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AUTOMOTIVE TECHNOLOGY AND FUEL ECONOMY STANDARDS

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HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

NINETY-SIXTH CONGRESS

SECOND SESSION

ON

S. 2015

TO AMEND THE URBAN MASS TRANSPORTATION ACT OF 1964 AND TITLE 23, UNITED STATES CODE, TO PROVIDE FOR AUTHORIZATIONS, AND FOR OTHER PURPOSES AND TITLES III, IV, V, VI, VII, AND VIII

APRIL 30, MAY 2, 9, AND 14, 1980

Serial No. 96-110

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AUTOMOTIVE TECHNOLOGY AND FUEL ECONOMY STANDARDS

WEDNESDAY, APRIL 30, 1980

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met at 10 a.m. in room 235, Russell Senate Office Building, Hon. Adlai E. Stevenson (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR STEVENSON

Senator STEVENSON. Today and on May 2, the subcommittee will consider automobile fuel efficiency, including several legislative proposals for Federal support of automotive research and technology development. One of these proposals requested by the administration is contained in title III of S. 2015. It proposes a 10-year cooperative industry research program. The alternative is proposed by Congressman Harkin in H.R. 4678, and in that bill NASA assumes a larger responsibility for automotive technology.

S. 1250, which was reported by this committee yesterday, proposes innovation centers involving industry, government, and universities for cooperative technologies. Although that bill is concerned with industrial innovation generally, it may offer a model for automotive technology development.

These hearings raise some large questions about the competitiveness of American industry in a very competitive world. Automotive technology in the United States is seeking to catch up with foreign technology, but to prosper or survive the industry will have to leapfrog foreign technology, including foreign manufacturing procedures. That will be difficult.

The capital requirements for the industry may pose even larger challenges. Later in these hearings we will consider automobile fuel efficiency standards for beyond 1985. And in this committee or another, we will have to go beyond the Chrysler legislation to consider what, if any, steps are needed in order to help the industry meet all of its capital requirements.

[The bill follows:]

96TH CONGRESS
1ST SESSION

S. 2015

To amend the Urban Mass Transportation Act of 1964 and title 23, United States Code, to provide for authorizations, and for other purposes.

IN THE SENATE OF THE UNITED STATES

NOVEMBER 15, 1979

Mr. RANDOLPH (for himself, Mr. CANNON, and Mr. WILLIAMS) (by request) introduced the following bill; which was read twice and referred jointly by unanimous consent to the Committees on Environment and Public Works; Commerce, Science, and Transportation; and Banking, Housing, and Urban Affairs

---

A BILL

To amend the Urban Mass Transportation Act of 1964 and title 23, United States Code, to provide for authorizations, 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 "Transportation Energy Efficiency Act of 1979".

★(Star Print)

TITLE I—ENERGY EFFICIENT PUBLIC TRANSPORTATION

SEC. 101. Section 4(c) of the Urban Mass Transportation Act of 1964 ("Act") is amended by adding at the end thereof the following new paragraph:

"4(c)(4) To finance grants and loans under sections 3 and 5(a)4(A) of this Act and to finance grants and contracts under subsection (i) and subsection (g) of this section, there are authorized to be appropriated for allocation by the President from the Energy Security Trust Fund aggregate additional sums not to exceed $1,050,000,000 by September 30, 1980, $2,100,000,000 by September 30, 1981, $3,200,000,000 by September 30, 1982, $4,300,000,000 by September 30, 1983, $5,600,000,000 by September 30, 1984, $6,900,000,000 by September 30, 1985, $8,200,000,000 by September 30, 1986, $9,500,000,000 by September 30, 1987, $10,800,000,000 by September 30, 1988, and $12,100,000,000 by September 30, 1989. In any fiscal year not more than 4 per centum of such year's appropriation pursuant to this paragraph shall be used for the purposes of subsection (i) of this section. Appropriations pursuant to the authority of this paragraph may be in an appropriations Act for a fiscal year preceding the fiscal year in which the appropriation is to be available for obligation and shall remain available for three years following the close of the

fiscal year for which such appropriation is made. Amounts transferred by the Secretary of Treasury to cover revenues forgone as a result of the tax credit for acquisition of intercity buses that expand the existing bus fleet shall be charged against the authorization contained in this subsection."

SEC. 102. Section 4(c)(3)(A) of the Urban Mass Transportation Act of 1964 is amended by inserting after the first sentence the following: "Not to exceed an aggregate of $650,000,000 of these authorizations may be appropriated from the Energy Security Trust Fund for allocation by the President."

SEC. 103. Section 5(a)(4)(B) of the Urban Mass Transportation Act of 1964 is amended by adding after the last sentence the following: "Not to exceed an aggregate of $250,000,000 of these authorizations may be appropriated from the Energy Security Trust Fund for allocation by the President. There is authorized to be appropriated from the Energy Security Trust Fund for allocation by the President for the fiscal year ending September 30, 1983, an amount not to exceed the difference between $250,000,000 and the aggregate amounts appropriated pursuant to the authority of this subparagraph from the Energy Security Trust Fund for prior fiscal years.".

SEC. 104. Section 4(i) of the Urban Mass Transportation Act of 1964 is amended by striking out "section 4(c)(3)(A)" and inserting "sections 4(c)(3)(A) and 4(c)(4)."

TITLE II—IMPROVED AUTOMOBILE USE

SEC. 201. Chapter 1 of title 23, United States Code, is amended by adding at the end thereof the following new section:

"SEC. 157. (a) Notwithstanding any other provision of law, the Federal share of projects under title 23, United States Code, may, at the discretion of the Secretary, be increased from the Federal share provided in section 120 and section 402(d) of this title to a Federal share of 90 per centum, for energy conservation projects under regulations which the Secretary shall issue. In those States containing nontaxable Indian lands, individual and tribal, and public domain lands which receive an increase in the Federal share under section 120(a) of this title, the Federal share shall be increased 15 per centum but shall not exceed 95 per centum. Funds for such increase in the Federal share are authorized to be appropriated from the Energy Security Trust Fund.

"(b) The Secretary is authorized to make grants to States, counties, municipalities, metropolitan planning organizations, and other units of local and regional governments, and private entities, for energy conservation projects, and for the purpose of planning, implementing, or evaluating innova-

tive transportation strategies for more efficient use of automobiles and alternatives to low occupancy automobiles. Grants to entities other than private entities shall be made through the State. Grants made under this section shall be consistent with regulations which shall be promulgated by the Secretary establishing eligibility criteria therefor. The Federal share of projects under this section shall be 90 per centum. Federal funds for projects under this section are authorized to be appropriated from the Energy Security Trust Fund.".

SEC. 202. Subsection (a) of section 402 of title 23, United States Code, is amended by inserting after the fifth sentence thereof the following: "Programs developed in accordance with this section may include programs for increased automotive fuel efficiency, including improved driver practices, vehicle operation, and vehicle maintenance, for which program funds may be provided at the discretion of the Secretary from the Energy Security Trust Fund.".

SEC. 203. There are authorized to be appropriated out of the Energy Security Trust Fund for allocation by the President, for carrying out the purposes of sections 154, 157, and 402 of title 23, United States Code, additional sums not to exceed $250,000,000 by September 30, 1980, $500,000,000 by September 30, 1981, $750,000,000 by September 30, 1982, $1,000,000,000 by September 30,

1983, $1,250,000,000 by September 30, 1984, $1,500,000,000 by September 30, 1985, $1,750,000,000 by September 30, 1986, $2,000,000,000 by September 30, 1987, $2,250,000,000 by September 30, 1988, and $2,500,000,000 by September 30, 1989. Not more than 3 per centum of sums so appropriated for any fiscal year may be used as the Secretary may deem necessary for public information programs directed to improve automobile use. The Secretary shall deduct a sum not to exceed 1 per centum of sums so appropriated for any fiscal year as the Secretary may deem necessary for the costs of administering programs arising under chapter 4 of title 23, United States Code. Appropriations pursuant to the authority of this section shall remain available until expended.

SEC. 204. Section 103(e)(4) of title 23, United States Code, is amended by striking the eighth, ninth, and tenth sentences and inserting the following in lieu thereof: "Notwithstanding any other provision of law, for highway projects approved on or after the date of enactment of the Transportation Energy Efficiency Act of 1979, there are authorized to be appropriated out of the Highway Trust Fund for liquidation of the obligations incurred under this paragraph such sums as may be necessary. Appropriations for public mass transit projects substituted pursuant to this paragraph are authorized under section 4(g) of the Urban Mass Transportation

Act of 1964, as amended. Obligations incurred after the date of enactment of this sentence under this paragraph for highway projects substituted as a consequence of withdrawals shall be charged against sums apportioned to the State under section 104(b)(5)(A) of this title. Unobligated apportionments for the Interstate System in any State where a withdrawal is approved under this paragraph after the date of enactment of the Transportation Energy Efficiency Act of 1979, shall, on the date of such approval, be reduced in the proportion that the amount made available as a consequence of such withdrawal for the Federal share of the cost of substitute public mass transit projects, as determined by the Secretary, bears to the Federal share of the total cost of all Interstate routes in that State as reflected in the latest cost estimate approved by the Congress, but an amount equal to such reduction shall remain available to the Secretary for reallocation to any other State in accordance with the provisions of the third sentence of section 118(b) of this title."

SEC. 205. Section 104(b)(5)(A) of title 23, United States Code, is amended as follows:

(1) By striking the twenty-third sentence and inserting the following in lieu thereof: "Upon approval by Congress, the Secretary shall use the Federal share of such approved estimates in making the apportionment for the fiscal year ending September 30, 1981.

The Secretary shall revise the estimates transmitted to the Congress within ten days subsequent to January 2, 1979, to reflect the amount available for highway substitution projects substituted as a consequence of withdrawals approved pursuant to section 103(e)(4) of this title, and transmit such revised estimates to the Congress not later than September 1, 1980. Upon the approval by Congress, the Secretary shall use the Federal share of such approved estimates in making the apportionment for the fiscal year ending September 30, 1982.";

(2) By inserting after the words "then designated Interstate System" in the existing twenty-fourth sentence, and each sentence thereafter wherever these words appear in the paragraph, the following: "and such revised estimate shall reflect the amount available for highway substitution projects substituted as a consequence of withdrawals pursuant to section 103(e)(4) of this title,".

TITLE III—BASIC AUTOMOTIVE RESEARCH PROGRAM

There is authorized to be appropriated not to exceed $800,000,000 to be derived from the Energy Security Trust Fund and for allocation by the President, to carry out cooperative basic automotive research to advance the state of

knowledge underlying automotive technology. The research shall include, but not be limited to, such areas as thermal and fluid sciences; structural mechanics; electrochemistry; aerodynamics; materials science and processing; control systems; tribology; surface science and catalysis; and acoustics and vibrations. Appropriations pursuant to this authority may be made through fiscal year 1989 and without fiscal year limitation.

TITLE IV—FUEL ECONOMY TECHNOLOGY ASSESSMENT

There is hereby authorized to be appropriated from the Energy Security Trust Fund for allocation by the President an aggregate amount of not to exceed $200,000,000 for the fiscal years 1980 through 1989, inclusive, to remain available until expended to assist in carrying out automobile fuel economy technology assessment under the Motor Vehicle Information and Cost Savings Act (15 U.S.C. section 1901 et. seq.).

Senator STEVENSON. I regret the delay in getting started. I am afraid, because of the wrangle on the floor, that we may be interrupted and delayed again by votes.

Our first witness this morning is Dr. Philip Smith, Associate Director, Office of Science and Technology Policy. I will invite you, sir, and all of our witnesses, if possible, to summarize the statements and your full statements will be entered into the record.

I didn't see Congressman Harkin. Would you like to go first?

Mr. HARKIN. Thank you, sir. I just heard the bell. I will go vote and then come back.

Senator STEVENSON. We will proceed, then.

STATEMENT OF PHILIP SMITH, ASSOCIATE DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT; ACCOMPANIED BY LAWRENCE LINDEN

Mr. SMITH. Good morning, sir. I have a long statement. I will submit this for the record and summarize part of it.

I appreciate the opportunity to be with you and discuss this important subject today. I have with me Lawrence Linden of our office and he will help me respond to your questions.

Over the past year and a half, the administration has actively pursued a number of initiatives and activities which relate to and support technological change in the automotive sector. The purpose of all of these endeavors is to insure a healthy and technologically active automotive sector which meets our transportation, energy conservation, environmental and safety needs.

Some of the highlights of these activities include the following: In late 1978 and early 1979, we reassessed our support of basic research as it related to the total research and development activity in the automotive area. And as a result, as you know, we proposed joining with the industry to initiate the cooperative automotive research program.

On another front, we have undertaken a set of activities designed to ensure a sound policy for the utilization of the diesel engine in the passenger car fleet in the late 1980's. The Department of Energy has continued to pursue vigorously its program to develop key alternative and advanced propulsional systems for automotive application, including expansion to two contractors for the gas turbine system.

And finally, the Congress and the administration have launched together a study of the automotive industry, which is under the leadership of Secretary Goldschmidt. This will address all of the major Federal policies which substantively influence the financial and technological strength of this industry over the medium and long terms.

In my testimony this morning, I will begin by discussing some of the underlying precepts that guide our approach to automotive technology development. These policies are implemented by several departments and agencies, with oversight in a number of committees of the Congress. In the automotive area, it is particularly important to understand the Federal role in research and development in relation to that of the industry. We welcome the subcommittee's hearings this week and next, as it provides an opportunity for both the administration and Congress to consider research and

development, along with the economic and regulatory policy issues that also influence technological change in the automotive sector.

Following this early discussion, I will review some of the operational and planning strategy that we have developed for the cooperative automotive research program, and finally, I will comment on several other proposals that have been made to advance automotive technology.

Our programs are guided by five precepts and I would like to briefly review these:

First, we believe the automotive manufacturers are best able to exploit science and technology for the development and mass production of passenger cars. The modern passenger car is for the most part a product which is remarkably efficient and reliable, and modern automotive production facilities remain among the best examples of mass production technology.

Second, the principal forces needed to spur technological change in the industry are market forces, especially realistic energy prices. Profit motivation in the face of domestic and foreign competition force individual firms to maintain technological progress, balancing short-run expenses against longer-term consumer desires. We have hindered the industry's response to the energy situation over the past 6 years by holding down energy prices. The President's decision to decontrol crude oil and to impose a gasoline conservation fee has rectified this circumstance.

Third, regulatory programs are required where market forces are inadequate. Emissions, safety, and fuel economy regulations have helped to stimulate technological change in socially productive directions over the past 15 years and will, in varying degrees, continue to be necessary as part of the industry's incentive structure.

Fourth, these market and regulatory forces should be supplemented by Federal support for technology development programs on technologically high-risk systems, and that is the underlying basis for the programs currently funded by the Department of Energy.

Fifth, the Government should insure the existence of an adequate program of basic research related to automotive technology to provide ideas and fundamental knowledge to the technology and systems development efforts supported by the public and private sectors. It is in this context that we are proposing an increase in the level of basic research supported by the Federal Government through the new initiative, the cooperative automotive research program. An automotive technology policy based on this framework will seek the balanced and integrated use of a set of policy tools, with each playing its appropriate role in the overall structure.

There are, Mr. Chairman, a number of programs already under way in the Federal Government. I would briefly like to review these; some of them will be discussed in more detail by other witnesses during these hearings.

The most important current program of Federal support for automotive technology development is that of the Department of Energy, whose fiscal year 1981 budget for automotive research development and demonstration is $101 million. This effort has an explicit statutory basis in the Electric and Hybrid Vehicle Re-

search Development and Demonstration Act of 1976 and the Automotive Propulsion Research and Development Act of 1978.

Much of the work in this program is carried out through the NASA Lewis Research Center in Cleveland, Ohio. Approximately 74 percent of the Department's automotive research efforts are handled in this way. The highly respected capabilities of the Center in the propulsion area are used to manage this important work, but the budget and planning responsibilities are are undertaken by the Department of Energy. This allows the work to be related well to other conservation programs and to the fuels programs, so that appropriate budgetary and policy tradeoffs can be made.

The Department of Transportation also has a research and development program in the automotive area. It is managed by the National Highway Traffic Safety Administration, primarily to support its rulemaking and regulatory functions in the safety and fuel economy area. The budget for this program for 1981 is $42 million. As a part of the administration's transportation energy efficiency initiative announced last August, the Department has developed a fuel economy technology assessment program to supplement ongoing work on mid-term technologies. This effort would be authorized by title IV of S. 2015. The Department will request appropriations for the effort beginning in fiscal year 1982.

Basic research in the physical sciences related to automotive technology is currently supported in six Federal agencies. The total of this effort across all agencies was approximately $35 million in fiscal year 1979. This figure is based on data assembled by a team from all of these agencies, who have been helping in the planning of the cooperative automotive research program.

While we have not made a detailed review for fiscal years 1980 or 1981, we believe that these efforts grew at about the same pace of other federally-supported basic research, bringing the total for 1981 to about $42 million.

Let me turn now to the cooperative automotive research program. This program first was under discussion in late 1978 and in early 1979. The discussions culminated with a meeting at the White House between the President and the leaders of the American automobile industry on May 18 of last year. At that time, the President announced a series of planning principles that would guide the continuing discussions to prepare for the cooperative automotive research program, or CARP. These are listed in my statement.

Since last May we have had continuing discussions with the five automakers in the United States. These include Ford, GM, Chrysler, AMC and Volkswagen of America. We are now simultaneously developing two agreements.

One is an agreement on the administrative guidelines that will guide this program; the second, being developed by a team of scientists and engineers from all over the Nation, it is a technical agenda which will serve to guide the research under the program.

The objectives of the program are three:

The first is to improve the scientific and technological base underlying automotive technology.

The second is to increase the level of production of new engineers and scientists oriented toward the automotive sector.

And the third is to provide a new cooperative element to the generally adversarial relationship between the automotive industry and the Federal Government.

The structure of the program and the financial arrangements are laid out in some detail in my prepared statement. Let me summarize briefly. The program relates to the basic precepts with which we guide our research policy for support of basic research. We believe that there is an underinvestment in basic research by industry generally, and this area is no exception. It is appropriate for the Federal Government to therefore support basic research which has usefulness in a broad way in the economy.

It is also equally important to remember the fact that work that is undertaken which is targeted toward one industrial sector, such as the automotive sector, will have particular benefit to that sector; therefore, it is reasonable to ask the industry to pay for some of the work that is related to that sector's particular interest.

For this reason, we have developed a proposal to have a 50–50 cost-sharing, in which we will split between the Government and the industry this new funding for basic research in the automotive area. The automotive manufacturers have agreed among themselves to split their share of the effort according to their share of production of automobiles in the United States.

The program will operate along the following lines: Each participating funder—that is, the companies and the Government agencies funding research—will make individual decisions about the work that will be undertaken through their research activity. The program is therefore a voluntary confederation of relatively autonomous participants.

In order to bring a larger proportion of our Nation's top scientists and technical talent to bear on scientific problems related to automotive technology, much of the Federal work will be funded in an extramural fashion; that is, going to performers outside of corporate research laboratories, in colleges and universities elsewhere. A significant portion of the industry's activity will also go extramurally outside of their own industry laboratory. However, we would expect a large portion, particularly in the case of General Motors and Ford, probably about half or more, to be funded and carried out in their own research laboratories.

There is an independent oversight committee that will review the program on an annual basis. That will be made up of five members appointed by the Federal Government and the industry, to review the program and insure that each side, each participant, has raised its level of effort according to the agreement and that the program continues to operate in the basic research area.

The program, as you can imagine, has raised a number of issues associated with antitrust policy. We have involved the Antitrust Division of the Justice Department in the planning of the program from the beginning, and we have from both the Assistant Attorney General for antitrust and the Chairman of the Federal Trade Commission opinions providing their concurrence and support for this program.

Research will be undertaken in 12 areas; in the prepared statement I describe not only the research areas but also in some respects how the research might go forward. I think, Undersecre-

tary Beckham and Dr. Dugoff will also address this portion of the overall planning framework for CARP, so I will not discuss it now.

We have worked over this whole year very closely with Secretary Goldschmidt to establish a sound capability within the Department of Transportation for the support of extramural basic research, so the Department of Transportation would, along with other Federal agencies, be a participant in the program. At the Secretary's request, Dr. Press convened a panel of experts to make recommendations to Secretary Goldschmidt. That report was sent to the Secretary in February, and the Secretary is making plans to implement the recommendations not only for the structuring of their research activity in the Department of Transportation but also for the provision of increased technological and scientific advice directly to him.

We believe that the other Federal agencies that will participate in the program will include the Department of Energy and the National Science Foundation and possibly others. In 1981 the Department of Transportation and the National Science Foundation will be the Federal funding agents. The Department of Transportation will be the lead or coordinating agency for the activity over the 5-year period that we envision as the startup and initial operational period for CARP.

Last August the cooperative automotive research program was incorporated in the transportation energy efficiency initiative to be funded out of the windfall profit tax revenues through an Energy Security Trust Fund. Subsequently, S. 2015 was introduced, by request incorporating title III, which would authorize $800 million to the President over fiscal years 1980 through 1989 for the program. Since that time several important developments have taken place. First, the windfall profits tax has been passed by the Congress and enacted into law, signed by the President. There was no special Energy Security Trust Fund created. Further, in the course of the development of fiscal year 1981 Federal budget, the level of effort for the Federal side of CARP has been better defined.

