust dilution corrections.

TABLE III - SUMMARY OF EMISSIONS DATA

Engine Class Cubic Inch	Yr/Cyl Displ. Trans.	Test Conditions	Carbon Monoxide Concentration		Hydrocarbons Concentration		Reactivity Units		Oxides of Nitrogen Concentration	
			Gasoline-1/ %		Gasoline-1/ ppm		Units		ppm	
			Nat. Gas-2/ %	Nat. Gas-2/ ppm	Nat. Gas-3/ ppm	Nat. Gas-3/ ppm	Gasoline	Nat. Gas-3/ ppm	Nat. Gas-2/ ppm	Nat. Gas-2/ ppm
a 0-140	1969/4	Baseline	1.97	393	-	1590	-	1079	-	275
	134 c.i. Man.	At conversion After 4000 mi.	.15 .59	321 365	158 218	1165 1320	35 270	1100 ^{5/} 1439	35 270	411
b 140-200	1969/6	Baseline	2.45	417	-	2420	-	1345	-	359
	199 c.i. Man.	At conversion After 4000 mi.	2.34 3.21	348 378	106 74	2065 1975	225 176	855 840	225 176	359
c 200-250	1968/6	Baseline	1.07	709	-	1950	-	1279	-	-
	250 c.i. Man.	At conversion After 4000 mi.	1.16 .96	418 248	168 123	2330 1345	205 160	679 522	158 ^{4/} 146 ^{5/}	-
d 250-300	1968/8	Baseline	1.3	273	-	-	-	736 ^{4/}	-	570
	289 c.i. Auto.	At conversion After 9000 mi.	1.8 ^{4/} .54 ^{4/}	331 ^{4/} 233 ^{4/}	118 97	- 1370	- 86	1476 ^{4/} 1581 ^{4/}	491 600 ^{5/}	122 172
e 300-375	1969/8	Baseline	1.11	471	-	2370	-	1051	-	-
	302 c.i. Auto.	At conversion After 4000 mi.	.86 .56	271 342	130 185	2940 1855	285 190	491 600 ^{5/}	122 172	-
f 375 +	1967/8	Baseline	2.20	272	-	1455	-	1200 ^{5/}	-	-
	440 c.i. Auto.	At conversion After 4000 mi.	1.66 2.26	178 158	547 79	1815 1470	270 175	484 477	410 ^{5/} 293 ^{5/}	-

NOTE: Data are continuous NDIR except Reactivity Units which are from F.I.D. tests on bag samples.

1/ Gasoline emissions are for cold start sequence, except as noted in footnote 4/, corrected to 15% CO₂.

2/ Natural gas emissions are from hot start cycles, corrected to 11% O₂. Previous test data show no difference between cold and hot starts, Table I.

3/ Reactivity Units for natural gas from Table IV.

4/ Hot start cycles.

5/ Oxides of nitrogen derived from bag samples, using mean ratio of bag to NDIR values.

TABLE IV - HYDROCARBON REACTIVITY

Engine Class Cubic Inch	Yr/Cyl Displ. Trans.	Test Conditions	Gasoline				Natural Gas				
			Concentrations		Reactivity Units	Concentrations		Reactivity Units	0-8-3 Reactivity ^{1/} Units		
			Par. ppm	Ole. Aro. ppm		Par. ppm	Ole. Aro. ppm		Units	Units	
a 0-140	1969/4 134 c.i. Man.	Baseline	230	110	160	1590	-	-	-	-	-
		At conversion	185	70	140	1165	270	4	1	305	35
		After 4000 mi.	160	100	120	1320	265	30	10	535	270
b 140-200	1969/6 199 c.i. Man.	Baseline	390	175	210	2420	-	-	-	-	-
		At conversion	475	165	90	2065	380	27	3	599	225
		After 4000 mi.	205	165	150	1975	185	22	0	361	176
c 200-250	1968/6 250 c.i. Man.	Baseline	370	115	220	1950	-	-	-	-	-
		At conversion	475	125	285	2330	470	20	15	675	205
		After 4000 mi.	225	95	120	1345	250	17	8	410	160
d 250-300	1968/8 289 c.i. Auto.	Baseline	-	-	-	-	-	-	-	-	-
		At conversion	-	-	-	-	-	-	-	-	-
		After 9000 mi.	230	105	100	1370	260	20	0	420	160
e 300-375	1969/8 302 c.i. Auto.	Baseline	330	195	160	2370	-	-	-	-	-
		At conversion	340	250	200	2940	600	30	15	885	285
		After 4000 mi.	270	140	155	1855	440	23	2	630	190
f 375 +	1967/8 440 c.i. Auto.	Baseline	125	140	70	1455	-	-	-	-	-
		At conversion	155	155	140	1815	820	30	10	1130	270
		After 4000 mi.	110	140	80	1470	240	30	0	480	240

^{1/} Data in Table V show that paraffinic component of natural gas exhaust is methane. Methane has zero photochemical reactivity; therefore, paraffins should be weighted zero in reactivity unit calculation.