As discussed above, we have made a determination of the Federal agency management structure for fiscal year 1981, and we are therefore in the process now of developing a budget amendment which will provide funding for the Department of Transportation and via the Department to the National Science Foundation for their fiscal year 1981 participation in the program. Because there is no Energy Security Trust Fund, no specific authorization of funds to be appropriated to the President to support CARP is required. Based on a legal review, we have concluded that no new programmatic authority is required for CARP—in the way of authorization for the agencies that will participate—the Transportation Department, National Science Foundation, the Department of Energy, NASA, or the National Bureau of Standards.

I would like to turn now to some other Federal proposals for automotive research and development. The first of these is the proposal that has been made by Mr. Tom Harkin of the House of Representatives, who is fortunately back to hear this part of the testimony. His proposal, H.R. 4678, proposes centralizing automotive technology-related research and development in NASA, and it proposes increasing the funding for this activity by the following

amounts: In fiscal year 1981, the amount would be $25 million; in 1982, $100 million; in 1983, $300 million.

The administration has three problems with Mr. Harkin's proposal, and we have discussed these with him personally as well as with his committee and with Chairman Fuqua of the House Science and Technology Committee.

First of all, we consider this an inappropriate extension of Federal support in research and development in activities that are now centered in the industry itself. Second, the bill proposes an institutional restructuring that would centralize current research and development programs related to automotive technology in the National Aeronautics and Space Administration.

We agree with Mr. Harkin that NASA has excellent capabilities to perform automotive-related research. However, we are deeply concerned that the primary focus of NASA continue to be on aeronautics and space. And as you know, Mr. Chairman, from your own work, NASA has a very substantial agenda at the moment, building and developing the national Space Transportation System that will be the transportation system for all U.S. space programs—civil, military, commercial—over the 1980's and the 1990's. We therefore believe that the current structure which has the Department of Energy and Department of Transportation involved as the primary policy organizations related to automotive technology is a sound one. We would and do support the continued use of NASA capabilities such as the Lewis Research Center to undertake or manage specific automotive research or development projects.

The third concern with the proposal is that it is a serious and obvious budgetary problem. Without more substantive analysis that would indicate what programs would be undertaken through this very large authorization, we would find it very difficult to support this legislation.

Some of the research that may be undertaken in the cooperative automotive research program will bear certain resemblances to the generic technology research that has been proposed in S. 1250, which has been sponsored by you, Mr. Chairman, and by Senator Schmitt.

We believe that it is very possible that there would be work, for example, in an area such as tribology that would be a candidate for a generic technology center since it would produce a broad underpinning of research and development for a number of industries or a wide industrial application.

At the same time, however, it very well may be feasible to undertake specific automotive-related work in tribology under CARP. We look upon the relationship between a generic center approach for some of the research that might be undertaken that bears relation to CARP, and the CARP program itself, as complementary and in no way mutually exclusive. In fact, in my estimation, in a number of the areas that we are thinking about related to CARP, there is very much the need for both direct support of basic research through a program such as CARP and the possibility of establishing one or more generic centers that would undertake work that would be supportive not only of this industrial sector but many others. I would be happy to discuss that further, if you would so desire.

In summary, I have tried to present a statement about the precepts that guide our program in the automotive research area. I have tried to briefly outline some of the basic planning strategy that we have used in the development of the cooperative automotive research program. As I have indicated, we believe that the objectives of this program are complementary and fit together with some of the objectives of S. 1250. We have difficulties, which I have enumerated, with the other approaches that have been introduced to the Congress. At this particular moment, when the domestic automotive industry is faced with the requirement of rapid conversion of both plant and product, there is a tendency to succumb to the belief that a massive injection of Federal funds for research and development would speed the rate of technological transition in the automotive sector. The requirements of the next several years will not be met by more research and development, nor is it obvious that a greatly accelerated Federal effort of advanced systems work would be as effective as normal market mechanisms and regulatory goals for the stimulation of technological development in the latter years of this decade.

As I indicated, Secretary Goldschmidt is undertaking a major review of the automotive area. Undersecretary Beckham will elaborate on this when he testifies a little later this morning. The research and development policy, along with other policies, will be reviewed in this context. If we find specific new programs that require or that would benefit from an increase of Federal work in technological development, we would be most willing to consider these new initiatives. But, as I have indicated, we believe now the basic need is to increase the basic research underpinning this area. That is why we have developed CARP.

This concludes my statement. I will be happy to respond to your questions.

[The statement follows:]

STATEMENT OF PHILIP M. SMITH, ASSOCIATE DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Chairman Stevenson, Senator Schmitt, and members of the Subcommittee, I appreciate the opportunity to be with you to discuss this important subject. With me today is Dr. Lawrence H. Linden of our office. The automobile is an intimate part of the American way of life; your inquiry into the needs and opportunities for automotive research and development is both timely and proper.

Over the past year and a half, the Administration has actively pursued a number of activities which relate to and support technological change in the automotive sector. The purpose of these endeavors is to ensure a healthy and technologically active automotive sector which meets our transportation, energy conservation, environmental, and safety needs in as economical a manner as possible. The following are some of the highlights:

In late 1978 and early 1979, we reassessed our Federally supported research and development programs related to automotive technology, and as a result, joined with the industry to initiate the Cooperative Automotive Research Program, the principal subject of my discussion this morning.

We have undertaken a set of activities designed to ensure a sound policy for the utilization of the diesel engine in the passenger car fleet. These include: (1) the initiation of a substantial program of research on the possible carcinogenicity of the exhaust products of diesel-powered vehicles; (2) the initiation of a major study by the National Academy of Sciences, under Professor Henry Rowen of the Stanford Business School, to advise senior Administration officials on the impacts of alternative policies for the diesel-powered passenger car; and (3) promulgated particulate emission standards for light duty vehicles to insure the rapid development and implementation of control technology.

The Department of Energy has pursued its vigorous program to develop key alternative and advanced propulsion systems for the automotive application, including expansion to two contractors for the gas turbine system.

Finally, we launched, under the leadership of Secretary Goldschmidt, a major assessment of the future of the automotive industry, which will address each of the major Federal policies which substantially influence its financial and technological strength over the medium and long terms.

There is, as you know, a second set of activities focused on the short-term financial problems of the industry and of the Chrysler Corporation in particular.

In my testimony this morning, I will begin by discussing the precepts underlying the Federal policies which influence and support technological change in the automotive sector. These policies are implemented by several Federal departments and agencies, with oversight in a number of committees of the Congress. In the automotive area, it is particularly important to understand the Federal role in research and development in relation to other Federal policies affecting technological change in this industry. In this context, the Subcommittee's hearings this week and next provide a welcome opportunity for both the Administration and the Congress to consider research and development along with the economic and regulatory policy issues that also influence technological change in this sector. Following this discussion, I will give a brief description of current Federal automotive research and development programs. Then I will describe the concepts, structure, and budget strategy for our initiative—the Cooperative Automotive Research Program (CARP). Finally, I will discuss several other related proposals, and assess them against our overall automotive technology policy framework.

AUTOMOTIVE TECHNOLOGY POLICY FRAMEWORK

The Administration's policy for ensuring a technologically vital and sound automotive sector is based on the following five precepts:

First, the automotive manufacturers are best able to exploit science and technology for the development and mass production of passenger cars. The modern passenger car is, for the most part, a product which is remarkably efficient and reliable, and modern automotive production facilities remain among the best examples of mass production technology. At the current time, the technology embodied in the passenger car is undergoing an evolution more rapid than at any time since the early decades of this century. While the industry is not undergoing simultaneously a cyclical downturn and a restructuring of its product and its physical plant, it remains a fundamentally sound sector of our industrial economy.

Second, the principal forces needed to spur technological change in the industry are market forces, especially realistic energy prices. Profit motivation in the face of domestic and foreign competition force individual firms to maintain technological progress, balancing short-run expenses against long-term consumer desires. We have hindered the industry's response to the energy situation over the past six years by holding down energy prices; the President's decision to decontrol crude oil and to impose a gasoline conservation fee has rectified this circumstance.

Third, regulatory programs are required where market forces are inadequate. Emissions, safety and fuel economy regulations have helped to stimulate technological change in socially production directions over the past fifteen years and will, in varying degrees, continue to be a necessary part of the industry's incentive structure. The Corporate Average Fuel Economy regulatory program, imposing a statutory goal of 27.5 mpg in 1985, served to stimulate the industry while gasoline prices were held down. The new light duty diesel vehicle particulate standard of 0.2 gram/mile in 1985 will insure rapid development of diesel particulate control devices. Other examples can be cited.

Fourth, these market and regulatory forces should be supplemented by Federal support for technology development programs on technologically high risk systems with potentially high contribution to our national objectives for the transportation sector, where appropriate. Such support should depend on a reasonably convincing case that the particular system or technology would not otherwise be supported at appropriate level by the private sector. The most obvious and legitimate areas where this case can be made is for alternative and advanced propulsion systems, which are well supported by the Department of Energy.

Fifth, the government should ensure the existence of an adequate program of basic research related to automotive technology to provide ideas and fundamental knowledge to the technology and systems development efforts support by the public and private sectors. As you know, we are proposing to supplement current basic research efforts with a new initiative, the Cooperative Automotive Research Program.

An automotive technology policy based on this framework will seek the balanced and integrated use of a set of policy tools, with each playing its appropriate role in the overall structure.

CURRENT FEDERALLY SUPPORTED AUTOMOTIVE RESEARCH AND DEVELOPMENT PROGRAMS

The most important current program of Federal support for automotive technology development is that of the Department of Energy, whose Fiscal Year 1981 budget for automotive research, development, and demonstration is $101 million. This effort has an explicit statutory basis in the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 and the Automotive Propulsion Research and Development Act of 1978, which provide fairly detailed management guidelines and mandated deadlines for the program. In the heat engine area, there are two contractor teams at work on advanced gas turbine systems for automotive propulsion system utilization, and one working on the Stirling system. The gas turbine contracts are cost-shared with the contractor teams, each of which includes a major domestic automotive manufacturer. There are a range of efforts in the research, development and demonstration area for electric and hybrid vehicles as well, including research on advanced battery concepts, development of efficient power conversion technology, systems integration, and demonstration of current technology.

The Department's gas turbine, Stirling, and electric propulsion system projects are managed by the National Aeronautics and Space Administration's Lewis Research Center. These total 74 percent of the Department's automotive research and development efforts. In this way, the highly respected capabilities of the Center in the propulsion area are used to manage this important program while the budgeting and planning responsibilities are undertaken by the Department of Energy. This allows the work to be well related to other conservation programs and the fuels programs so that appropriate budgetary and policy tradeoffs can be made. Managers at the Department of Energy and the National Aeronautics and Space Administration assure me that the current system is structurally sound and the division of labor appropriate.

The Department of Transportation also has a research and development program in the automotive area. It is managed by the National Highway Traffic Safety Administration, primarily to support its rulemaking functions in the safety and fuel economy area. The Administration is committed to maintaining a sound scientific and technological basis for the government's regulatory programs, and therefore considers this an important effort. It is focused on near- and mid-term technologies knowledge of which would allow more effective and efficient safety and fuel economy regulation. It has also resulted in several useful longer-term technologies, such as foam-filled automotive structures, which offer excellent crushability and low weight, although their costs in mass production are not yet clear. The Fiscal Year 1981 budget for this program is $42 million. As part of the Administration's Transportation Energy Efficiency Initiative announced last August, the Department has developed a Fuel Economy Technology Assessment Program to supplement the ongoing work on mid-term technologies; this effort would be authorized by Title IV of S. 2015. The Department will request appropriations for the effort beginning in Fiscal Year 1982.

Basic research in the physical sciences related to automotive technology is supported by six Federal agencies—the Departments of Defense, Energy, Transportation (through the Research and Special Programs Administration), Commerce (through the National Bureau of Standards), the National Aeronautics and Space Administration, and the National Science Foundation. The total level of effort for Fiscal Year 1979 is approximately $35 million. This figure is based on data that was assembled by a team of agency staff, assisted by consultants, which made judgments concerning the relationship of particular projects to automotive technology and to distinguish between basic and applied work; the reported levels are functions of these judgments. We have not made detailed estimated for Fiscal Year 1980 or 1981; assuming that these efforts grew at the same pace of other Federally-supported basic research, the total for Fiscal Year 1981 would be $42 million.

Taken together, the efforts of the Departments of Energy and Transportation constitute a vigorous and balanced technology development program at a level which is appropriate for taxpayer support. As I have previously stated, it is our view that the efforts in automotive-related basic research of both the public and private sectors needs to be increased.

THE COOPERATIVE AUTOMOTIVE RESEARCH PROGRAM—BACKGROUND, OPERATING PRINCIPLES, AND OBJECTIVES

The concept of the Cooperative Automotive Research Program grew out of discussions within the Administration and between the Administration and the automotive industry during the period from December 1978 through May 1979. These discussions culminated in a meeting at the White House between the President and the leaders of the American automobile industry on May 18 of last year. At that meeting, the President and the automotive industry leadership announced the principles for a new initiative. As stated in the Fact Sheet released by the White House on that day, they were the following:

Focus on basic research, which can contribute substantially to improved automotive technology by developing knowledge in such fields as thermodynamics, combustion and fluid dynamics; structures; noise and vibration; materials science and processing; control systems; and friction and wear.

A pluralistic approach, involving a range of university, industry and Federal laboratories in performing the research, to insure that there are independent sources of new ideas . . .

Personnel exchanges, especially between industrial and university laboratories, to maintain the flow of information and the transfer of new engineering knowledge.

Wide and open dissemination of results to all interested parties subject to appropriate patent provisions.

A level of effort and timing determined by the capacity of the science and engineering community to absorb new funds and the competing demands on Federal and corporate resources. . . . The initiative could possibly involve government and industry funding totalling up to $50 to $100 million after three to five years of build-up.

Industry financial participation. Industry cost-sharing is an important feature of this effort. Mechanisms will be developed for industry contribution through direct grants to universities, increases in effort at automotive industrial laboratories, and other arrangements.

Federal agency participation. Which Federal agencies will be involved, and how many, will be determined by an evaluation of the policy responsibilities, research management capabilities and the appropriate role of research within each agency. In order to help insulate the program from the political and technological pressures of the fuel economy, safety and emissions regulatory programs, the initiative will not be managed by a regulatory agency.

Decentralized project selection mechanisms, within an agreed upon general agenda of research areas, and avoiding specified quantitative technology targets, because of the inherent unpredictability of the basic research.

Since the May 1979 meeting, the Director of the Office of Science and Technology Policy and the Secretary of Transportation have carried forward discussions with the industry to design a protocol which will guide the administrative aspects of the program in accordance with these principles. These discussions are now almost complete. Simultaneously, a team of scientists and engineers from around the nation have been developing a technical agenda which will serve to guide the research under the program. This work also is nearing completion.

The objectives of the Cooperative Automotive Research Program are the following:

To improve the scientific and technological base underlying automotive technology. We believe that the automotive industry will utilize ideas which come from fundamental scientific research, and that current levels of effort in this area are inadequate. The Program will not provide solutions to short or even mid-term problems. The Program will stimulate new segments of the scientific community to work on automotive technology-related problems. It will provide directly no new automotive systems. It will, however, greatly increase the flow of ideas, techniques, and knowledge into the industry. It will also provide research to underpin the Federally-sponsored automotive systems development programs.

To increase the level of production of new engineers and scientists oriented toward the automotive sector. By comparison to other scientific and engineering areas, for example electronics or aerospace engineering, the automotive sector has not been seen by students as a dynamic one where there are attractive careers. Over the decade of the 1980's and beyond, there will be heavy demands for scientists and engineers from the major defense and synthetic fuels programs the nation has launched. It is an objective of CARP to ensure that a reasonable number of students from our major research universities recognize the exciting prospects for technological change in the automotive sector. The university-industry linkages established through CARP will aid in this.

To provide a new cooperative element to the generally adversarial relationship between the automotive industry and the Federal Government. While this relationship is, of necessity, adversarial in large part due to the Federal Government's regulatory responsibilitues, we believe that a cooperative element can be usefully added to this relationship, and that over time this modest level of cooperation may appropriately grow.

THE FINANCIAL AND OPERATING STRUCTURE OF CARP

The structural elements of the Program are based for the most part on generally accepted concepts of research policy. Support of basic research is a natural and widely accepted role for the government. It is often difficult to forecast beforehand in what ways the results of a basic research effort will be useful. Even if a project is successful the knowledge generated will be exploited by firms, and probably even industrial sectors, beyond those which financed the work, and which are very difficult to identify beforehand. Due to these inherent scientific and economic characteristics, basic research is not adequately supported by the private sector. Furthermore, research related to some of the nation's specific needs, such as energy and transportation, merits special attention. This is the conceptual basis for the financial matching arrangement which is the core of the Cooperative Automotive Research Program.

The projects funded under the Program will be selected in part for their relevance to future automotive technology; the Program will provide results of use to the automotive industry. It is therefore reasonable for the industry to finance a major share of the effort. For the reasons discussed above, it is also reasonable for the government to finance a major share. The government's support also recognizes the significance of long-run technological change in this particular industrial sector which is central to the nation's energy, environment, health and safety, and economic concerns. The government and the industry have agreed to a one-to-one matching program. The automobile manufacturers have agreed among themselves to split their share of the effort according to their share of production of automobiles in the United States.

The Program will operate as a voluntary confederation of relatively autonomous participants, i.e. automotive firms or Federal agencies, each of whom will select and fund the research projects supported with its share of the total efforts, consistent with the mutually agreed-upon administrative and technical guidelines. The relative autonomy of project selection by each participant assures that range of different ideas will be funded. The participants will choose to support the research areas in varying degrees and will select differing institutional modes for supporting and organizing the work. Such plurality of support is a well accepted concept in basic research management due to the uncertain and judgmental criteria necessary for project selection.

The Program is designed to assure each private participant that, while it may not be able to capture all the benefits of the new work it supports, this will be compensated by the benefits it gains from the work funded by the other private and Federal agency participants. The Framework calls for wide and open dissemination of research results, subject to appropriate patent provisions. Publication of research results in technical journals, personnel exchange programs, and extramural funding of work, will enable diffusion of the new knowledge to all those who can utilize it.

In order to bring a larger proportion of our nation's top scientists and technical talent to bear on the scientific problems related to automotive technology, and to produce more engineers and scientists interested in automotive technology problems, the Program is oriented toward the university sector, which has been largely untapped by this industry. The Federal Government's support will therefore be primarily extramural, i.e., in the form of grants awarded to universities, non-profit research institutions, and possibly research-oriented firms. There will also be some work in Federal establishments, such as the Sandia Laboratory in Livermore, California, which have the capability to bring the latest science to bear on automotive-related problems. The work supported by the industry under the Program will be significantly extramural, i.e., a large fraction will be extramural, but I would expect that the larger firms will support half or more in their own laboratories.

An independent CARP Oversight Committee will be established to monitor each participants expenditures to assure that the bargain is fulfilled. Projects which the Committee judges inapplicable to the Program—for example, if they are not sufficiently basic in character—will not be counted as a part of a participant's matching effort under the Program. There are reporting requirements to assist the Committee in ensuring that new support of research, above a well-defined base level, is taking place. However, it is assumed by all parties to the agreement that each participant

endeavors to honestly fulfill its share of the bargain. The Committee will also advise the participants in the funding balance among the research areas covered.

Any cooperative research program of this sort naturally raises antitrust issues. The Justice Department was therefore involved from the very beginning in the discussions leading to the design of the program and has provided a statement of support for the effort. Likewise, the Federal Trade Commission is also supportive of the Program. The Program is consistent with the current automotive antitrust consent decree because it is confined to basic research which is explicitly exempted from the prohibitions under that decree.

Twelve research areas have been identified for inclusion in the Cooperative Automotive Research Program. These are the following: Combustion, Thermal and Fluid Sciences; Structural Mechanics; Electrochemistry; Aerodynamics; Materials Science and Processing; Control Systems; Tribology; Acoustics and Vibration; Surface Science and Catalysis; Environmental Science; Biomedical Science; and Behavioral Science.

A team of approximately 100 scientists from university, industry, and government laboratories has been preparing advisory reports which will lead to a techincal framework for the Program. This framework will describe a range of research topics for each of these areas and will serve as a guide for the Program's participants.

The Aerodynamics report, for example, was prepared under the direction of Professor Fred Abernathy at Harvard University. One of the research topics which Professor Abernathy and his working group have recommended is the study of boundary layers, separation, and separating regions which effect the aerodynamic forces on an automotive vehicle—its lift and drag as well as side forces. Aerodynamic drag is an important contributor to automotive vehicle fuel consumption at moderate to high vehicle speeds, and side forces affect handling and safety. The three dimensional boundary layers on road vehicles are not the inviscid regions responding to pressure gradients determined by the inviscid flow on which most theoretical models are based; the interaction is much more complicated and is not well understood. Organized vortex structures can be formed at separations which may be connected to the wake. These structures alter the pressure gradients and the aerodynamic forces on the vehicle. Studies recommended by Professor Abernathy's group include:

Three dimensional boundary layers in the presence of typical pressure fields, their development and prediction.

Closed and opened separated regions, including small separation bubbles associated with boundary layer transition and free shear layers.

Mechanisms of flow separation leading to the development of organized vortex structures convected to the wake.

Understanding in these areas will ultimately contribute to changes in vehicle shapes which will reduce aerodynamic drag and other undesirable forces over the course of the next decades.