TABLE V - NON-METHANE HYDROCARBONS IN NATURAL GAS EXHAUST
1968, 8 cyl., 289 cu. in., Automatic Transmission

Fuel	Subtractive Column + F. I. D.			Gas Chromatograph + F. I. D.		
	Total HC ppm C ₆	Olefins ppm C ₆	Aromatics ppm C ₆	Total HC ppm C ₆	Paraffins Less Methane ppm C ₆	Olefins Plus Aromatics ppm C ₆
Pure Methane (99.6 %)	335	15	0	280	1	8
	295	5	0	168	1	2
LNG Vapor (98 % Methane)	325	15	0	191	3	4
	280	5	0	183	0	2
Syn. Nat. Gas (95 % Methane) (2 1/2 % Hydrogen)	275	10	0			
Pipeline Gas (89 % Methane) (7 % Ethane)	290	25	0	232	1 ₁	8
	280	20	0	239	27 ₁	29
LNG Liquid (86 % Methane) (12 % Ethane)	270	50	0	269	1 ₂	5
	290	40	0	228	38 ₂	7

1/ Ethane = 22 ppm (C₆)

2/ Ethane = 35 ppm (C₆)

TABLE VI - EFFECTS OF NATURAL GAS COMPOSITION AND AIR FUEL RATIO ON EMISSIONS
 1968, 8 cyl., 289 cu. in., Automatic Transmission

Mileage	Fuel	CO ₂ Average %	Continuous NDIR, 11 % CO ₂		
			CO %	HC ppm	NO _x ppm
4,987	Pipeline Gas	11 %	.12 %	118	570 ^{1/}
5,928	Pipeline Gas	11 %	.12 %	99	640 ^{2/}
6,621	Pipeline Gas	11 %	.17 %	105	-
9,568	LNG Vapor	9 %	.09 %	91	133
	LNG Liquid	10 %	.10 %	107	248
13,511	Pure Methane	8 %	.15 %	108	64
14,060	Pipeline Gas	8 %	.15 %	119	223

^{1/} Bag Sample Data

^{2/} 50 MPH Cruise

CURRENT EMISSION VS FUTURE STANDARDS

TABLE VII

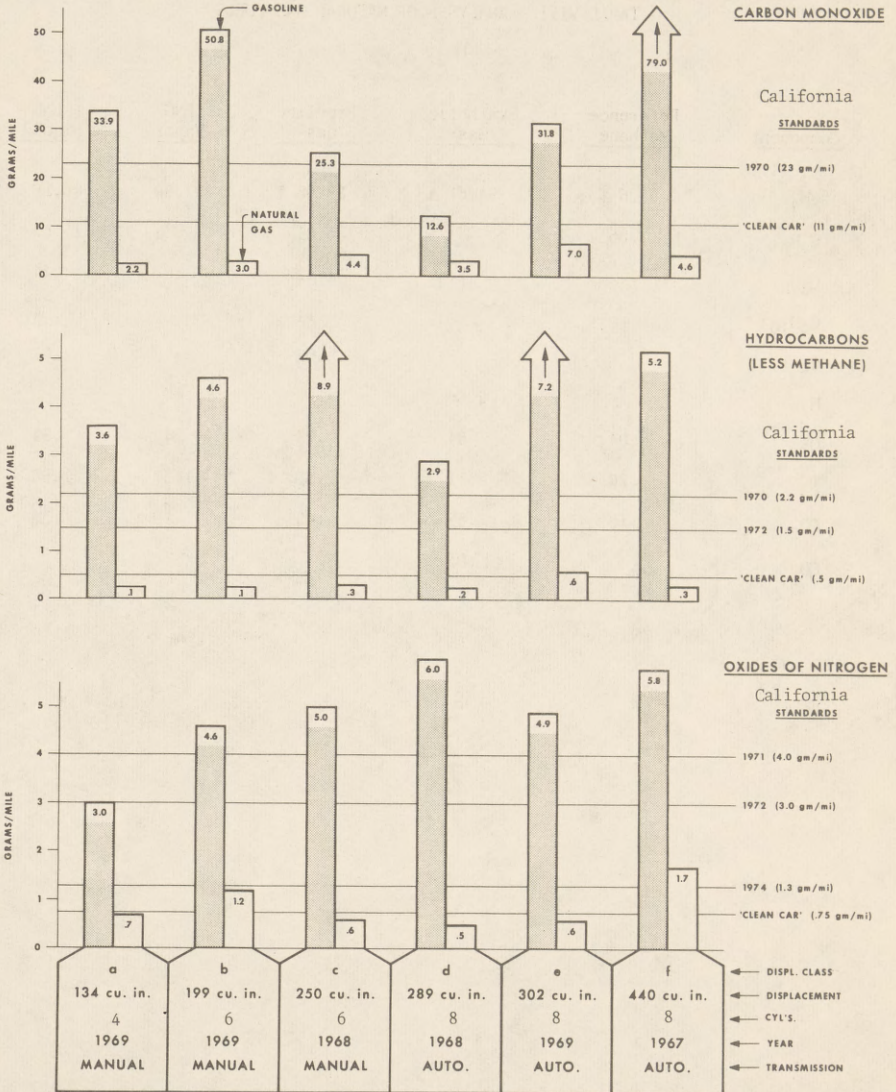


TABLE VIII - ANALYSES OF NATURAL GAS FUELS

<u>Component</u>	<u>Reference Methane</u>	<u>Synthetic Gas</u>	<u>Pipeline Gas</u>	<u>LNG Vapor</u>	<u>LNG Liquid</u>
CH ₄	99.6 %	94.61 %	88.98 %	97.80	86.19
C ₂ H ₆	.06		6.81	.21	11.63
C ₃ H ₈			1.12	.01	.44
C ₄ H ₁₀			.11		.01
C ₅ +			.02		.01
H ₂		2.56			
O ₂	.04	.04	.03	.42	.31
N ₂	.20	2.11	2.50	1.37	1.08
CO ₂	.10	.65	.43	.19	.33
CO		.03			

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