We would expect a range of different types of research projects to be initiated under the Program to address topics such as these. There will be personnel exchanges whereby, for example, a scientist from an automotive laboratory might spend a year working at a university, and a graduate student from a university might perform a set of experiments for his or her thesis on experimental equipment only available at one of the companies. Both parties would benefit from experiences of this type. We would expect that standard basic research grants to be awarded by participating Federal agencies to individual faculty members to support research at universities, and similar arrangements to be made by the automobile manufacturers. There may also be some joint projects where, for example, a Federal agency and an automotive company might jointly support a center for materials research at a university, where fundamental work on a range of materials related to automotive applications might be conducted.

The Cooperative Automotive Research Program structure which we have developed with the industry is rather unique from the perspective of Federal science and technology policy. The concept of cooperation in research between the industry, government and university sectors is an important one and one which we believe must slowly evolve toward a more central role in our scientific and technological establishment. We also believe that sectorally-oriented basic research can legitimately be expected to be supported in part by the relevant sector; both the government and industry can leverage their respective efforts in this way. The linkages between the industry and university sectors could be better than they currently are; the structure we have developed in CARP is one of a number of experiments that the Administration has underway which may lead to better mechanisms for making university-performed basic research more relevant to the nation's industrial technology needs. We would like to develop a more cooperative spirit of mutual support

between the major industrial sectors and the Federal Government, and research is one area where such cooperation may indeed be possible and desirable and thereby allow us to lower the level of tension associated with this relationship.

ADMINISTRATIVE AND BUDGET STRATEGY FOR CARP

We have given considerable thought to the organization of the Federal side to this Program. It was decided at the outset, and approved by the President, that several government agencies would participate to maintain a pluralistic approach for the government's participation. It was also decided that no regulatory agency or subcabinet level regulatory administration would participate; this excluded the Environmental Protection Agency and the National Highway Traffic Safety Administration.

My office has worked very closely with Secretary Goldschmidt to establish a sound capability within the Department of Transportation for the support of an extramural basic research program, so that the Department could be a participant. At the Secretary's request, Dr. Frank Press convened in January a panel to advise himself and the Secretary on the institutional and administrative aspects of basic automotive research in the Department. The panel was chaired by Dr. H. Guyford Stever and seven other eminent scientists or engineers, most with government or private sector managerial experience were members. Copies of the panel's report have been provided to your staff. The panel made a set of recommendations for organizing the Department's particiption in CARP, gave detailed guidelines on the administrative aspects of such a program, and also suggested a broader review of the Department's research and development structure. Deputy Secretary Beckham will discuss the Department's response in his statement before you later this morning. The Department of Transportation is currently studying its organization for research and development.

Secretary Goldschmidt agrees with the panel's view that an improvement is needed in the capability within the Office of the Secretary for providing scientific and technological advice on matters related to research and development programming, the technical aspects of regulatory proposals, liaison with scientific and technical institutions, and other scientific and technological functions at the Secretarial level. He also agrees that a new office needs to be established in Washington to implement a system of mechanisms for ensuring the scientific quality of the work of the extramural basic research under CARP. The importance that the Secretary and the Deputy Secretary attach to this program and their clear intention to move the Department in the direction of becoming an important contributor to transportation, science and technology are fully supported by Dr. Press, and we will continue to work with them on improving the Department's capabilities. The Department's capabilities for economic and systems analysis for the automotive sector have become well known in recent months as the financial problems of the automotive industry have become the government's concern. Their capabilities, embodied primarily in the Transportation Systems Center in Cambridge, Massachusetts, have underpinned the Federal Government's efforts to respond to the current situation and are well appreciated in the Administration. The Department's role in the Cooperative Automotive Research Program will provide an appropriate complement to these systems analysis capabilities.

After an intense review, we have decided that the Department of Transportation will be the lead agency for the effort. This follows from our fundamental conviction that each Federal agency should have principle responsibility for research and development related to its mission. We have been impressed by the efforts of the top management of the Department to develop a structure to fulfill its roles as lead agency and participate in the Program, and believe they will do the job well. The duties of the new senior official in the Office of the Secretary will include implementation of DOT's responsibilities as lead agency; an office to fulfill its responsibilities as a participant will be located, organized and managed in such a way as to avoid any substantive relationship with the NHTSA's regulatory programs. The Department's duties as lead agency will primarily be to act as a spokesman for the Federal side of the Program, to provide administrative and financial support to the Oversight Committee, and to gather and collate data on the Federal efforts. Consistent with the confederation nature of the Program, other Federal participants will manage their own project selection and grant administration procedure, in accordance with the Program's administrative and technical guidelines.

In fiscal year 1981, the other Federal agency participating as a member of the CARP confederation structure will be the National Science Foundation. A decision on the participation of the Department of Energy, and possibly other agencies, in fiscal year 1982 and beyond will be made after the Department of Transportation completes its own organizational review and makes recommendations on the matter.

Participating agencies utilize the capabilities of the laboratories and centers of other agencies to perform or direct research as appropriate depending on the scientific content of the Program. Possibilities include the combustion analysis capability at DOE's Sandia Laboratory in Livermore, California, the capability in propulsion-related sciences at NASA's Lewis Research Center, and the materials research capability of the laboratories of the National Bureau of Standards.

Our proposed budget for the Program for fiscal year 1981 is $12 million of obligational authority and $6 million of outlays. Our current thinking is that about sixty percent of these would be allocated to the Department of Transportation and about forty percent to the National Science Foundation. Our planning target remains at a combined government-industry level of $100 million in three-to-five years; how and whether we approach this or exceed will depend on our experience with the effort as it grows.

Last August, the Cooperative Automotive Research Program was incorporated in the Transportation Energy Efficiency Initiative, to be funded out of Windfall Profit Tax revenues through an Energy Security Trust Fund. Subsequently, S. 2015 was introduced by request, incorporating Title III which would authorize $800 million to the President over fiscal years 1980 to 89 from the proposed Fund to support the Program. Since that time, several important developments have taken place. First, the Windfall Profit Tax has been passed by the Congress and signed into law by the President; no Energy Security Trust Fund was created. Further, in the course of the development of the fiscal year 1981 Federal budget, the level-of-effort for the Federal side of the Cooperative Automotive Research Program has been better defined. Second, as discussed above, we have made a determination of the Federal agency management structure of the effort for fiscal year 1981. We are therefore in the process of developing a budget amendment which would provide funding for the Department of Transportation (and via the Department to the National Science Foundation) for their fiscal year 1981 participation in the Program.

Because there is no Energy Security Trust Fund, no specific authorization of funds to be appropriated to the President to support CARP is required. Based on a legal review, we have concluded that no new programmatic authority is required for CARP since each of the agencies under consideration for participation has the authority in their organic or other acts to support basic research related to automotive technology. It is now our view, therefore, that Title III of S. 2015 is no longer required.

OTHER PROPOSALS FOR INCREASED FEDERAL SUPPORT OF AUTOMOTIVE RESEARCH AND DEVELOPMENT

A week ago, the House Science and Technology Committee decided to report to the House of Representatives H.R. 4678, sponsored by Congressman Tom Harkin and others. The Administration has not supported this bill for a number of important reasons. First, we consider it an inappropriate extension of Federal support of research and development into activities that must be and are now centered in the industry. As discussed above, the Federal Government already has in place a vigorous and balanced automotive technology development program. This program supports the development of systems which may be important in the automotive sector a decade hence and possibly less. While we continue to believe that these systems are the most appropriate for such support, we do and will continue to reevaluate the content and level-of-effort of this program. H.R. 4678 is not based on any such substantive or programmatic evaluation. The programmatic gap we currently see is the basic research area and this is why we have initiated the Cooperative Automotive Research Program.

Our second objection concerns the institutional restructuring proposed in the bill. H.R. 4678 would centralize current researh and development programs related to automotive technology in the National Aeronautics and Space Administration. We believe that the current structure of the systems and technology development programs and the proposed structure for the CARP are sound. They are based on the principle of lodging the primary responsibility for policy direction, budgeting, and the overall conduct or sponsorship of research and development activities in the agencies most responsible for the relevant mission. In case of development efforts aimed at safe, fuel-efficient transportation technology, the most appropriate Federal agencies are the Departments of Energy and Transportation. Of course, in the basic research area, the National Science Foundation has a role as well. We share Congressman Harkin's view that NASA has considerable expertise in science and engineering. In recognition of the unique expertise of NASA in the propulsion area, the Department of Energy uses NASA for the management of several of its most important automotive technology development projects, as discussed above. Placing budget and policy responsibility for automotive research and development in NASA

would imply that automotive technology is a desirable outcome in-and-of-itself, rather than one component of a socially desirable transportation or energy system; we do not accept this view.

Furthermore, the aeronautics and space areas are two extremely challenging and difficult missions that require the focused attention of NASA management. This is especially the case now when NASA must lead the nation's successful development and flight program for the space shuttle. New programs peripheral to NASA's essential mission could refocus attention away from the priorities of the National Space Transportation System, space science and applications and aeronautics.

Our third principal concern with H.R. 4678 is a serious and obvious budgetary problem. The bill will authorize $25 million, $100 million, and $300 million of new funding in fiscal years 1981, 1982 and 1983, respectively. Because of the urgent necessity for fiscal restraint, budget expenditures, and projections of this magnitude above the expenditures already proposed in the Administration's program, cannot be supported. Even if the amounts for fiscal years 1982 and 1983 were unspecified, we would have serious reservations because the legislative history of H.R. 4678 provides clear intent to establish large additional future programs for automotive technology development that we feel are unnecessary and inappropriate.

Some of the research that will be sponsored under the Cooperative Automotive Research Program may bear certain resemblances to generic technology research proposed in S. 1250 sponsored by you Mr. Chairman, and others. It may well be the case that certain centers that may be developed under either the Administration's innovation initiatives announced last October or S. 1250 would undertake research that relates to the work to be sponsored under CARP. A possible example is the study of tribology, the fundamental science associated with friction and wear. Tribology problems are associated with many types of machinery, including aircraft and automotive vehicles, and the current level of work in tribology nationwide may be less than is appropriate to this important topic. It is generic because it underlies and is important to many different industrial sectors. Some have suggested that tribology be considered a candidate for a generic technology center. It may well be that groups such as the newly formed National Research Council Manufacturing Studies Board would recommend this, and provide a conceptual definition of a program for such a center. We would expect the tribology sponsored by the CARP participants to be basic but oriented toward the automotive sector. Within a center, it is conceivable that applied research and some technology development might take place. In the case of tribology, it would seem to me that there would be reason to support both work under CARP and a generic tribology center, which would have a different orientation.

CONCLUSION

I have tried today to present a clear statement of the precepts that guide the Administration's policies in automotive research and development, and to explain how the newly proposed Cooperative Automotive Research Program augments automotive research and development sponsored by both the industry and the Federal Government. Our policies are grounded in the belief that the industry itself is capable and is best able to perform most systems engineering and advanced technology development. It is motivated to do so, especially in light of the Administration's fuel pricing policies. Regulatory policy can and should also be an important policy tool where appropriate. These incentives are for this sector more effective in fact than direct Federal expenditure of research and development funds. Some high technology advanced systems, such as alternative engines, are an appropriate area for Federal research and development and are the focus for sizeable programs. Several agencies sponsor longer term basic research. CARP will augment this in a way that will induce increased expenditures by industry itself, and the establishment of new linkages between the nation's scientists and engineers in industry, universities and Federal laboratories.

At this particular moment when the domestic automotive industry is faced with the requirement of rapid conversion of both plant and product, there is a temptation to succumb to the belief that a massive injection of Federal funds for research and development would speed the rate of technological transition in the automotive sector. The requirements of the next several years will not be met by more research and development. Nor is it obvious that a greatly accelerated Federal effort of advanced systems work would be as effective as normal market mechanisms and regulatory goals for the stimulation of technological development in the latter years of this decade.

As I indicated earlier, Secretary Goldschmidt is undertaking a major review of Federal policies and programs in the automotive area, and a study of the industry itself. Deputy Secretary Beckham will elaborate on this. The research and develop-

ment agencies and our office are participating in this study. If we find need for other research and development activities or Federal institutional mechanisms to carry it out, we will certainly work with the Congress in seeking to put these in place. In the meantime, we seek your continued support of the research and development being carried out or sponsored by the Departments and agencies, and your support of the Cooperative Automotive Research Program that I have discussed today.

This concludes my statement, Mr. Chairman. Dr. Linden and I will be pleased to respond to your questions.

Senator STEVENSON. Thank you, sir.

Congressman Harkin, would you like to go on now? And then we can go back to Dr. Smith for questions after your testimony. I want to accommodate you if you have no preference.

Mr. SMITH. Either way is fine with me, sir.

STATEMENT OF HON. TOM HARKIN, U.S. REPRESENTATIVE FROM IOWA

Mr. HARKIN. Mr. Chairman, thank you very much for letting me come in like this. I appreciate your indulgence. I appreciate the opportunity to be here today.

I have a prepared statement. I will paraphrase it, and I would request that it be entered in the record in full.

Mr. Chairman, let me just bring you up to date briefly on legislation in the House. In the past year, as I have talked to you privately, our subcommittee has had numerous hearings and field trips. I think we have basically covered the waterfront in this area. We developed this legislation in the subcommittee, and it has been changed substantially from its initial draft. It has been reworked in consultation not only with the administration, OMB, people in the science adviser's office, but also at NASA and others.

The subcommittee reported out H.R. 4678 by unanimous vote earlier this year. The full Committee on Science and Technology reported the bill by a 28–10 vote on April 22. So it has strong support in the House Science and Technology Committee. I don't know how many cosponsors we have in the Science Committee, but it is about 59 cosponsors in the House. So it has strong bipartisan support also in the full House. I just want to bring you up to date as to where we were with that legislation.

Mr. Chairman, if I could, let me just respond to some of the arguments that have been brought up by Mr. Smith and others in the administration with regard to their approach versus the approach that we have been trying to take. First, some people have said that it is unnecessary for the Government to undertake a comprehensive program of automotive research, that basically Detroit is doing enough, and that the Federal Government really doesn't have to be involved in this effort. My answer to that basically is that Detroit indeed is running all out to meet the various near-term standards for fuel efficiency, safety, and things like that. They really have little left over for the kind of R. & D. that will get us beyond, let's say, 1985 standards. When we visited Ford's research center last year, they told us that about 95 percent of their R. & D. dollars were directed just in meeting the 1985 standards.

Now, I have also been told by people from the industry and by my colleagues from the Detroit area as well, that the capital requirements the automotive industry is going to need in the next

few years is going to be tremendous in order to retool for the smaller cars. So we see that they will be coming to the Congress asking for various pieces of legislation in terms of tax credits and tax breaks, to enable them to retool.

Basically, I think I will be supporting that, but I think one way we can lessen the need for that is for the Government to get involved in this R. & D. effort. Now, I understand that the automotive companies are trying to meet the 1985 standards. And this, I think, comes down to the point of the regulatory push versus the technology pull that I have been talking about for a long time.

Let me just refer to Mr. Smith's testimony. He said: "Regulatory programs are required where market forces are inadequate." I don't think I can disagree strongly with Phil on that. I believe that regulatory programs are required to protect the health, safety, and welfare of people. But I feel the market forces are there right now to bring along fuel-efficient automobiles.

Regulation—we need technology pull to pull it along. I think at this point in time it is wrong to think about legislation. I understand there is now legislation pending in the Senate or being talked about, anyway, that would extend the 1985 standards of 27.5 on the CAFE to something like 40 miles per gallon. I don't think that's necessary.

I think the market is going to pull that along. So the way then I think for us to help this divergence in time between the market demands now and what the industry can provide now is to provide technology pull to get into a very determined, comprehensive, cohesive type of R. & D. effort. We need to provide the technology that is going to be needed to close that gap, not regulation, not regulation.

The market forces are already there, so you don't need it. The demand, like I say, is there. Last year, Americans spent $12 billion on imported automobiles, $12 billion on Volkswagens, Datsuns, and Toyotas, et cetera. Probably even more this year. So they are going after that. Detroit is going to respond, but there is going to be a timelag.

I think one way we can help them out is through this kind of a program of technology pull. Again, Mr. Chairman, it is the kind of program that NASA and its predecessor agency, the National Advisory Committee on Aeronautics from 1950 developed. They are not regulated, but they have gone into developing technology to pull it along. That is why I brought this airplane along, this new DC–9 Super 80. I have been using this in a lot of my testimony, just to show the new airplane that is coming out, with the new engines, the new supercritical wings, the new materials that are in it, most of which was developed under NASA auspices.

There wasn't any regulation. Nobody regulated the airlines to say that you have to have this wing. Nobody regulated that you have to have this very fuel efficient engine. Market forces brought it along.

We were involved through NASA with developing the technology to spin off to them so they could use it and implement it. That's the kind of approach I think we are taking in this automotive approach in H.R. 4678. Develop the technology, let them have it,

let them implement it. The market forces will respond, as they are responding right now.

So I think this kind of approach is much better than the regulatory kind of push approach. In regulatory push, if for no other reason, the only people who can respond automotively are Ford, General Motors, Chrysler, and American, I suppose. But if you have technology pull, you can go to a lot of high tech firms around the country: Airplane companies; TRW's United Technology is the big one; plus the small backyard ones, the real innovators that are out there working in their shops across the country to develop this new technology.

Some of it is good, some of it is not. But I think NASA can weed it out and bring that kind of technology along.

Second, another related argument is that it is an inappropriate extension of Federal support. Again, they have said that the DOE and what DOT is doing is adequate. I would point out the DOE right now is spending about $100 million a year. I would also point out that about 70 percent of the automotive R. & D. work is being done by NASA under contract with DOE. So really, they are doing most of the work.

Again, in terms of inappropriateness, I would point out that in the aeronautic area we are spending about $500 million a year through NASA and about $3 billion a year through DOD for civil aeronautics research and development, aeronautical research and development that will spin off into civil work, $3.5 billion a year, to bring along the state of the art of the airplane. And we are spending $100 million a year on the automobile.

Look at the impact that the automobile has on our society in terms of fuel and what the airplane does. So I think, again, it is a matter of priorities. We have to, I think, again move to this kind of a system simply because of the impact that the auto has in our society. I don't think it is an inappropriate extension of the Federal system.

The third argument is the fundamental policy difference between our bill and the administration approach, and that is that the administration is concerned only with basic research, the CARP program. They believe that this program, along with a heavy dose of regulation, will do it. Again, they have even admitted that this basic research program would only give us results some time after the turn of the century.

Again, I would submit to you that a lot of this basic research is already being done through NSF, through DOE, through our national labs. Livermore has a combustion lab just outside of San Francisco. They are already working on basic research. So a lot of that is already being done.

But we can collapse this time frame and bring this technology along in the 5- to 10-year time frame if we extend it beyond basic research to applied research. Again, that is what NASA does in aeronautics.

The fourth argument is that the Federal budget would expand when we want to balance the budget. I understand that and I understand the need for a balanced budget. But again, the Government is still going to be spending $613 billion, so we have to spend some money some place, and it is a matter of setting priorities. I

think when we are talking about the fact that we are spending $60 billion a year to import oil, then the expenditures in the range of up to $500 million a year for automotive R. & D. is not all that much.

Besides, in our bill, Mr. Chairman, which I have not discussed with you recently, we have added a provision in the full committee that would allow funds to be taken from the windfall profits tax energy trust fund to be used for this purpose, to the extent that they are appropriated. So it may not have that much of a budget impact in the future.

The fifth argument is that it is going to detract from NASA's aeronautic and space program. As a pilot, as someone who shares, as I know, with Senator Schmitt, a—not only a love, but a dedication to continuing our space program, that would be the last thing I would want to see happen. I would again point out that NASA is already doing 70 percent of the automotive R. & D. work for DOE.

I would also point out that up until 1958, I believe, NACA was solely concerned with aeronautics. What was added in 1958 or 1959? The space issue. And there were lots of aeronautical engineers and aeronautical people in NACA at the time who said, no, there ought to be a separate agency set up for space; don't detract from aeronautics. Well, they put them together and aeronautics hasn't suffered a bit. They have been able to pull the two together.

I again would submit that there is a lot of technology involved in aeronautics and in space that is very appropriate for automobiles. You're talking about an aircraft, a plane with engines that uses some kind of fuel and materials put together in a body to transport people from point A to point B. Same thing as an automobile: transport, engine that uses fuel. So I don't see any fundamental reason why this would detract at all from NASA's role in space.

Besides, in our legislation we added language that would permit the Director of NASA to outline his needs for the automotive R. & D. effort and to request from OMB and the administration the necessary personnel to fulfill that. So they won't have to detract from the space mission.

Finally, I would just like to say a word about why we chose NASA. Why NASA? Why not DOE? And believe me, in the last few weeks I have had a number of people from DOE, DOT, the White House, down to see me. And the one word that is always used is: Congressman, I want you to know this is not a turf battle. No jurisdiction involved; not a turf battle.

Well, I hear that all the time. It is a turf battle. People don't want to give up what they are doing, whether it is in DOT or DOE. But we thought about NASA—I have no jurisdiction over NASA as such. I am not feathering my own nest. But again, we want to look for certain elements.

A good track record of R. & D. that has been turned into useful products.

Second, an agency that is independent of all regulatory responsibility. NASA has no regulatory authority. It can't regulate. It would only be involved in the technology pull.

Third, someone that's had experience in the automotive industry. NASA has. They are really doing the work now.

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Experience with management projects that tended to advance technology. They have been doing that since 1950.

And again, independent from jurisdictional limits that would prevent the conduct of this comprehensive program—they are free of those kinds of jurisdictional limits.

When we looked around for these kinds of requirements, there is really only one agency that fits that and that is NASA. There really isn't any other. I guess you could establish a new agency. But I don't know that that is necessary. I think NASA is there, and in my discussions with present and former high-level people in NASA, including the Administrator and former Administrator of NASA, they have all told me in my private meetings with them that not only could they handle it, they would like to have it and they believe they can do an outstanding job in the automotive R. & D. effort.

So any expressions to the contrary that may be official documents from them to your committee, your subcommittee or to mine, I believe that NASA does indeed have this ability and they have a desire to do it and they can do a good job.

Mr. Chairman, I again thank you. I believe that is what I see as the differences between the administration's approach and this approach. I guess, to sum it up, one is a basic research approach only; the other is research and technology pull, technology development. If we don't want to make any major impacts in this until the year 2000, we can go with the administration program. I have no problems with that. I have no problems with basic research.

But if we want to collapse that time frame, I believe it is necessary to do something more than that, more than just the basic research that is involved in the CARP program.

Thank you, Mr. Chairman. I would be glad to try to answer any questions that you or Senator Schmitt might have.

[The statement follows:]

STATEMENT OF HON. TOM HARKIN, U.S. REPRESENTATIVE FROM IOWA

Mr. Chairman, I appreciate the opportunity to be here today. As you know, the subcommittee that I chair has a long standing interest in the subject of these hearings.

Over the past year we have literally emersed ourselves in countless hearings, field trips and informal discussions. We have talked to high Government officials, representatives of industry, university professors, "back yard" inventors, labor leaders and lots of just plain folks. We have considered issues ranging from the philosophical, to the institutional, to the technical. In short, I think we have covered the water front.

So, I'm very pleased to see a subcommittee of the Senate involved in much the same process. I obviously believe it can have a very important result for our country.

As you know, the Subcommittee developed legislation, (known as the National Automotive Research Act of 1980) based on this extensive inquiry. That legislation is currently making its way through the Congressional process. The most recent milestone was consideration by the Science and Technology Committee on April 22.

I'm happy to report that the Full Committee gave the Bill a strong endorsement. The vote to report was 28–10.

Mr. Chairman, I think you know the main features of H.R. 4678 and its underlying philosophy. So I won't repeat them here.

But I would like to respond to the major arguments that have been raised against my approach. Specifically, I would like to respond to certain Administration and industry concerns:

First, some people have said that it is unnecessary for the Government to undertake a comprehensive program of automotive research. They say Detroit is already spending hundreds of millions on new technology.

My answer is that Detroit is indeed running all out to meet the various near-term standards for fuel efficiency, safety and emissions. But when it comes to anything beyond 1985, they just aren't doing much. For example, when we visited Ford's Resarch Center last year, they told us that about 95 percent of their R&D dollars were directed toward meeting those near-term standards.

I don't mean to be critical. If I were in charge of a large auto comapny, I'd be doing exactly the same thing. The standards are tough, and meeting them is a matter of economic survival.

But I do think someone should be looking beyond 1985. The future of the automobile, and all it means to our way of life, is really at stake.

We could of course simply continue the "regulatory push" approach of the past. We could, simply extend the standards. I understand you will be considering just such a move soon.

But this approach has some disadvantages. Only the largest companies can play in the game. And even some of these have had difficulty in recent months. I'm convinced, for example, that Chrysler's troubles are at least partly due to the cost of developing new technology.

For another thing, regulatory push has not resulted in the best possible technology. Auto companies, faced with strict deadlines, have quite naturally gone with the most conservative approach. The more promising, although riskier, R&D has been deferred.

An alternative to this, is "technology pull." As you know, this is the approach that we have incorporated in H.R. 4678. It's also the mechanism that NASA has used in aeronautics since 1915. It has worked well, as the Members of this Subcommittee are well aware.

It has permitted the participation of small- and medium-sized, high technology that has allowed us to dominate world aviation markets. And very importantly, it has led to commercialization of much Government-sponsored research.

I think it's a better way to go. And I see no fundamental reason why technology pull can't also work in the automotive industry.

A second, related argument has been that H.R. 4678 is an inappropriate extension of Federal support. The Administration has said that the DOE Propulsion program, by itself, is adequate.

I would just point out that DOE is spending about $100 million each year on this effort. I might also say, parenthetically, that about 70 percent of this is "subcontracted" to NASA. So they actually do most of the work

In contrast, NASA is spending more than $500 million annually on civil aircraft technology. The DOD is spending another $3 billion, a large part of which is applicable to the civil market.

So if these kinds of expenditures are appropriate for aviation, the automobile ought to be able to do as well. Certainly, it is just as important, and probably a lot more so, than the airplane.

The third argument concerns a fundamental policy difference between H.R. 4678 and the Administration's proposal. As you know, their Cooperative Automotive Research Program (or CARP) is limited to basic research. The Administration argues that, along with the modest DOE program and a heavy dose of regulation, this presents a complete auto technology strategy.

Yet, even they admit that such a basic research program won't be able to make any real contribution before the next century. I think, and the House Science and Technology Committee agrees, that our current dependence on foreign oil requires a more vigorous response.

Of course we must do the basic research. Any well structured program would include a component of basic research. But if we want results within 5 to 10 years, we must also do some applied research. We have to take the concepts that come from basic research and build some hardware to verify that they work.

This is what NASA does in aeronautics. And it is what must be done in the automotive field, as well.

A fourth argument against H.R. 4678 is that it expands the Federal budget at a time when restraint is of the utmost.

I heartily concur with the need for a balanced budget. But I see this as a need to set priorities carefully; not, to reject automatically all new programs.

The need to reduce our dependence on foreign oil is vital. The costs of continuing along our present course will dwarf the costs of H.R. 4678.

We are talking about expenditures in the range of $500 billion last year. By contrast, imported oil costs us $60 billion last year. And the prices are going up all the time.

So I think H.R. 4678 is a prudent investment. Even a small improvement in fuel economy would pay for the whole program.

I would also like to point out that funds for this program will be derived from the Windfall Profit Tax account. As you know, these monies will come from motor vehicle users.

So it is entirely proper that some of these funds go toward improving their vehicles. In fact, I believe, the public has a right to expect such a result.

A fifth argument has to do with concern about detracting from NASA's aeronautics and space mission. This is something the committee was very concerned about too.

So we gave the Administrator a very strong voice in determining the numbers of people and the resources that should be transferred to carry out the program.

I would also say that many people were worried 20 years ago when space was added to the aeronautics role. But those fears proved unfounded. The aero program is alive and kicking today.

Finally, I would like to say a few words about why we chose NASA to manage and coordinate this program. I say "coordinate" here because we, like the administration, envision a cooperative effort—one that uses the best available talent from industry, government and academia. We expect that NASA would lead a truly national effort to advance the state of automotive technology.

In finally deciding on NASA, we wanted to find an agency with the following qualificatiions:

1. A good track record of doing R&D that has been turned into useful products by the private sector.
2. Independent of all regulatory responsibility.
3. Experience with the auto industry.
4. Experience with the management of projects that are intended to advance technology, and
5. Independence from jurisdictional limits that would prevent the conduct of a comprehensive program of auto R&D.

Well, there is only one agency that fits this list of qualifications—NASA. So we really had not other choice—if we wanted a comprehensive program and one that could show early results.

Mr. Chairman, there are many other, lower-level issues in this complex and interesting subject. But I have hit the highlights.

In summary, I think H.R. 4678 goes to the heart of our national problem. I truely believe it can be effective. And I would urge you to give it your support.

Senator STEVENSON. Would you like to respond, Mr. Smith?

Mr. SMITH. Let me make just two or three comments. First off, we don't disagree about, I think, the issue of regulation. It is very true that the regulatory picture in the latter part of the 1980's and the rest of this century is going to be much different with regard to this sector than it has been up to this point. This is one of the reasons why we believe, in the administration, that we should approach the idea of extending the mandated CAFE fuel economy standards with some care. Because it may be possible to devise a different incentive for both the industry and for the individual consumer that would begin to work very effectively, that would change the price of energy and other incentives already in place, so there will be a stimulation by other forces, including the incentive within the industry itself to move more aggressively and more dynamically with new technology.

Now, with regard to the comprehensiveness of the program, I think you must view what we are proposing in relation to what is already going on in the Federal Government. I don't think that either Mr. Harkin or I would say that you can starkly lay out his bill and the CARP program, in the absence of considering what else is going on.

We have tried to locate the areas of greatest weakness in our current programs and have tried to come up with a method of inducing cooperation between the Government and industry and a method of causing the industry to increase its own effort in longer-term research. We consider that a method of beginning to lay the

base for additional technological change in the latter part of this century.

Now, with regard to the NASA role I would have to disagree a little bit with Mr. Harkin. I was at Lewis Center just 2 weeks ago reviewing a lot of the programs there, and I come away with a different impression of how aeronautics has in fact been impacted by the other missions that have been assigned to the Lewis Research Center over the period of time of the 1960's, during the massive buildup of the Apollo program. It is not all that clear to me that centralizing and putting these programs in NASA is the best thing for aeronautics and for automotive technology and automotive research. So we continue to hold the position that we have held right along over the last year since the first time that we testified before Mr. Harkin's subcommittee in May of last year.

The question that is most fundamental, Mr. Chairman, is this question of what Mr. Harkin and I have talked over on several occasions, the question of technology pull: what combination of forces and Federal policies do you put in place to try to get technology moving forward in this industrial sector. This is an issue of great concern to you also. We believe that, particularly in this industry and in some of the other industrial sectors, that things are somewhat different than they have been in the aeronautics industry, especially in its relationship to the Defense Department, which has been a large Federal user in the way that we do not have a large Federal user in the automotive technology area—that is, a partner in the whole development of aeronautical systems activity. This is an industry that is building a product for the individual consumer, not for several handfuls of aviation companies.

There are some conceptual problems with the aeronautics analogy that we have discussed on several occasions with Mr. Harkin. That's all I would say at this point, I would think.

Senator STEVENSON. Did I understand you to say, Congressman Harkin, that your bill contemplated funding levels of about $500 million a year?

Mr. HARKIN. It will eventually rise to that amount. I think we started at $25 million the first year, $100 million the next and $300 million the next.

Senator STEVENSON. Is that right? I thought I saw it said such sums as may be authorized.

Mr. HARKIN. It was $25 million, $100 million, $300 million, and then such sums as are annually authorized.

Senator STEVENSON. It specifies starting at $25 million and up to——

Mr. HARKIN. Yes.

Senator STEVENSON. Do you have any idea as to how long the effort would take, what total moneys might be?

Mr. HARKIN. No, sir. I wouldn't speculate on that. Again, why do we put in those amounts? Because we look at what is being done right now, taking that into account and trying to increase the level of effort.

Again, talking to R. & D. people both in and out of industry, it seems the program we have envisioned would require about that much money after about 3 or 4 years of time.

Senator STEVENSON. Do you have any idea about the fuel efficiencies that would be produced by this effort, and at what point?

Mr. HARKIN. The fuel efficiencies? Now and again, I think—this is my own personal feeling—I think it would be wrong to specify in the legislation that at certain times we have to meet certain types of goals.

Again, I think when you get into that kind of regulatory thing where you set up a certain date when something has to be done, you may not get the best technology. So we have not set up any kind of goals at all.

What kind of fuel efficiency can we expect? Off the top of my head I can say that in some of the new engines that we are working on right now in NASA, like the Stirling, for example, within a few years we could probably see fuel efficiencies at least 50-percent greater than the most efficient internal combustion engine right now—either the turbine or Stirling.

Senator STEVENSON. Dr. Smith, is the administration still proposing $800 million over 10 years?

Mr. SMITH. Yes.

Senator STEVENSON. That is the overall funding?

Mr. SMITH. Yes, we are ramping up a little more slowly at the beginning, sir. We originally in our 1981 budget had $21 million. We reduced that to $12 million for 1981. But we have as a target reaching within 3 years a $50-million-a-year expenditure by the Federal Government and a $50-million-a-year expenditure by industry, making a total expenditure annually in the neighborhood of about $100 million.

Senator SCHMITT. Is that about what is being done today?

Mr. SMITH. There is today, Senator, approximately—I guess about $175 million altogether. There is about $100 million in DOE. There is a program in the Department of Transportation largely related to the regulatory activities of NHTSA and we estimate the current activity of basic research to be in the neighborhood of about $42 million.

We would triple the level of basic research being undertaken in the sciences and engineering related to the automotive sector through this program.

Our discussions with the industry over the last year have led us to the conclusion that they are spending something in the neighborhood of $10 to $20 million on basic long-term work, which is, regretfully, quite low.

Senator STEVENSON. And what kind of fuel efficiency do you expect an effort of the magnitude that you propose to produce, and when?

Mr. SMITH. We have not approached the development of this program concept from the view that it would work toward a fuel efficiency goal or targeted or mandated performance standards. There will be a wide range of activities undertaken in material science, for example, that would lead to new materials, mixtures of materials, such as carbon fibers. Development of this material, as you know, is already beginning to be discussed seriously by the industry and there is much research going on in this area.

There will be work that will be undertaken on aerodynamics that will also relate to fuel efficiency. You would think that after

all this period of time, we would have a good body of basic knowledge about aerodynamics as it relates to automotive vehicles, but we do not. There is only a limited amount of work that has gone on in this area. There is great interest on the part of the industry, both here and abroad. Some months ago I visited the corporate research labs of the VW company in Wolfsburg, Germany, and there was a great interest in expanding the level of effort in aerodynamics.

Collectively, we think there will be a great many new ideas begin to flow into engineering that will, in the aggregate, make a great deal of difference in fuel efficiency in the out-years of this century.

But we have not set a specific goal of achieving 40, 50, 60, or 70 miles per gallon.

Senator STEVENSON. Can Volkswagen achieve 65 right now?

Mr. LINDEN. Senator, there are a number of concepts for vehicles for the latter part of this decade that can achieve that kind of mileage, of various companies.

Senator STEVENSON. I mean right now. I haven't seen any industry projections through 1985 that shows what Volkswagen has right now in production.

Mr. LINDEN. You have to distinguish between a fleet average and what a single car can attain.

Senator STEVENSON. My first reference was to a car developed by Volkswagen, 65 mpg. If there was any need to produce it, they would produce it. Now how on earth do we catch up with that kind of capability?

Mr. LINDEN. Well, sir, I am not sure we are behind. There is little in the way of technology——

Senator STEVENSON. What was that again? You're not sure that the United States is behind?

Mr. LINDEN. In technology. You see, it is very difficult to sort out whether there are technical qualities in the Volkswagen or other foreign cars that are not——

Senator STEVENSON. How many small diesels do the American manufacturers make like Volkswagen?

Mr. LINDEN. That is not a shortage of technology. It is just that we have been behind in adjusting——

Senator STEVENSON. How about the manufacturing procedures?

Senator SCHMITT. Quality control.

Senator STEVENSON. Even the American automotive industry, recently surveyed, concluded themselves that the technology of the Japanese automobiles is vastly superior to the technology that they have developed for American automobiles.

Mr. SMITH. These statements are frequently made——

Senator SCHMITT. Frequently supported, too.

Senator STEVENSON. Supported in the marketplace. I haven't come to capital yet. If you have the technology, how do you get it into production?

Mr. SMITH. In all of our discussions, in all of our work, we have come across no major technological superiority in any other producer any place around the world.

GM has an enormous program going on right now in diesel engines. They intend to introduce diesel automotive technology into their fleet in the 1980's. If there are no adverse health effects,

this will definitely enter into the fleet and it will produce enormous efficiencies, as we all know, in terms of fuel economy.

But this is not a technology gap.

Senator SCHMITT. The efficiency of production, the quality and control in production, and automation of production is a technology game. We are not in that game right now. Both the Germans and the Japanese are beating the pants off of us.

Mr. SMITH. I would like for you to ask the industry witnesses about that question.

Senator SCHMITT. Don't worry, we will.

Senator STEVENSON. Have you been to an assembly plant?

Mr. SMITH. I have not.

Senator STEVENSON. About 67 production line workers produce about 1,300 cars a day. Where do you find that in the United States? Even the technology—that isn't in operation.

Mr. SMITH. I think it is very important to distinguish between the various factors that relate to production. It is true that many of these firms in the other countries have been very adept at bringing technology into their designs.

But when you hear discussions of quality control, of the amount of production going on in the factory and so forth, I do not think that you are basically talking about technological issues. I think you are talking about other management and economic issues that relate to the way in which technology flows.

This worker circle idea that is in use in Japan was invented in the United States. This came out of management concepts that were used in our own automotive industry many years ago.

Senator STEVENSON. Why wouldn't they exploit the technology that comes out of either of the average you propose?

Mr. SMITH. We are not proposing in our suggestions for CARP that we are going to try to solve management problems that may or may not be solvable. If they are not solvable, then we will have a declining domestic industry.

Senator SCHMITT. Do you think that you can separate technology from how you manage the use of technology in production of a product? You can't. The NACA didn't. A great deal of what they were doing had to do with how you manufacture turbine blades, for example.

Mr. SMITH. I would not disagree with that, Senator Schmitt. I think from the standpoint of Federal policy, there are different approaches that one should take. Massive injections of funds into technological development may not in the end solve the problem. You will not necessarily have a technology pool or push, either one, depending on your point of view if some of these other forces which also influenced the rate at which technology is used are not also addressed.

These are not things that can be addressed by the research and development agencies of the U.S. Government, be they NASA, the Department of Energy——

Mr. SCHMITT. They have been in the past. The aeronautics partnership that developed was not a massive injection of funds from this civil sector. It was a system of cooperative research and technology development that allowed the aeronautics developed within the military to be refined and transferred to the private sector.

The agriculture research program again was a cooperative research program that allowed the development of an agricultural economy and production techniques second to none in the world.

The communications technology area was one which, again, was a Government-funded technology base that, through legislative action and the creation of Comsat, was transferred into the private sector.

This is not say that any one of those models is the perfect model for automobile work, but it does not mean we cannot do it.

Mr. HARKIN. The bells rang for me to vote, so if I could respond briefly. I think that is correct and I think one of the problems we are having perhaps with the auto industry, when I talked to them, is the only history of relationships that they have had with the Federal Government has been one of regulation.

So when we come along and say that we want NASA to get involved, they say, more of that we don't need. They have not had that kind of history of involvement as the airline industry has had, for example, or the aerospace industry has had with NASA in the past.

I think as they develop more and more of that kind of working relationship, they will see that it is to their benefit and to all our benefit.

Senator STEVENSON. The American industry just doesn't respond to the most obvious market opportunities. Getting back to your analogy of the airlines, when we deregulated the airlines, we went to NASA and said, can you help the airline industry develop short-haul aircraft to supply burgeoning new markets for computer aircraft. We need a safe fuel efficient, fast aircraft to supply that market.

NASA said yes. NASA went to the American industry. NASA came back and said to us, they are not interested. They are too busy making long haul aircraft and general aviation aircraft; whereas, the Brazilians, Russians, Swedes, and the Canadians moved to supply that market.

And this morning you pick up the Washington Post and you hear the president of U.S. Air plead too late for the great American industry to supply that huge global market. I don't think you can be confident that the market will drive any American industry any more than it did in that case, which is, I think, a relatively progressive industry.

And in this case, you have got one of the most regressive industies. Look at it.

I was in hearings here in 1970 in which witness after witness predicted the coming of the energy crisis. Industry after industry throughout the world saw it coming. It was only this industry that didn't, and it still doesn't.

What did you say, they are investing now in research?

Mr. SMITH. In long-term research, sir, about $20 million. Something more, I am convinced, is needed.

Mr. HARKIN. I don't know what you do. You cannot do anything. You can do the regulatory and you can do this or perhaps there are some other ideas that I perhaps haven't thought about.

But it seems to me that we have gotten to the crisis—we can point to a lot of industries and blame. But if we want to rejeuven-

ate the industry, if we want to keep our American people employed, if we want to build the automobiles here—let's not look back. We have to look and see what can we start doing right now to inject the kind of new technology into that which will bring them along.

Now, certainly, there is going to be some kind of regulation in the future. I don't say that we have to give up on all regulation. But I don't think that that alone will be the kind of spur that will get them to this point. I think that more is needed in terms of this technology developing.

Now you are correct that they haven't responded in the past. But, again, I think—I guess maybe hope springs eternal. I'm hoping now they will because of what they are facing with the foreign imports.

We can't leave it fractured all over. It is the smallest part of the program in DOE. They come up to us and don't ask for the amount of money that they need to carry out the program, because it is a small part. They're more interested in solar and conservation than they are the automotive.

One case in point is the Stirling engine. I believe, from what I have seen of the Stirling development, in talking to the people who are developing it, that within the next 7 or 8 years we can have a Stirling engine that we would get at least 80 miles per hour and won't have to burn gasoline. It would burn alcohol or anything.

Yet DOE has been sluggish in moving along in that area, not even asking for a second contractor approach to develop that Stirling engine. That is one technology that I think we can make a great contribution to in this country. And DOE is just not doing it.

Senator SCHMITT. I think the Congressman has a point.

We appreciate your testimony. I think you are roughly on track. I am not sure that NASA is the place—you can saturate management. Clearly, the history would say NASA is the place to do a lot of this work and it is being done.

I would claim credit for getting started in NASA, the reimbursable work that is being done for DOE. In 1974, we set up a small energy office—that was one of the major areas that we went after—and sold NASA's expertise.

Mr. HARKIN. We are starting to get money back on that program right now.

Senator SCHMITT. But the question is: Are they saturated in a managerial sense? That is a decision we have to discuss a great deal more. There may be another interim way to handle it.

I do think we have to recognize that everything Senator Stevenson just said about the industry and its reaction to a clearly foreseeable energy crisis is true.

At the same time we entered the early 1970's, instead of encouraging them through some kind of an aeronautics-like, research development partnership, what did we do? We put all of the wrong regulations on the auto industry. We said let's clean up the effluents and not make a more efficient engine.

When I first got into this game, the industry at one point was looking at 100 different research and development projects they were having to undertake in order to meet regulatory standards.

They had nothing to do with more efficient engines; they had to do with how do you clean up the effluents.

We lost years because of that particular goof on the part of the Government. Congress and the administration both made a mistake. We went the wrong direction and looked at the wrong end of the cycle. We looked at the tailpipe.

It didn't do us any good. All we did was burn more fuel. Maybe we can learn, but the regulatory environment in which the industry now operates and had to operate for years has made it very difficult even for programs like the NASA-DOE partnership to get going. They are saturated themselves in the industry with these other kinds of standards.

Senator STEVENSON. Thank you, Congressman.

Mr. HARKIN. Thank you very much.

Senator SCHMITT. Dr. Smith, I am a little bit concerned about the time perspective. Even though you may not agree, I think that we are not only behind in basic use of technology in our automotive industry, but we are falling farther behind very rapidly.

The market shows that the American people are more and more preferring to buy better quality, more fuel-efficient foreign automobiles. Hopefully some of the new line cars coming on will be able to stem that tide. But there is a very strong tide turning against the automobile industry.

Do you really think that a long-term basic research program—in the absence of a sustaining R. & D. program such as we have had in aeronautics and the absence of a research and technology program aimed at manufacturing can do anything to stem this tide?

Mr. SMITH. I think this program that we are developing with the automotive industry is one of a number of things that are desirable to do. We hopefully have to assume that there is going to be a domestic automotive manufacturing industry in this area and we will weather the short-term storm that is going to be a very major problem for the next 5 years.

The program is premised on the fact that we need to increase the basic fundamental understanding in science and engineering related to automotive technology and that there will be many ways in which this will come into automotive production in the latter years of the century.

Now, this is not the only thing that needs to be done. It is true that this industry has not been responsive to anticipated changing perspectives on energy.

I would disagree a little with both you and Senator Stevenson, I think, about the degree to which anybody in the United States, in the period of 1970 to 1973, was thinking very much about energy.

There was a very important study done by the predecessor office or our office around 1965, 1968, that could enlist no political interest anywhere——

Senator STEVENSON. That isn't a very good study, because when I came to the Senate in 1970, I was warned of the energy crisis and got coal production doubled in 1972, before the oil crisis increased. And then on—starting in 1973, everybody was aware.

Mr. SMITH. There were, in the years before that, however—in Europe, for example—some forces influencing manufacturing. There has for many years been a much higher gasoline tax in

Europe, and the prices historically have been much higher in Europe for gasoline than they had been in the United States. This induced a different perspective on the part of the manufacturers with regard to automotive development.

I think every executive I have talked to about this problem in the industry has said that they made a grave mistake after the OPEC first embargo by not realizing that the American consumer was, in effect, ready to a much larger degree than was first anticipated in 1974 and 1975—they were anxious for small cars.

Now, I think the conditions now are very different and the perspectives are very different in this industry. Of course, they have a major problem that will require major financial investment over the next 4 or 5 years in order to be ready, structurally, to manufacture this new line of products.

I think that if that transition can be made, they will be just as capable of handling technological development as European or Japanese manufacturers.

There are other things that are going on that will change the condition in Germany and Japan. Labor has been, in Japan, a low-cost item over the last decade and a half. Labor is a changing kind of thing in Japan now, and in the 1980's in Japan they are going to be different than the 1960's and the early 1970's.

I don't think we ought to panic and think that we have some technological problem here that has made up incapable of competing on a world basis.

Mr. SCHMITT. Dr. Smith, I believe the industry is capable—American workers and management are capable. But we have not created an environment—and the industry has not insisted in creating an environment—which development is going to occur. I think that is what we are after.

It is not clear that the Administration's proposals are going to do anything to more rapidly create the environment in which they can become more competitive. The tax policies and regulatory policies of this administration and previous administrations have been all in the opposite direction. Just having a basic research program at the NSF—even it it is a cooperative basic research program with industry—doesn't solve some of the more fundamental problems that we are facing.

Mr. SMITH. We cannot look at this proposal as being the only proposal that this administration is interested in that relates to the automotive sector. Our record on regulatory reform is—our joint record on regulatory reform between the Administration and the Congress in the last three years is remarkable.

Mr. SCHMITT. Except in energy.

Mr. SMITH. There may be things coming in that area. We are not unresponsive to the role of taxes as they relate to innovativeness of American industry.

Senator SCHMITT. You haven't been so far.

Mr. SMITH. We have a number of other things that will be recommended as a result of the review Secretary Goldschmidt has undertaken that relate to the automotive industry. So I don't think you have—you should look on the CARP program as the only interest of the administration in relation to the automotive industry.

Senator SCHMITT. I don't want to keep harping on this, Mr. Smith, but my final question has to do with the Department of Transporation. What is there in the track record of the Department of Transportation that makes you think that they are the appropriate lead agency for this kind of an effort?

Mr. SMITH. That question is asked many times. The Department of Transportation has historically not been a funder of this kind of research.

Senator SCHMITT. They haven't been interested. I went to them and tried. I saw transportation in their name, the Department of Transportation in 1974. I went over there, trying to see whether they wanted to set up a cooperative research program in automobile technologies, bus technologies, and so forth. They weren't interested. They said, "We don't do that kind of thing. We do modal analysis." I haven't seen much change.

Mr. SMITH. This administration, the Secretary is interested. As you know from our testimony over the last 3 years, we have worked very hard to get a longer-term research perspective in many departments and agencies. And we have tried to strengthen longer-term research across all Government departments. There has been an increase in several, in EPA, in the Department of Defense, and a new program in the Department of Agriculture.

Senator SCMITT. I don't think you understand my point. My point is there isn't a basic tradition and a basic infrastructure for good research programs in that department or in EPA.

Mr. SMITH. There is no reason why, just because there has not been—I recognize it is a major problem. There is no reason why though one should assume that if it has not been a part of the infrastructure, it cannot become a part of the infrastructure.

Senator SCHMITT. That is true in theory. But I would submit that in practice, when you look at where we have tried to change an agency drastically in terms of its basic culture and traditions, we haven't been very successful. We really haven't.

The NSF did a super job, and still does, in stimulating basic research and having the kinds of programs that provide funding for education and research in the university system.

But when we asked it to become a mission agency, it didn't do very well. The cultural structure just doesn't work when you talk about mission. It does well when you talk about basic research, but not when you talk about mission.

The Department of Transportation unfortunately is suffering from a different kind of cultural inertia, but it is still there.

Mr. SMITH. If you didn't think there was some possibility for change, I think you wouldn't be working in this city, either in the executive or in the Congress.

Now, I think that the Department of Transportation has a prospect of developing this tradition.

Secretary Goldschmidt has been intensely interested in the problem. He asked Dr. Press to put a group together to specifically help him, the same way that Secretary Brown asked Dr. Press to put a group together to help him, the same way that Secretary Schlesinger asked Dr. Press to put a group together to help him.

Now, it is true that this is a process that takes some time. I must say, however, that in the case of the Department of Energy, for

example, in some areas like fossil—longer-term fossil research, 3 years ago the argument was whether, between the administration and some committees of the Congress. Now the argument is not whether, it is how much. I consider that substantial change in perspective and the building of the beginning of a new tradition in the area of energy research, where we need more longer-term research.

I think the Department of Transportation, along with other departments, can be a very effective player in this area. Obviously, we don't want to entrust at the moment—it would be unwise to put the entire program in the Department of Transportation.

That is one of the reasons why we have structured the program so that there would be several players. We can draw upon the traditions of the National Science Foundation, the Department of Energy, possibly the National Bureau of Standards and NASA.

Senator SCHMITT. The multiagency programs are very difficult to coordinate. Unless you fire half the people in the Department of Transportation and replace them with new people at all levels who are going to build a new tradition, I don't see how you will get there very fast. And I am not sure you can do it with NASA or with any of the existing agencies for these same kinds of reasons.

Thank you, Mr. Chairman.

Senator STEVENSON. Just a few quick questions of Dr. Smith.

First, we still don't have a program. CARP has been under development or consideration for almost a year now. When are we going to get the technical framework for this program?

Mr. SMITH. The technical framework working groups are completing their reports. There are three that are finished. I could give them to you—I didn't bring them with me this morning, but I could give them to you right now. They will all appear in the next month.

Senator STEVENSON. Not right this minute, but we would like to see those.

Mr. SMITH. In our judgment, they are very good, and I think you will find them interesting. They are provocative about the kinds of problems that need research in this area.

Senator STEVENSON. Give us what you can for our record. Let us see what you have got as it is completed.

Next, you are proposing, although I recognize the funding isn't flat but funding in the magnitude of $80 million a year for a 10-year period, do you mean to say that the market doesn't offer the incentives in this largest American manufacturing industry—that it doesn't have resources with which to come up with that $80 million a year for basic research? And if not——

Mr. SMITH. From your deep interest in innovation you know the kinds of changes that take place in industrial sectors as they grow from their fledgling years into maturity—and the automotive sector is a classic case of a mature industrial sector, as is steel and several others, unfortunately. As they have become more mature, they have become frequently more risk-averse and have not invested in the longer term work the way that the chemical industry and the electronic industries in the United States are right now.

We are trying to create a device that is appropriate for the Federal Government to induce more industry activity without

either side assuming the whole burden, which would be inappropriate. That is what we are trying to do by this mechanism.

Senator STEVENSON. I am agreeing basically with what you said earlier, which is that the technology is available. We are not technologically inferior, although we clearly are in some respects.

The real problem is not a technological problem. It is a problem of capital, and the Congressional Budget Office indicates that—I guess it assumes availability of technology capital in the order of some $4 billion a year is going to be necessary for this industry to retool and then to begin producing vehicles that incorporate the technology that is already available or could be readily made available.

So why are we fooling around with peanuts, with $80 million a year for technology, when the real problem is in a magnitude of billions for the retooling of the largest manufacturing industry in the United States? You can do that to come up with some vehicle—and there are indeed the technologies that will come along, and then you have a market that could pull it, but what would the Administration do? Pull them out?

The syndrome is everywhere. A billion and a half for Chrysler already; $80 million here for research. Ford is in deep trouble. What do we do? Wait until they go down and then bail them out?

Mr. SMITH. First let me comment on the research issue. I think the underlying science that will be created through this program will be useful in this industry. I have never proposed, Dr. Press has never proposed, Secretary Goldschmidt has never proposed, nor have the industry leaders proposed that this is a program targeted at short-term issues.

This is a program directed at the longer term. The capital requirements for the structural retooling of the industry over the next 5 years are enormous; they are higher—the numbers I have heard—and hear discussed are $70 to $80 billion. We have a working group under the Economic Policy Group, which is chaired by Secretary Miller, which is working on this problem.

We don't have a proposal ready. I would suggest that Mr. Beckham ought to speak a little more fully about this particular issue than is appropriate for me to address, because this is basically not an R. & D. issue; this is an economic policy issue.

Senator STEVENSON. A final question. Is it true, as the newspapers reported this morning, that the industry is backing off from the proposals that apparently it endorsed or apparently endorsed earlier for standards beyond 1985?

Mr. SMITH. That the Federal Government is?

Senator STEVENSON. The administration.

Mr. SMITH. No. The discussions—I think—I take it, you are referring to the article that was on the business page of the Washington Post?

Senator STEVENSON. Yes.

Mr. SMITH. We believe in the administration that there may need to be post-1985 standards. The opportunity that needs to be considered very carefully now is whether we continue with the current CAFE approach that we have used over this recent period of time, or whether there are some other kinds of incentives that can be put in place. That is what is being discussed.

I don't think that there is any senior policy official in the Administration who would support the idea of just abandoning fuel economy standards in 1985. The question is designing the post-1985 regulatory standards to go from 1985 on to 1990 and 1995. That is why we are not at this moment endorsing, for example, the specific proposal that is in the amendment into the bill that would mandate 40 miles per gallon.

Senator SCHMITT. Mr. Chairman, a quick followup.

Do you think that if we just got rid of all fuel economy standards that the industry would fall back on its smug early ways and not try to compete in the economy marketplace? Why do we need those economy standards?

Mr. SMITH. Well, we have needed them in the past, and up to the moment, to induce automotive efficiency in periods in which we had unrealistic pricing for fuel.

Senator SCHMITT. Isn't the marketplace doing that now?

Mr. SMITH. We have now come to a point where we begin to have some decontrol and more realistic pricing of oil imports. We think these will help. This is what we are discussing in the Administration now: That there may be some different kinds of inducements beyond 1985 that will bring along greater fuel efficiency.

Senator SCHMITT. Well, since the Administration and OPEC are now competing in raising prices, why do we need standards? That's not a facetious question. You're both doing the same thing. Prices are going up, and the marketplace is demanding more fuel efficiency. What is the purpose of these fuel efficiency regulations?

Mr. SMITH. Beyond 1985, the question is what kind, if any, we ought to have. And that is what we are discussing right now. There is going to be a dramatically different world beyond 1985 than 1975–76.

Senator SCHMITT. We might have all the energy we need.

Mr. SMITH. And up through the early 1980's.

Senator SCHMITT. If we did the right thing, we could probably have all the energy we need and the prices would start going down. Is that why you need fuel efficiency standards? When the prices start to fall?

Mr. SMITH. Not having a mandated set of standards like we have had up to this point and on through 1985 is one of the options under discussion. And I would again say Deputy Secretary Beckham would be the one prepared to talk about that here today in further discussion in your committee on fuel efficiency.

Senator STEVENSON. Well, let me conclude with one note. By 1985, the world may be in a deeper depression, and the marketplace is demanding vehicles of and beyond efficient rail transportation. The United States is now reduced to one rail equipment manufacturer for passenger transportation, and that one company is owned by a German corporation.

Maybe we ought to demonstrate a little more what Government and industry demonstrated in the early part of the 1970's, by preparing for a lot of contingencies, some of which are far worse than any I have suggested yet, and require not the reinvention of the automobile but a generation of passenger equipment beyond the automobile, including rail.

Senator SCHMITT. We are down to two bus manufacturers.

Senator STEVENSON. We are now importing a far larger percentage of our market reqirements for railroad companies than we are for automobiles. We may be a whole lot worse on the railroads today.

Senator SCHMITT. We have in our windfall tax energy funds a large proposal for mass transit. And again I would say that Secretary Beckham would be able to do the dynamics of that sector.

Senator STEVENSON. Thank you, Dr. Smith. You have been very patient and helpful.

Our next witness is William Beckham, the deputy secretary of the Department of Transportation.

Beg your pardon. I am told that Dr. Sternlicht has to catch an airplane, so let me call Dr. Beno Sternlicht, chairman and technical director, Mechanical Technology, Inc.

My apologies, Mr. Beckham.

STATEMENT OF BENO STERNLICHT, CHAIRMAN AND TECHNICAL DIRECTOR, MECHANICAL TECHNOLOGY, INC.

Mr. STERNLICHT. Mr. Chairman and members of the subcommittee, it gives me great pleasure to testify on this very important national issue. But before I answer the specific questions raised by Senator Stevenson, I would like to put the issues in proper perspective.

Prior to the oil embargo, I had been one of the more vocal voices crying in the wilderness, predicting the automotive problem that we have today and recommending a very high-priority national program in automotive R.D. & D. By now, I must sound like a broken record.

My views are summarized in reference 1, parts of which are appended to this testimony.

Lots has happened since the oil embargo, affecting this very important national issue: We have lost almost a decade. We have recognized an energy crisis which is symptomatic of a much larger problem, which I have identified as the energy revolution.

Could I have a slide?

[Slides shown.]

Mr. STERNLICHT. If you will look at the two arrows, you see the industrial revolution where we have moved from handpower to power-driven machinery, which resulted in the industrialized Western world, and we are now entering into a transitional period where we are trying to move from the exhaustible energy resources to inexhaustible. But these inexhaustible energy resources have some of the power from the hand-driven industry to the power-driven industry, and the automotive propulsion is one of these.

We are going to collect large amounts of money from the oil companies windfall profit tax and, hopefully, spend it wisely.

We have recognized that our rate of innovations are behind virtually all of the industrial nations. Japan has overtaken us in yearly car production. Our foreign-car imports have greatly increased. Our automotive industry is sick. We are simultaneously faced with inflation and recession.

These are some of the things that have occurred in the last decade. Based on that, I believe that the repeated question as to whether the Federal Government has a role to play in the auto-

motive R.D. & D. should not be raised again, for if the Federal Government does not play a key role, then it can count on continuing subsidy of industry that is nationally of highest importance but one that is critically sick.

Now, turning to the specific questions raised by Senator Stevenson's letter of April 9, 1980, I will not read the questions, but will give specific answers to them.

The answer to the first question is: "Unequivocally, yes." However, as pointed out in the appendix, while basic research represents an important foundation and is necessary, it is not sufficient in itself to insure end-result-oriented viable automobiles.

And I would just like to illustrate this, since there was some mention made of the Stirling engine. MTI, together with United Stirling of Sweden, are engaged in one of these new powerplants. What is demonstrated over here is basically a powerplant which is very similar to the internal combustion engine. And the upper half is basically a heater head which can operate with any fuel all the way from solid to gaseous to liquid fuels. That obviously is a major advantage of a powerplant for the future.

That powerplant has already been put in a car—that is an important accomplishment—and has already performed as well as a diesel engine, utilizing a variety of fuels. It can be lowered in noise level and meeting emission standards of 1985.

Now, discussing basic research——

Senator STEVENSON. Excuse me, Dr. Sternlicht. The Stirling is basically an external combustion engine.

Mr. STERNLICHT. That's correct.

Senator SCHMITT. And that has a lot to do with the efficiency and noise levels.

Mr. STERNLICHT. Correct.

Now, as I mentioned before, I am very much in favor of basic research. We are all for motherhood. However, it has to be somewhat put in proper context. And what I would like to illustrate over here is a mission-oriented program which is basically where research becomes part of a program rather than a separate element of it.

We talk about basic research, applied research, generic technology, component development and engine development. This is what I would consider a mission-oriented program and in which we have two specific objectives: The high efficiency and the fuel economy that you brought up before. The question of safety and the question of cost, which is part of the manufacturing technology that has been touched on today.

All those elements are part of an overall R.D. & D. effort. As a typical example, in the Stirling engine there are two critical problem areas.

They are identified over here. You can start with basic research in fuel synthesis and gas kinetics and go all the way to two specific examples: One dealing with elastohydrodynamics, which is applicable to the whole area of gearing and seals, et cetera; and the other one dealing with the kind of combustion that you want to have, which is oriented to the specific thing, which is the Stirling engine.

I am demonstrating this thing because I feel very strongly that basic research can best fit when it is part of a mission-oriented effort. And in itself, it has got some very specific limitations.

Now, to answer the second question: Basic research should be part of a directed-focus R.D. & D. effort and should represent about 10 percent of the total budget allocation to automotive R.D. & D. Thus, $1.6 billion are proposed for basic research—$800 million from Government and $800 million from industry—there then should be a $16 billion R.D. & D. automotive program in the 1980s. This would correspond to an average funding level of $1.6 billion per year. Presently, Government-funded automotive R.D. & D. program is an order of magnitude smaller.

Since need is the mother of invention, best results from basic research generally emanate when they are part of a total mission-oriented R.D. & D. effort and a recognized and focused program of national priority provides the emphasis and motivation. Under these circumstances, there is also more effective and rapid technology transfer and utilization.

Within the educational sector, it is probably more important to refocus our attention on the teaching programs and not just on basic research, which is generally limited to graduate students and some members of the faculty.

With the strong emphasis in the past few decades on nuclear and aerospace, our educational programs on engines and power engineering in high schools, trade schools, colleges, and universities have almost disappeared. Most universities have discarded or mothballed their engine laboratories.

Education in this area is essential so as to create the future mechanics, technicians, engineers, and managers. Such an educational program will also be of value in other areas of energy conversion applicable to many other end-use products. It will also greatly help our innovation, in which we are seriously falling behind. Basic research at colleges and universities can, of course, help in such an educational program.

Until very recently, the automobile industry has strongly opposed any Government involvement in automotive R.D. & D. Today, there is some ambivalence on this point of view. I believe that the U.S. automotive industry has endorsed and seems ready to financially support the basic research program primarily to try to keep the Government from supporting the more applied work that is necessary in development and demonstrations, generating in Congress and OMB a debate on priorities between basic versus applied research—and these meetings are an example of it—and leading to an erroneous conclusion that we do not have the money to do both.

In addition, from a public relations standpoint, the support of basic research is beneficial to the automotive industry in fighting a variety of regulations by showing that they are working on a basic understanding of the problems.

In conclusion, it would be dangerous, therefore, if federally supported basic research shortchanged the more important need for directed-focus R.D. & D. effort. Also, it would be devastating if complacency permeated the administration, OMB, and Congress,

and there emerged a feeling that the troubles of the automotive industry are over since we are sponsoring basic research.

To answer you third question, this program is so important to the health of our national economy that it must use all of the available resources. It should not exclude the automotive industry, but at the same time it should not be limited only to the automotive industry.

It is not clear who will be the automotive industry in the next century, and innovations can spring from anywhere.

The funding in the high-risk/high-payoff areas will undoubtedly have to come from the Federal Government. In the applied and demonstrations areas, it is not very important where the funding originates.

If industry does not support it, the Government must. There is very little advantage for the automotive industry, on the one hand, to support basic research and, on the other hand, receive large Government subsidies.

There is absolutely no valid reason to limit the program to the large automotive companies, universities, and nonprofit institutions.

Many small companies are highly innovative, yet they generally cannot afford to cost share. They still can make very significant contributions to solving our automotive dilemma.

These industries create new employment opportunities and greatly help in the innovation process. Therefore, they should be strongly encouraged to participate in the R.D. & D. effort.

Again, in conclusion, what is needed is a national program of very high priority which utilizes the best available talent from all sectors of industry, Government, universities, and institutes. A good example of this is the coupling program between industry, Government, and universities, and Japan—the MITI program. It is about time we learned something from the way the foreigners are doing some of the programs.

We must create a climate conducive to innovation to insure progress.

In this regard, I consider innovation equivalent to creating a climate which induces risk taking, which is influenced by the education of our managers, and not just the people that are going to be doing the innovative process; motivation in universities in order to create a climate for this innovation, coupling obviously of the very resources shown on the previous slide.

Thus, a variety of factors are a part and necessary to insure this innovation process.

As for the management, it should be so chosen and organized in this undertaking of this national program as to minimize bureaucratic delays. It should be competent, experienced, and dedicated to this very important mission.

Project selection should be left entirely to the management if they are to be measured by their accomplishments.

In answer to your fourth question, it is important and that the administration and the Congress recognize the importance of this program and legislate a national program that can function efficiently and on a timely basis.

Since the program crosscuts the charter and resources of several governmental agencies, it may be advantageous to create a small program office with the director reporting to the White House and the program execution to be divided among several agencies—DOE, NASA, DOT, NSF, the Commerce Department, EPA, et cetera.

Industry, institutes, and educational institutions must be an integral part of such a program. Each Government agency, through its established channels, can interact with the private sector groups.

The spirit of competition can be very healthy. The program director should be responsible for funding allocations through the various governmental agencies and for program coordination. He presents and defends the program and budget with the respective congressional committees.

In conclusion, with reference to this question, a multi-agency activity will have the benefit of creating a broad-base that utilizes the best available resources and should also have a positive effect in the innovation process.

As an alternative, NASA/Lewis can be singled out as the center having the greatest technical resource applicable to the automotive R. & D. DOE has recognized this and is effectively using part of this resource.

An alternative approach would be to separate this center from NASA and give it the charter of the National Automotive Center, with the responsibility of interacting with the other national resources in various Government departments, industry, universities, and institutes for the sole purpose of conducting automotive R.D. & D.

Such a move would demonstrate the national priority of this program and remove the conflict within NASA of manpower allocations to aeronautics and space.

I do agree with Senator Schmitt that you cannot serve too many masters because of the management problems, personnel problems, and facilities problems.

In answer to your fifth question, the automotive R.D. & D. program has been a stepchild that has moved from one house to another—from EPA to ERDA to DOE, and now moving someplace else may not be the most advantageous thing.

Since it's beginning, it has been way underfunded and submerged with other programs of much lower priority.

Year after year, I have testified before the Congressional Authorization and Appropriations Committees on the question of automotive R.D. & D. funding. While my estimates have been consistent, neglecting inflation, OMB and Congress never saw fit to bite the bullet and come up with the required budget to make the automotive R.D. & D. effort timely.

Appendix B presents my 1978 estimate required, recommending $140 million to $150 million total per year through 1985, and $120 to $150 million per year through 1990 for the heat engine program.

Today, if we include inflation, and also add to it the electric and hybrid vehicle programs, the number would be about $350 million per year.

While Congressman Harkin, in H.R. 4678, recommends this level of funding, it reaches it way too slowly—1983. He and the other sponsors of the bill should be complimented for recognizing the

need for a high-priority and visibility program in automotive R.D. & D.

If we also include R.D. & D. on vehicles, composite materials, and structures, transmissions, a number of accessories and demonstrations, it is quite easy to show that the funding level of $1 billion per year over a decade can be very effectively used on this very important program area.

When Brock Adams challenged the U.S. automotive industry to come up with a revolutionary automobile, past the year 1985, he recommended a budget of $10 billion for the 1980's. I tend to agree with this funding level in order to get timely results and proper national emphasis.

This does not include the billions of dollars of investment that would be required in retooling.

Money from oil windfall profit tax should be directed to areas of energy productivity or efficiency that the automobile represents, just as much as to the production of new synthetic fuels and renewable resources.

In fact, a balanced program in conservation and new energy resources would be much more cost-effective for our Nation.

We all recognize the President's strong desire to balance our budget and curb inflation. However, judgment is required in the funding allocations and establishing priorities.

An unrealistic budget for automotive R.D. & D. will have devastating long-term effects on our economy. It is inconsistent to pass Public Law 96–185, which subsidizes one such automotive company, and not face the much broader issue of the real national need of a well-funded and timely automotive R.D. & D. effort.

I am therefore delighted that Senator Stevenson and his committee have raised this question of funding level, emphasizing optimal results in the decade of the 1990's.

Procrastination and delays can only make the already recognized illness eternal.

Thank you.

Senator STEVENSON. Thank you, Dr. Sternlicht.

I agree wholeheartedly with what you said about the methods of our foreign competitors. But don't we know, from their methods, that if the United States made a commitment basically to research and organized it, as you suggest, that foreign producers would simply step up their own commitments to R. & D. and soak up any technological developments used by the United States and exploit them, as they frequently do, and allocate the necessary capital to the retooling and production of automobiles which are incorporated in the technology?

What assurance can you give us that the world will stand still and wait for us to catch up with a program of your magnitude?

Mr. STERNLICHT. First of all, I just have a lot of faith in the Yankee ingenuity.

Senator STEVENSON. A lot of the Japanese think that, too.

Mr. STERNLICHT. The one thing that we have demonstrated is that when there has been a mission which was clearly understood and recognized from top to bottom, that somehow we managed to pull ourselves up by our bootstraps and do the job.

A typical example of that, I think, going all the way to the Manhattan project, if you look at the Apollo project, if you look at our present submarine fleet, they are examples—good examples where something has been identified, a mission has been established, and people started working actively in a variety of places—small business, large business, universities, et cetera.

We can't be complacent. This particular industry and the housing industry govern our U.S. economy. We can't go and just wonder what is going to happen in Europe or what is going to happen in Japan. We have to take the bull by the horns and provide some leadership.

Via that route, we have a better chance of innovation, even though other countries will be generating other products as a result of a our effort.

Unfortunately, at the present time we do not have such a national effort going on in any industry. And if we consider the automotive industry as being, in order of importance on the top, we just have to take action and hope that with a lot of blood, sweat, and tears, we come through.

And the thing that is discouraging is that we discuss forever a little basic research here and some other research there, and we don't have a program.

And if you don't have a program, we are not going to get the accomplishment. We are just going to procrastinate until the Japanese and the Europeans are going to beat our pants, because they are highly innovative, highly competent, and have newer facilities than we have.

And I was shocked at some of the comments which I heard made, that everything is hunky-dory, we have basic research, everything is going OK. But that's what concerns me most.

Senator STEVENSON. Senator Schmitt.

Senator SCHMITT. Yes. Following up on that, Beno, I think you're on the right track. You and I have talked about these things many times.

Mr. STERNLICHT. Yes, we have.

Senator SCHMITT. But I think we have got to be careful in our equating an effort of this kind to those efforts that have a clearly definable product—Apollo, the Panama Canal, the Transcontinental Railroad. Those efforts mobilized and motivated hundreds of thousands, and in some ways millions.

In the case of war, the young men and women in this country did accomplish a goal, that you can't stop us. You can set that kind of a goal and articulate it in the way it motivates young men and women. It's a uniquely American characteristic, I believe.

But on other occasions, without such a product, we have also done very well. I think it's those cases that we have to examine.

In the automobile case, I have been searching my mind for some way to establish a goal within the automobile industry that would be comparable to digging the Panama Canal or flying to the Moon the first time. I haven't been able to come up with anything.

I have been searching my mind in the same way, and I think I can come up with a 20-year goal. But you've really got to think in terms of 10-year cycles in order to handle the human characteristics of this kind of motivation.

We have to look at what we learned from our agricultural revolution, from our aeronautical revolution, from the broad communication revolution that we have, to find the lesson for an automobile cooperative management structure. I don't think you would disagree with that.

Mr. STERNLICHT. No, I don't. I don't disagree with that. I think we just do everything in our power to find a variety of similarities and differences, but most importantly, to start moving forward and move forward fast, because it's going to take a decade to make some significant changes.

And those people that think we are going to do this overnight, I think are wrong.

They have really not looked at how long it takes to produce a variety of new things.

And the concentrated effort thus far in the automotive area has been on reducing the size of the vehicle. There's virtually been no work done on anything to see how you can come with much higher efficiency propulsion systems, and that is going to be long and time consuming.

Senator SCHMITT. Well, the MITI program in Japan, except in some of the cultural ties along the side of the triangle, resembles the aeronautic program more than it does anything else this country has tried. Do you agree with that?

Mr. STERNLICHT. Yes, it does.

Senator SCHMITT. Obviously, the Japanese have a different cultural basis and can do some things that, for example, our antitrust laws and our commitment to those would not allow us to do.

But it doesn't mean the concept of tieing academia and Government and industry in the various apexes wouldn't work. Do you see any modification of the MITI or NACA/OAST model that you would make if that were the approach for an automobile technology effort?

Mr. STERNLICHT. One of the key things that occurs let's say in Japan is that from top to bottom, they recognize a need which has been established. The one most important one, which I can illustrate, has nothing to do with automotive. It is their uranium enrichment program. They made a decision that they have to have it. They copied, in some cases; in other cases they extended the European technology. But they moved forward with the thing.

But it has been recognized and once it has been established, everything fell in place—the universities and the government and the industries.

Their objective, in general, is very much tied with the national needs, but at the same time oriented to its exports. And this is another lesson that we have to learn, that in the future, the United States is going to have to depend much more on export, and the aeronautical industry is a good example of that. And the automotive industry hopefully should be, too.

In fact, if it wasn't for the foreign business by General Motors and Ford, both of those companies would be very, very sick today. I think it's going to be extremely important to try to find various incentives and various organizational arrangements which are hopefully going to weigh this program.

And the reason why I suggest one of two different arrangements is, one, where it's advantageous to use a variety of agencies because they already have links with the industry. NSF, for example, deals with the university environment; NASA, with a variety of other industries; DOE with other groups.

So that's already established.

However, the thing that's needed is for somebody to pull this thing together. This management that you were discussing before, and on a high enough level so that all of the congressional committees and the administration recognize that this is a problem before us. That would be one possibility.

Senator SCHMITT. If I may interrupt, you held my hand a few years ago when we were trying to get some kind of Federal coordination of this kind of an effort.

Mr. STERNLICHT. Yes. It was almost impossible.

Senator SCHMITT. And the number of places were too large. We just couldn't pull it together. Why do you think we can do it now?

Senator STERNLICHT. Well, hopefully, the Congress and the administration have recognized that this is probably one of the most important programs for the Nation. They would then establish a director of this program who reports to the Congress and to the administration.

Senator SCHMITT. But after what you heard this morning, do you think they recognize that?

Mr. STERNLICHT. I am, to say the least, confused and concerned. The other approach which would be a possibility which goes a little bit more along the generic technology standard—and I know that you and others will oppose this strongly, being so committed to space and aeronautics, and that is to yank NASA loose, since this is the group that has got the greatest capability in this field.

They are already about 70 percent, as was indicated, involved in the automotive program of DOE, yanked them out completely from NASA.

Now, you already have an agency. You've got a body of people who have certain capabilities and resources.

Senator SCHMITT. Put them under an interagency coordinating committee?

Mr. STERNLICHT. No, no. That one was not an interagency. That would be a separate group, starting as a generic center oriented strictly to the automotive R. & D. I should say automotive R.D. & D.

By the way, sometimes the D on the end is missing, and that's a major problem, because one of the ways that this whole area can be really—let me call it induced and the automotive industry be much more interested—is by a very significant demonstration.

Now, here I would like to compare it to the aeronautics program. One of the reasons why the Government has been very effective in this is in the DOD and DOD mission needs. But it so happens that the U.S. Government is the largest owner of automobiles. There's no reason why it cannot induce these demonstrations by saying we will only buy cars which have got this and this kind of efficiency or that we will buy cars which have lifecycle costs, such as costs based on so many miles of travel.

So, via these techniques, they are an end-user, just like DOD is the end-user of the aircraft, the Government is an an end-user of the vehicle.

Now, these demonstrations with the new kinds of powerplants with the higher efficiency systems could be a tremendous inducement on the American automotive companies. Which automotive companies are going to be in the year 2000 remains to be seen, but this could be tremendously useful.

There are over 100,000 vehicles bought by the Government each year, and that's a tremendous number of vehicles that could be replaced which are obsolete from the standpoint of reliability and a variety of other things, efficiency and everything else.

So there are a variety of inducements that could be created. And that is why I feel the D on the end must remain and it's a very important D. It's not just R. & D.; it's the demonstration policy.

Senator SCHMITT. Well, I think that's very important and I think we have to have an even mind on how it's organized. I'm a little bit concerned about that many agencies being able to work together.

The possibility of some kind of a new NACA holds some possibilities, with the A now standing for automobile technology, with NASA/Lewis, or the Lewis Research Center being the basic component.

I think we have to consider that and consider the impact on the aeronautic industry because there's a considerable amount of work done by Lewis in aeronautics and in space technology.

Mr. STERNLICHT. Yes.

Senator SCHMITT. We just have to examine it.

Mr. STERNLICHT. I think what we have to do is to be as creative in this arena. But most importantly, we have to move and not talk about it. We have talked about it for a decade.

Senator SCHMITT. It has to be a comprehensive program involving the three elements of society that you mentioned.

Mr. STERNLICHT. That's right.

Senator SCHMITT. It has to extend from basic research with industry providing the demonstration technology. It can also include joint test facilities.

All of those things are certainly possible and have been done before. The question is, do we have the will to do it and will we expend the resources to do it?

Mr. STERNLICHT. And I don't have the answer to that.

Senator SCHMITT. Thank you.

Senator STEVENSON. We will hear from the industry later, but my impression is that, really, the large automobile manufacturers don't want Government involvement in applied research. How do you help these reluctant customers?

Mr. STERNLICHT. Well, we agree on that fully 100 percent. I don't think you can force anything. I think the economic pressures are going to force it. I think there are going to be a variety of changes. Having the technology available is a prerequisite because then you can choose something.

What has happened to us, there are a variety of technologies. You are right to point out that we have a variety of technologies, but many of them haven't been reduced to practice.

For instance, the Stirling engine was an engine that was first developed in 1816, as I showed on the first slide. But there are some new things that have happened in the economy. The external combustion brings out a new need. The emission requirements bring out a new need, and it's almost a rebuild of a very, very old engine and this other technology that would be added to it to make it a viable powerplant.

So that rather than pushing it on the automotive industry, I think what we have to do is to create options from which they can pick. That's one thing.

Second, we are not sure who are going to be the automotive industry in the future. I'm not in any way indicating that General Motors or Ford is going to disappear at all, but there may be other new industries born, or a combination of industries, and where these options exist, this enables different groups to get into a business. That's going to be essentially important.

But in addition to this, I see a scenario in which you could have a variety of general manufacturers and a variety of product assemblers and distributors just out of the aircraft industry.

Today you've got Boeing and McDonnell-Douglas, you've got the Pratt Whitney and General Electric Co., and, obviously, General Electric making engines and the others distributing it.

So the options in the area of automobiles are many. The companies are many. The electrical vehicles are beginning to show up. We don't know who are going to be the key companies in the electric vehicle arena.

The key thing is that it takes a long time to establish and prove these technologies, and that cannot be done overnight. And while you are working up to 1985 in the reduction of weight, which is going to be viable in any of these other engines, we at the same time have to be working on other things.

So that by past 1985, we will have those things at least available in a State where we can start demonstrating. And today we don't have it.

Senator STEVENSON. Recognizing there is some synergism between different modes of transportation and that we require at least fuel efficiency in all modes of transportation and that technology developed for one can be applied in another—engine materials and so on—shouldn't we consider recasting this effort, however it's organized, as a transportation fuel efficiency project instead of thinking of it or casting it as an automobile efficiency product?

Mr. STERNLICHT. I think it should be fuel efficiency propulsion for vehicles—for some form of vehicles.

Senator STEVENSON. Just propulsion?

Mr. STERNLICHT. No, not just propulsion. There obviously has to be research going on, for instance, on a variety of materials that could have major technological breakthroughs both for the automotive industry and other industries which would change the vehicle, the kind of structures and mechanisms.

There is need of the propulsion system in itself. There is a need of all of the accessories, for instance, in other areas in which we lag way behind.

It's the whole area of infinitely variable transmissions. We lag way behind Europe. That's going to be a very important technol-

ogy, not just for the automobile, but for a variety of other products. We have just not addressed ourselves to the areas that are needed to make this package the system of propulsion viable past the 1985 timeframe.

The whole aspect of what fuels we will be using, for instance, there has been very little work in assessing what it is going to cost us and how inefficient it is going to be to make diesel fuel, vis-a-vis a variety of other fuels that can be used in the gas turbine, for instance, or the Stirling engine.

So the whole system approach has not been addressed and we have bits and pieces that are completely underfunded, without any integration, just going on with the hope that something is going to happen.

And now the basic research is certainly being thrown in and we will sit back and say, boy, everything is hunky dory, and that's the part that I am frightened by the most.

I would like to also add the work we are doing in the Stirling engine area is in cooperation with the leadership of the technology achieved in Europe—Holland and Sweden—United Stirling of Sweden, my colleague, we are working together trying to establish this technology and advance it and make it into a viable powerplant of the future.

By the way, there are already a variety of missions, not just for the automobile, but it appears right now the Stirling engine is ideally suited for a solar application, for solar power generation, because it can use the Sun as an energy source.

So we can talk about the technology and one can't predict always where it's going to lead in innovation from a variety of other products.

But the emphasis on doing it is going to be extremely important if a variety of people with competence are really going to orient themselves into doing something in a given time. And that's why I was delighted when you talked about doing something specific in the 1980s so we would have something ready for the 1990's.

And that's a realistic timeframe.

Senator SCHMITT. Mr. Chairman, if you would yield for a further thought.

It's clear that a major, if not the major, benefit of all of this would be increased fuel efficiency. But I think we have to be a little more general than that because there's a quality control problem, a manufacturing technique in automation that fits into this.

So it's a broadly based, sustained program of technology that is really what the aeronautic program was.

It was propulsion, aerodynamics, materials, quality control, manufacturing techniques, and so forth. I think that's really what we're coming down to. At least I feel that what you need is some broad based effort, or organization, which is still centralized in basic control.

Senator STEVENSON. I'd accept that and go one step further and include the environmental considerations.

Senator SCHMITT. Oh, yes, safety and environment. When I think about good fuel efficiency, except for the nitrous oxides, you're going to have most of those——

Mr. STERNLICHT. I'm glad you brought that point up because here are three examples. It so happens all of them are in propulsion, which were mission-oriented. But the technology became very, very broadly applicable to the jet engine.

The whole area of technology is applicable. The whole combustion technology eminated out of the jet engine work and, of course, there was a tremendous amount of materials. If you look at the U.S. Navy nuclear submarine, the same thing that emerged out of that was the whole question of reliability and quality control.

There's no question the U.S. Navy program established some of the quality control. And I wonder how the helicopter business would have been in Iran if it was under his jurisdiction of establishing helicopter heat transfer technology.

Senator SCHMITT. The only thing we disagree with him on is on the patent technology.

Mr. STERNLICHT. I disagree with him on that also. The NASA program—the whole area of guidance and control that emerged out of that, the rocket propulsion, communications, the whole field of communications, energy conversion technology, the reason why we are discussing that today is because it's so heavily involved in a variety of energy conversion technology.

And you could add some others. But that's exactly what we're seeing. Once you generate, say, the automotive heat engine program where we need definitely the basic research and applied research and technology, et cetera, you are going to focus on that, but there will be a lot of spinoffs which are going to be extremely important in the generation process for other things.

[The statement follows:]

STATEMENT OF DR. BENO STERNLICHT, CHAIRMAN AND TECHNICAL DIRECTOR, MECHANICAL TECHNOLOGY, INC.

Mr. Chairman and members of this subcommittee, it gives me great pleasure to testify on this very important national issue. Before I answer the specific questions raised by Senator Stevenson, I would like to put the issue in proper perspective.

Prior to the oil embargo, I have been one of the more vocal voices crying in the wilderness, predicting the automotive problems that we have today and recommending a very high priority national program in automotive RD&D. Each year I have been invited to testify before the various congressional committees (by now I must sound like a broken record). My views are summarized in Reference 1 parts of it are appended to this testimony. Lots has happened since the oil embargo effecting this very important national issue:

We have lost almost a decade;

We have recognized an energy crisis, which is symptomatic of a much larger problem which I have identified as "The Energy Revolution";[1]

We are going to collect large amounts of money from the oil companies windfall profit tax and hopefully spend it wisely;

We have recognized that our rate of innovations are behind virtually all of the industrial nations;

Japan has overtaken us in yearly car production;

Foreign car imports have greatly increased;

Our automotive industry is sick; and

We are simultaneously faced with inflation and recession.

Therefore, the repeated question as to whether the Federal Government has a role to play in the automotive RD&D should not be raised again. For if the Federal Government does not play a key role then it can count on continuing subsidy of industry that is nationally of highest importance, but one that is critically ill.

Now turning to the specific questions raised by Senator Stevenson's letter of April 9, 1980.

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[1] May 9, 1979, Testimony by B. Sternlicht to the House of Representatives Subcommittee on Transportation, Aviation and Communication.

Question. 1. Is a federally-funded basic research program necessary for development and application of automotive technology in order to promote energy conservation, exports, safety, and environmental protection? Title III of S. 2015 (attached) proposes such a program.

Answer. The answer is uneqivocally *yes.* However, as pointed out in Appendix A (Viewgraph 10) "while basic research represents an important foundation and is necessary it is not sufficient in itself to insure end result oriented viable automobile."

Question 2. Should such a program be restricted to basic research or extended to experimental components and vehicles to verify the feasibility of newly developed technology? H.R. 4678 (attached) included such extension.

Answer. Basic research should be part of a directed/focused RD&D effort and should represent about 10% of the total budget allocation to automotive RD&D (product improvement, such as cost reduction, are not considered as part of this effort). Thus, if 1.6 billion dollars are proposed for basic research (half gov/half industry) there then should be a 16 billion dollar RD&D automotive program in the eightees (this would correspond to an average funding level of 1.6 billion dollars/year). Presently government funded automotive RD&D program is an order of magnitude smaller.

Since need is mother of invention, best results from basic research generally eminate when they are part of a total mission oriented RD&D effort and a recognized and focused program of national priority provides the emphasis and motivation. Under these circumstances, there is also more effective and rapid technology transfer and utilization.

Within the educational sector it is probably more important to refocus our attention on the teaching programs and not just on basic research which is generally limited to graduate students and some members of the faculty.

With the strong emphasis in the past few decades on nuclear and aerospace our education of engines and power engineering in high schools, trade schools, colleges and universities have almost disappeared. Most universities have discarded or moth balled their engine laboratories.

Education in this area is essential so as to create the future mechanics, technicians, engineers and managers. Such an educational program will also be of value in other areas of energy conversion applicable to many other and use products. It will also greatly help our innovation in which we are seriously falling behind. Basic research at colleges and universities can, of course, help in such an educational program.

Until very recently, the automotive industry has strongly opposed any government involvement in automotive RD&D. Today, there is some ambivalence on this point of view. I believe that the U.S. automotive industry has endorsed and seems ready to financially support the basic research program primarily to try to keep the government from supporting the more applied work that is necessary in development and demonstrations. (Generating in Congress and OMB a debate on priorities between basic versus applied RD&D and leading to an erroneous conclusion that we do not have the money to do both.)

In addition, from a public relation standpoint this support of basic research is beneficial to the automotive industry in fighting a variety of regulations by showing that they are working on basic understanding of the problems.

It would be dangerous, therefore, if Federally supported basic research shortchanged the more important need for directed/focused RD&D effort. Also, it would be devastating if complacency permeated the White House, OMB and Congress and there emerged a feeling that the troubles of the automotive industry are over since we are sponsoring basic research.

Question 3. Should such a program be funded and carried out through government facilities and educational and other non-profit institutions without direct involvement of the auto industry? Alternatively, should it involve a cooperative government/industry relationship for funding, project selection, and program management?

Answer. This program is so important to the health of our national economy that it must use all of the available resources. (Appendix A, Viewgraph 4). It should not exclude automotive industry but at the same time it should not be limited only to the automotive industry. For it is not clear who will be the automotive industry in the next century and innovations can spring from anywhere.

The funding in the high risk/high payoff areas will undoubtedly have to come from the Federal government. In the applied and demonstration areas it is not very important where the funding originates. If industry does not support it, the government must. There is very little advantage for the automotive industry, on the one hand, to support basic research and on the other hand receive large government

subsidy. There is absolutely no valid reason to limit the program to the large automotive industry, universities and non-profit institutions. Many small companies are highly innovative, yet they generally cannot afford to cost-share, they still can make very significant contributions to solving our automotive dilemma. These industries create new employment opportunities and greatly help in the innovation process. Therefore, they should be strongly encouraged to participate in the RD&D effort.

What is needed is a national program of very high priority (Appendix A, Viewgraph 14) which utilizes the best available talent from all sectors (industry, government, universities and institutes). We must create a climate which is conducive to innovation to insure rapid progress.

As for the management it should be so chosen and organized as to minimize bureaucratic delays. It should be competent, experienced and dedicated to this very important mission. Project selection should be left entirely to the management if they are to be measured by their accomplishments.

Question 4. Should such a program (a) be structured and administered within a Federal department or agency, (b) be structured as a multi-agency activity, or (c) be carried out in some newly established institutional framework? S. 2015, H.R. 4678, and S. 1250 (attached) contain alternative approaches.

Answer. It is important that the White House and the Congress recognize the importance of this program and legislate a national program that can function efficiently and on timely basis. Since the program cross cuts the charter and resources of several governmental agencies it may be advantageous to create a small program office with the Director reporting to the White House and the program execution to be divided among several agencies, e.g., DOE, NASA, DOT, NSF, Commerce Department, EPA. Industry, institutes and educational institutions must be an integral part of such a program. Each government agency through its established channels can interact with the private sector groups.

The spirit of competition can be very healthy. The program Director should be responsible for funding allocations to the various governmental agencies and for program coordination. He presents and defends the program and budget with the responsible congressional committees.

A multi-agency activity will have the benefit of creating a broad-based program that utilizes the best available resource and should also have positive effects in the innovation process.

NASA-Lewis can be singled out as the Center having the greatest technical resource applicable to the automotive RD&D. DOE has recognized this and is effectively using part of this resource. An alternative approach would be to separate this Center from NASA and give it the charter of National Automotive Center with the responsibility of interacting with the other national resources in various Government departments, industry, universities and institutes for the sole purpose of conducting Automotive RD&D. Such a move would demonstrate the national priority of this program and remove the conflict within NASA of manpower allocations to Aeronautics and Space.

Question 5. What Federal funding level would be required for optimal results in the decade of the nineties?

Answer. The automotive RD&D program has been a stepchild that has moved from one house to another (EPA to ERDA to DOE). Since its beginning, it has been way under funded and submerged with other programs of much lower priority.

Year after year, I have testified before the congressional authorization and appropriation committees on the question of automotive RD&D funding. While my estimates have been consistent (neglecting inflation) OMB and Congress never saw fit to bite the bullet and come up with the required budget to make the automotive RD&D effort timely. Appedix B presents my 1978 testimony recommending $140–$150M/year through 1985 and $120–150 M/year through 1990 for the heat engine program. Today, if we include inflation and also add to it the electric and hybrid vehicle programs the number would be about $350 M/year. While Congressman Harkin in H.R. 4678 recommends this level of funding it reaches it way too slowly (fiscal year 1983). He and the other cosponsors of the bill should be complimented for recognizing the need from a high priority and visibility program in Automotive RD&D.

If we also include RD&D on vehicles, composit materials and structures, transmissions, a number of accessories and demonstrations it is quite easy to show that funding level of $1 B/year over a decade can be very effectively used on this very important program area. When Honorable Brock Adams challenged the U.S. automotive industry to come up with a "revoluntionary automobile" past the year 1985 he recommended a budget of 10 billion dollars for the eighties. I tend to agree with this funding level in order to get timely results and proper national emphasis.

Money from oil windfall profit tax should be directed to areas of Energy Productivity (effeciency improvements) that the automobile represents just as much as to the production of new synthetic fuels and renewable resources. In fact, a balanced program in conservation and new energy resources would be much more cost effective for our nation.

We all recognize the Presidents strong desire to balance our budget and curb inflation. However, judgment is required in funding allocations. Unrealistic budget for automotive RD&D will have devastating long term effects on our economy. It is inconsistent to pass Public Law 96-185 which subsidizes one such automotive company and not face the much broader issue of the real national need of a well funded and timely automotive RD&D effort.

I am, therefore, delighted that Senator Stevenson and his committee have raised this question of funding level emphasizing optimal results in the decade of the nineties. Procrastination and delays can only make the already recognized illness terminal. Thank you.

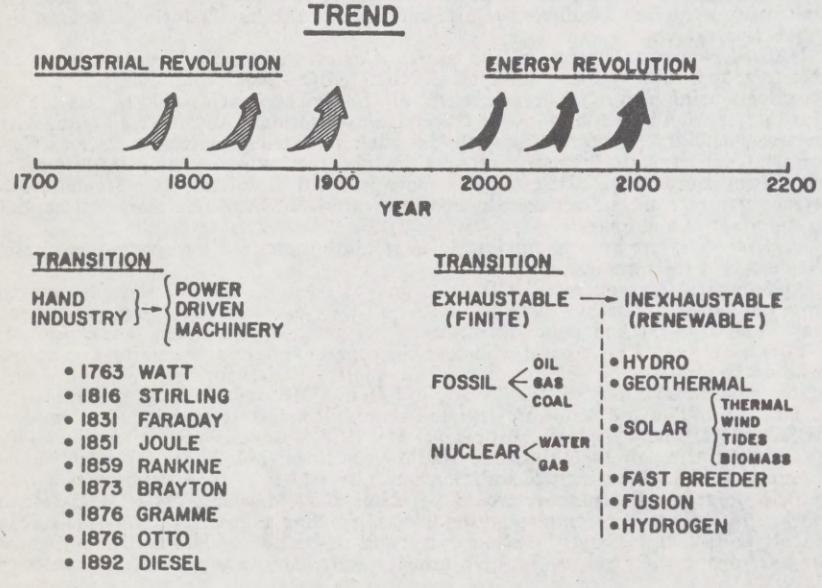
Attachments.

Appendix A[1]

I will make my brief remarks with the aid of viewgraphs. They are divided into six parts:

1. Perspective.
2. The Challenge.
3. The Need for Innovation.
4. System Considerations.
5. The Stirling Engine—Advantages and examples of some of the RD&D needs.
6. Concluding Remarks.

1st Viewgraph.—The period that we are in, I have called the Energy Revolution because it is comparable to the Industrial Revolution. In fact, the more successful is the industrialization of developed and developing parts of the world, the more critical and demanding will be the energy transition. The periods for both of these eras are rather long. Note that all the automotive engines considered today are based on innovations and early development that occurred prior to 1900.



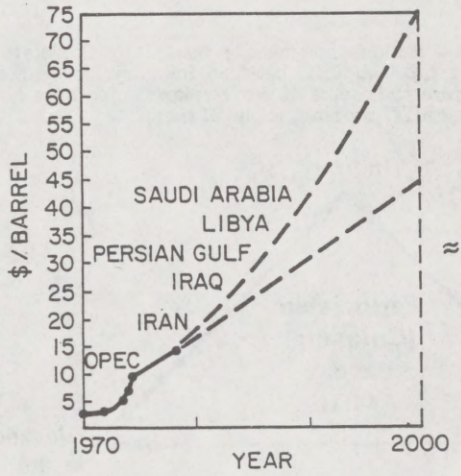
[1] Remarks made by Dr. Beno Sternlicht, Board Chairman and Technical Director, Mechanical Technology Inc., Latham, New York on February 13, 1979 at the DOT Meeting in Boston.

2nd Viewgraph.—This viewgraph presents three highly undesirable scenarios. The first involves rapidly rising cost of energy and our vulnerability to the Middle East and Russian influence in the oil rich parts of the world. Note that the rapidly rising cost of energy has a significant effect on inflation, consumer purchasing power of non-automotive goods and services, etc. The second scenario shows relatively low total sales of automobiles and rather large foreign automobile penetration into the U.S. market. Both highly undesirable conditions from the standpoint of employment, balance of trade, etc. The third scenario is also highly undesirable from the standpoint of very low total sales which will obviously effect employment and the high import tariffs will have highly negative impact on our international relations with many of our allies, e.g., Germany, Japan, Italy, France and Britain.

MORAL EQUIVALENT OF WAR
(LEGACY TO OUR CHILDREN)

SCENARIOS

① FUEL PRICES



15,000 MILES/YEAR

TODAY

$0.7/GAL

20 MILES/GAL

FUEL COST $525/YEAR

≈ YEAR 2000

$5/GAL

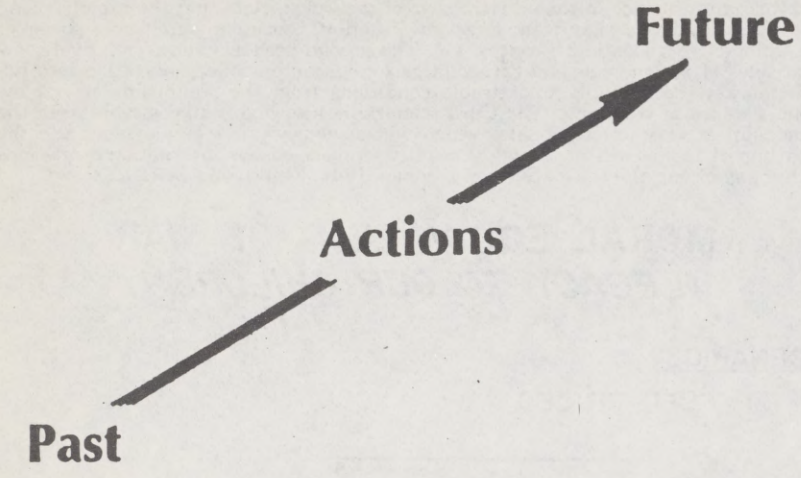
30 MILES/GAL

FUEL COST $2500/YEAR

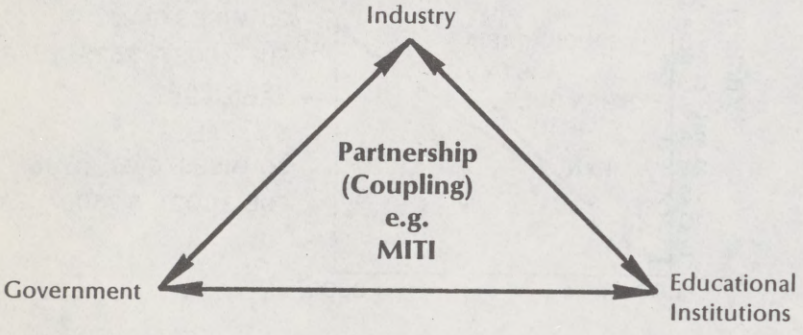
② CAR SALES – 10M/YEAR < 50% U.S. MADE / 50% FOREIGN MADE

③ CAR SALES – 5M/YEAR – 100% U.S. MADE
MAJOR FOREIGN
TRADE RESTRAINT

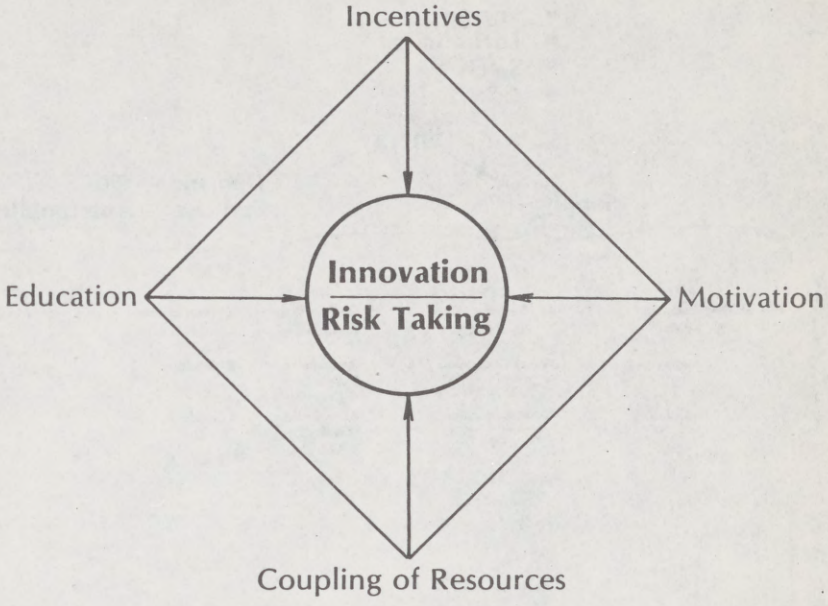
3rd Viewgraph.—If we want to influence the future, we have to act now.



4th Viewgraph.—One of these actions has been proposed by Secretary Brock Adams. It represents a partnership (coupling) between industry, government and universities. We have to recognize that some of our foreign competitors have successfully done this. The Japanese MITI program is one of them.



5th Viewgraph.—As a member of the Domestic Policy Review on Industrial Innovation, I have concluded that Innovation is synonymous with Risk Taking and that Innovation is strongly influenced by the four factors listed on the viewgraph.

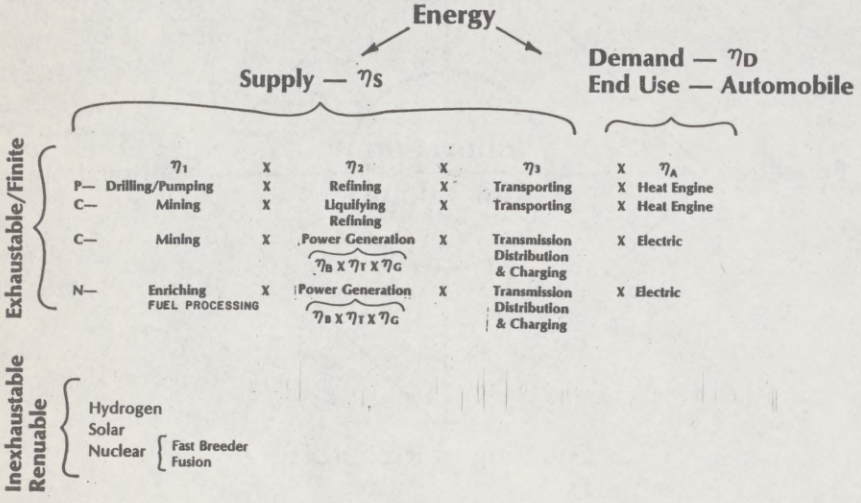


In the past, there have been major innovations in manufacturing technology which should be credited to the automobile industry. Today, we need many new innovations in the automobile, e.g., enines, materials, etc. if we are to remain leaders and capture a large share of the world automobile market. We must also relearn to take high risks and, in fact, create a climate which is conducive to risk taking. Thus, incentives rather than regulations should be emphasized so that we improve the innovative climate.

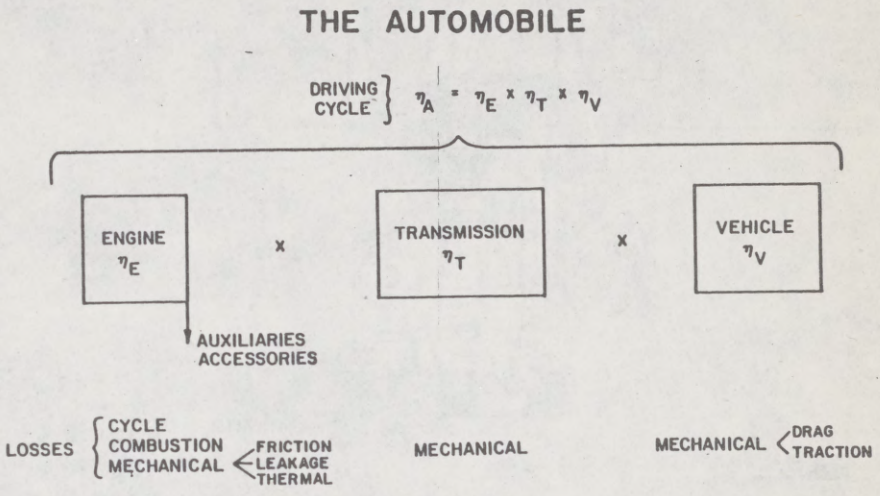
6th Viewgraph.—The automobile represents a very important mobility system. For this system to be highly effective, we must optimize many highly complex factors such as energy, environment, safety, cost, etc. The viewgraph considers just one key issue: that of energy. The system should consider both supply and demand requirements, rather than just one side of the equation. We must investigate a variety of energy sources that could be used by the automobile. Coal (C), for example, can be converted to synthetic liquid fuel for future heat engines or electrical power for electric vehicles. These two options should be carefully analyzed and compared. From an overall national standpoint, we must consider engines with multifuel capability, fuel switching and a variety of inexhaustible energy sources which, hopefully, will become available in significant quantities sometime in the 21st Century.

System Considerations

- Energy
- Environment
- Safety
- Cost



7th Viewgraph.—In the case of automobile efficiency, we must consider the engine with its accessories an auxiliaries, the transmission and the vehicle itself. The losses of each should be minimized in order to conserve energy. The materials used in the vehicles are important both from the standpoint of weight and safety. The transmission has to be matched to the engine and the traction requirements. Thus, high efficiency infinitely variable transmission may be the answer. These subsystems must then be integrated into an effective automobile.



8th Viewgraph.—Now turning to the engine. One automotive powerplant that offers considerable potential is the Stirling engine. Its four primary advantages are listed on the viewgraph. Being an external combustion engine, it can use not only a variety of liquid fuels, but also solid, solar radiation and gases. The Stirling engine can be used in a variety of applications. The technology today resides primarily in Europe (Sweden and Holland). It must be transferred to this country, then advanced further and commercialized. It is interesting to point out that both the Diesel and the jet engine technologies also came from Europe.

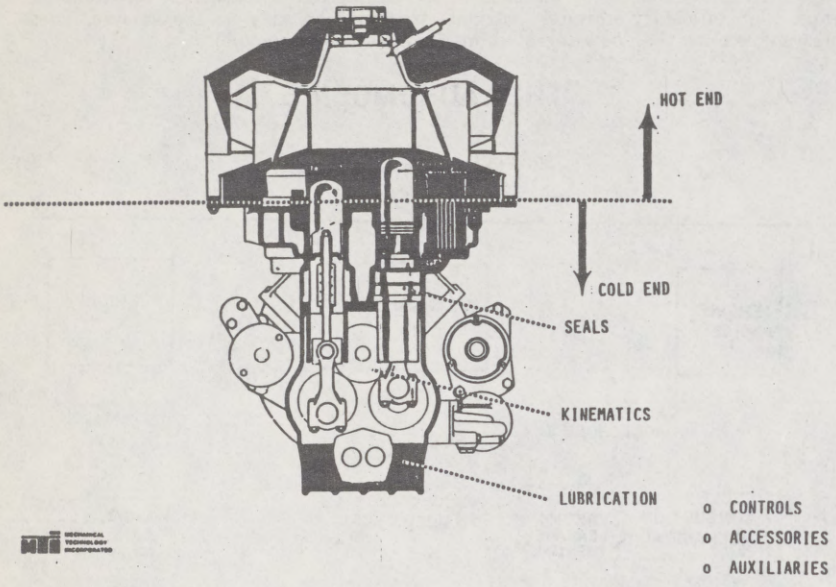
THE STIRLING ENGINE

Multi Fuel Capability—External Combustion
High Fuel Economy
Very Low Emissions
Very Low Noise

9th Viewgraph.—Shows schematic of the Stirling engine. Note that the engine can be divided into the hot and cold end. There are a number of areas that require R&D before this powerplant can become a serious contender to the spark ignition and Diesel engines.

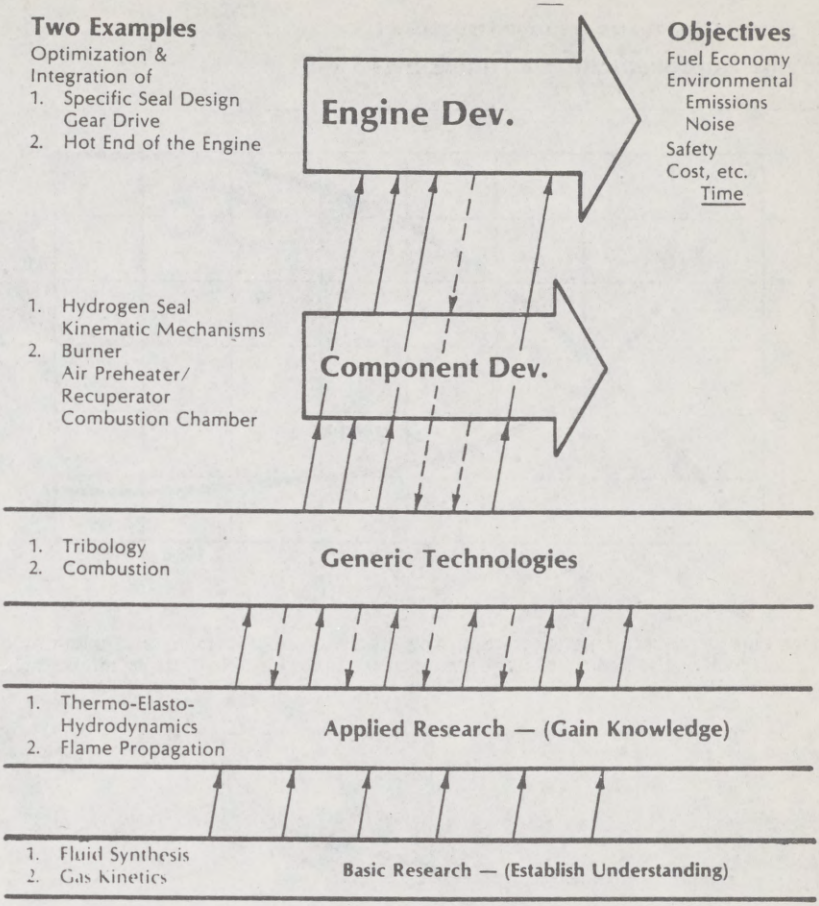
AUTOMOTIVE STIRLING ENGINE DEVELOPMENT PROGRAM

Stirling Engine



MTI MECHANICAL TECHNOLOGY INCORPORATED

10th Viewgraph.—While I am a firm supporter for the need of vigorous programs in basic research, I would like to stress the strong need of focused/directed research in the case of the automobile. There is of course, considerable cross fertilization between development, technology and research. The viewgraph presents two RD&D programs that span basic research—engine development. One program deals with the hot end and the other the cold end of the engine. A number of other areas require R&D effort before the Stirling engine can become a viable automobile powerplant.



Thus, while basic research represents an important foundation and is necessary, it is not sufficient in itself to insure end result oriented viable automobile.

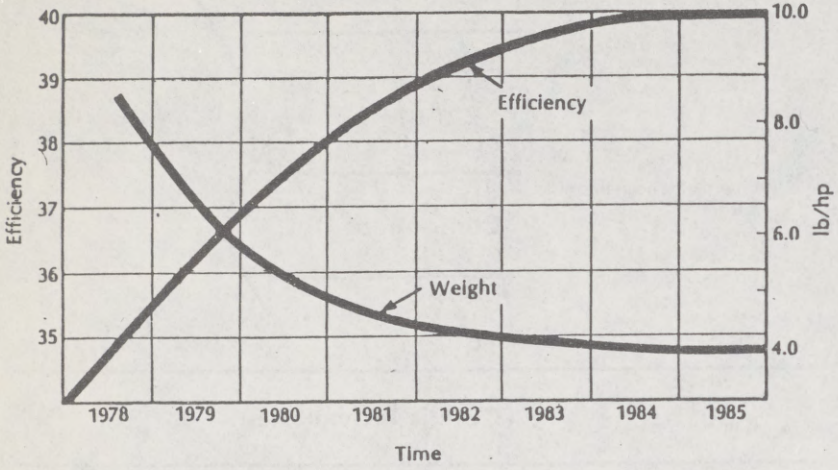
11th Viewgraph.—Our program objectives for the Stirling engine automobile are listed on this viewgraph. The 30 percent fuel economy is above the 1985 fuel consumption for a car of the same weight. In addition, as pointed out earlier, the Stirling engine automobile lends itself to a variety of fuels since it is an external combustion engine.

AUTOMOTIVE STIRLING ENGINE DEVELOPMENT PROGRAM—FINAL PROGRAM OBJECTIVES

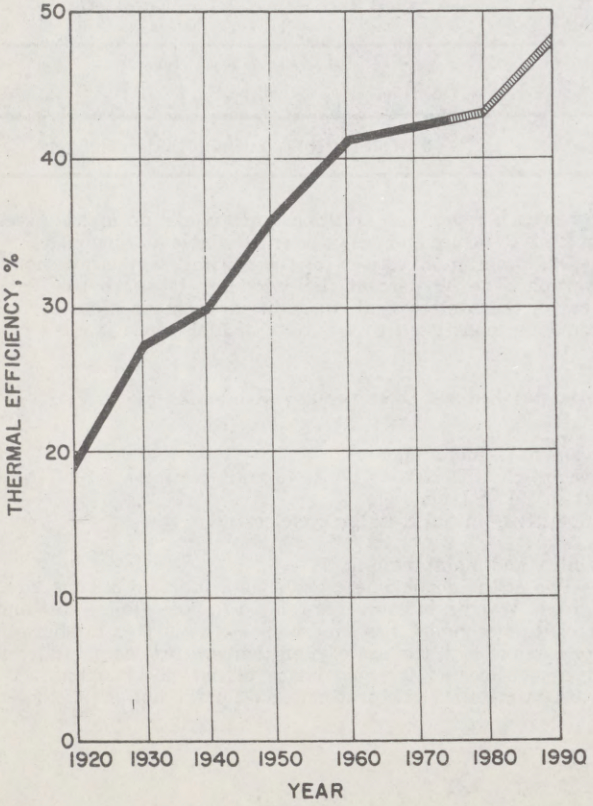
30 percent Improvement in fuel economy.
Low exhaust emission—HC/CO/NOx=.41/3.4/.40 gram per mile.
Noise no greater than 1977 S.I. engine.
Economically Competitive—initial cost; life cycle cost.
Reliable, durable, safe.
Acceptable driveability and maintainability.

12th Viewgraph.—Two of the development goals, as a function of time, are illustrated on this viewgraph. Weight, of course, is related to both engine cost and also reflects itself in vehicle fuel economy. It should be pointed out that further efficiency improvements are possible with the use of high temperature, nonmetalic materials. In the limited time allocated for this phase of our development, we have selected to concentrate on metalic structural material for the hot end of the engine.

Engine Improvement as a Function of Time



One can get a better perspective on the efficiency improvement and magnitude when we look at the history of large steam turbines for electrical utility application, Viewgraph 13.



14th Viewgraph.—As a nation, we have been very successful in programs that received national priority. Three examples are given of programs in which government and industry were effectively coupled. It is enteresting to point out that all three programs were related to transportation. Each example presents "spinoff" technologies that emanated out of these programs; they have had far-reaching benefits.

This is a very important observation for it shows that directed/focused RD&D not only produces timely results but also that as a byproduct it can generate very important generic technologies. These programs, because of national priority, motivated students and professors who intitiated basic research in a variety of fields. It is clear that setting national priority for a program produces a climate that is conducive to innovation in a variety of fields.

EXAMPLES

Aircraft—Jet Engine.—Propulsion; aerodynamic technology; combustion technolog; and materials.

U.S. Navy—Nuclear Submarine.—Nuclear reactors; reliability and quality control; heat transfer technology; and noise technology.

NASA—Project Apollo.—Guidance and control; rocket propulsion; communication; and energy conversion technology—Let's add the automobile.

15th Viewgraph.—The automobile industry has been highly innovative in the area of manufacturing. Major manufacturing technology advances were made in the automobile and also found their way to other mass-produced products. These innovations enabled the US automobile industry to capture large shares of the world market and made it possible for most of the American public to afford one or more cars per family. In the past few years, the price of cars and fuel costs have risen sharply. Today, yearly energy costs have consumed much larger percentages of an individual's total income.

Life Cycle Cost = **First Cost** (Equipment and Installation)

+ **Energy Cost** for the Total Life of the System

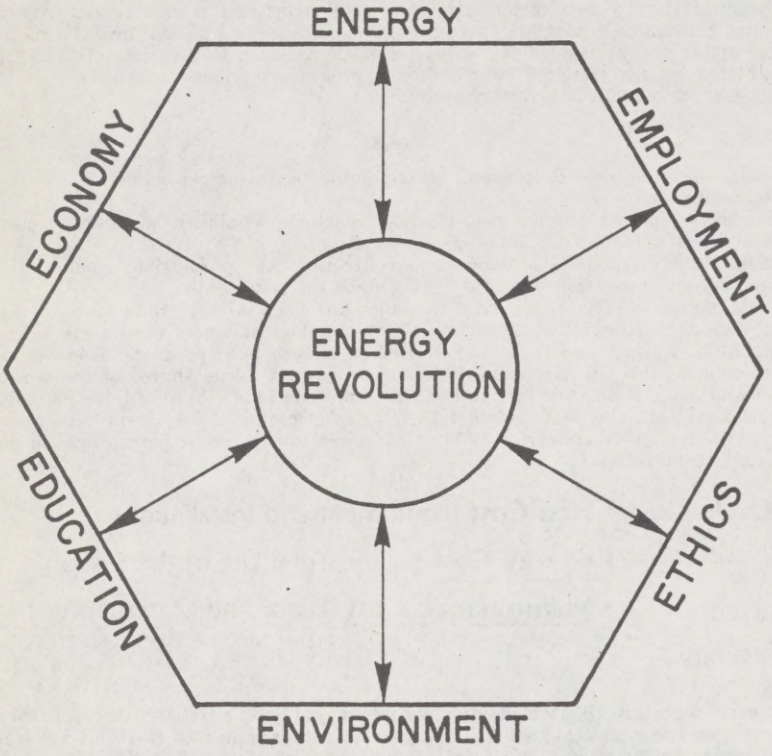
Efficiency → + **Maintenance Cost** (Labor and Material) for the Total Life of the System

Reliability →

It is very important that we rapidly educate the public to purchase cars and other equipment on life cycle cost basis (Viewgraph 15), rather than first cost. The Federal Government can, of course, institute this as its purchasing policy. This approach represents a much sounder buying practice and can result in a major conservation benefit.

16th Viewgraph.—In closing, the energy revolution is multifaceted. It impacts on our life and will effect the lives of our children. Since the automobile today is solely dependent on petroleum, and as a major user of it, we must establish a much higher priority on efficient use of this scarce resource. A partnership between government, industry and educational institutions must be established in order to solve this very important problem on a timely basis and to ensure that the health of our nation is preserved.

PROJECT E^6 OR E-HEXAGON



Appendix B

RD&D Program History, Objectives and Funding Levels

BASIC PREMISE

Personal transportation (public) is essential to U.S. society.

(There is no conceivable way for public mass transit to provide for the known and predicted transportation demands.)

(Mass transit can help, and is vitally important in urban areas, but it is only a small piece of an overall solution.)

HISTORY OF ALTERNATIVE AUTOMOTIVE POWER SYSTEMS (AAPS)

When the AAPS program of EPA was transferred to ERDA in January of 1975, its advocates hoped that this new agency would place considerably higher priority on this very important area of national need—somehow it never did. Now that the Department of Energy (DOE) has been in existence for some time, it still does not have a well-funded program, and it has not received the priority that it deserves. An advanced automotive engine that can use any liquid or gaseous fuel in a highly efficient way can provide insurance for effective mobility and continued health in our automotive industry.

We obviously have not placed very high priority on this very important R&D area. This is exemplified by the history of Title III of the "Automotive Transport Research and Development Act of 1978," which finally passed Congress but did not

receive any appropriation. I am sure that you will agree with me that this area should be on top of the list of priorities. It is, therefore, completely inconsistent that the 1980 proposed budget (especially if we factor in inflation) is actually considerably lower than the 1979 budget which in itself was inadequate.

Automobile heat engines

[Budget in millions of dollars]

1979	47.8
1980 (proposed)	43

RD&D PROGRAM

All of these observations clearly point to the urgent need for a well-balanced automobile engine RD&D program. Time is at a premium because of the foreign competition and also because we are very rapidly consuming the exhaustible natural resources—petroleum. Our balance of trade is very badly affected by our oil imports and, unless we do something, it is bound to get worse. Thus, we have at least three motivating forces justifying a significant development effort in this area: Minimize petroleum imports; Maximize our share of the automobile market; and Preserve our economy and life style.

CURRENT DOE PROGRAM AND SITUATION

About $225M over 5 or 6 years for a technical feasibility demonstration of the Stirling and gas turbine alternative engines (annual funding—approximately $40M).

Many program plans prepared in the past all were above the current annual level.

OBSERVATIONS

The current program is inadequate.

It does not reflect: Urgency of the situation; and U.S. need for personal transportation.

It is not a well-rounded, complete approach to solving a critical national problem.

It will provide some technical feasibility answers, but not the broad technology base required for industry to be willing to take the very high risk required in making an engine change.

WHAT IS NEEDED

A program approach that recognizes both the long-term U.S. need for personal transportation and the long-term nature of the effort required (20 years, not merely 5 or 6).

A. Mainline of core technology feasibility demonstrations of gas turbine and Stirling engines as rapidly as practical. (Funding levels approximately $40M/year/engine type.)

B. Aggressive, wide-scale advanced technology program in areas such as: Materials; Heat transfer and heat exchangers; Combustion; Seals; Controls; Kinematics and lubrication; and Auxiliaries (Build up to about $40–$50M/year and sustain).

C. Transmission/drive train technology.

D. University grants approximately $20M/year. Required for the establishment of basic research, education, technology advancements and for coupling with industry.

We have shown that we can solve very difficult and complex techno-socioeconomic problems. Today, we are leaders of aerospace and nuclear industries. Project Apollo and Manhattan were examples of concentrated and dedicated efforts leading to positive accomplishments in these two fields. We must establish similar commitment to the transportation conservation mission and establish a national project—"TRANSENERGY."

We have two broad options: Heat Engines and Electric. The former presently uses oil, an exhaustible energy resource which, with external combustion, has multifuel capability. The latter could use inexhaustible energy supply. The Hybride Electric represents a bridge between the Heat Engine and an economical and high-performance Electric Vehicle of the future. In all cases, conversion efficiency is very important as is multifuel capability and low emissions.

The various options are at different levels of "technology readiness." Thus, they will require different amounts of time for R&D and demonstration. In order to increase the chances for success, several competing programs in each system must be initiated. In the case of the Heat Engines, several investigators (References 1, 2 and 3) have concluded that only the Stirling Engine and the gas turbine are the potential engines for the future. This observation is now well accepted. Both of these engines use external combustion have multifuel capability. Only one of these

engines can win the race against the Internal Combusion Engines. It is too early to make the final selection. We are entering an era very similar to the one at the turn of the century which was earmaked by competition between the Spark Ignition Engine, the Steam Rankine and Electric Propulsion System (Reference 4). Since that time, many well-known companies have gone out of the automotive business. It is expected that technological breakthroughs will generate new companies and most likely obsolete some of the existing leaders. Government incentives can play a major role in accelerating the introduction and market penetration process. The Defense Department has been a very good customer for aircraft engines. The Federal Government can likewise be an excellent customer for high-performance automobiles. Thus, government purchasing policies can provide very good incentives. Premature regulation can produce a negative impact. Regulations, therefore, should be used only as a last resort.

PROGRAM OBJECTIVES

Personal (public) transportation must have liquid fuel for 40–50 years. (Electric vehicles will also help, but are again only part of a solution.)

Personal transportation must use as little fuel (measured in total Btus) as possible. (Oil, coal-derived, hydrogen, etc.)

Personal transportation must have the lowest practical pollution emission levels.

Personal transportation must be safe.

These four major objectives require continuing, high-level, federal R&D support.

E. Systems Analysis: Continuing dedicated effort to understand efficient use of energy from basic fuel to drive wheels of vehicles. (Efficiency gains in propulsion can be lost in fuel modification or drive trains of other areas.) Must concentrate on obtaining least Btus/mile.

COST

Rough estimates indicate annual funding of $140–$150/year is necessary through 1985. Past 1985, levels of $120–$150M are needed. When the technologies are mature, universities fully involved, and alternative fuels understood, it is likely the level could become $50–$75M. It would not go to zero until the U.S. no longer requires personal surface transportation.

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1. Sternlicht, Dr. B., "Which Automotive Engines in the Future?", ASME 74–DGP–16.

2. Richardson, R. W., Easton Corporation, "Automotive Engines for the 1980s," Abstracted Automotive Engineering, October, 1973.

3. "Should We Have a New Engine?", JPL Report SP 43–17, Volumes I and II.

4. "History and Future of Spark Ignition Engines," prepared for Senator E. S. Muskie by Congressional Research Service, September, 1973, No. 94–10.

Senator STEVENSON. Thank you, Dr. Sternlicht.

The next witness is William Beckham, Deputy Secretary of the Department of Transportation.

Senator STEVENSON. I apologize for keeping you waiting, Mr. Secretary. If you would like to summarize, or if you would like to read the whole statement.

STATEMENT OF WILLIAM BECKHAM, DEPUTY SECRETARY, DEPARTMENT OF TRANSPORTATION; ACCOMPANIED BY HOWARD DUGOFF, ADMINISTRATOR, RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION

Mr. BECKHAM. Thank you, Mr. Chairman. I apologize for being a little late this morning. With me is Howard Dugoff, who is Administrator of the Department's Research and Special Projects Administration.

I will just go through the statement in a kind of summary form and then answer any questions.

Title III of the Transportation Energy Efficiency Act of 1979, as originally proposed by the administration, dealt with the necessary authorization to carry out a cooperative basic automotive research program. This legislation was contingent upon the establishment of

the Energy Security Trust Fund and since this feature did not become law we no longer seek this legislation. The existing legislative authorities of the participating agencies are sufficient to conduct the program, and we will request the necessary funding through the appropriations process.

We in the Department have expended substantial effort on the development of this major new program of basic research related to automotive technology. On May 18, 1979, President Carter met with the leaders of the American automobile industry at the White House. There was agreement on a set of guiding principles for a cooperative program, and the decision was made to enter into further discussions aimed at defining a formal agreement between industry and Government.

The Department of Transportation is identified as the lead Federal agency with responsibility for coordinating the efforts of the Federal participants and for serving as a central point of contact for the program. This responsibility has been actively sought by the Department and is one we take seriously and intend to satisfy fully. The other participant in fiscal year 1981 will be the National Science Foundation.

The planning staff includes representatives from the National Science Foundation, the Departments of Energy and Transportation, and the Office of Science and Technology Policy. In addition, our Transportation Systems Center has been an active member and the major technical and staff resource for several of the activities of the planning staff.

The planning staff developed information on a number of important issues which influenced and shaped the discussion between the industry and the Government and the nature of the organization proposed for the Government share of the program. Issues include the institutional alternatives for the program within the Federal agencies, the capacity of the Nation's research establishment to respond to this new initiative, and the need for new specialized research facilities. All of these issues have been answered positively and have encouraged us to proceed with this new undertaking.

The research activities of each agency contacted had to be screened and judgments made concerning the relationship of particular projects to automotive technology and to distinguish between basic and applied research. By this process, some $35 million in Federal research in fiscal year 1979 in six different agencies was identified and cataloged in the inventory.

The technical framework will be the most important of the programmatic guidance documents produced for CARP. It will, one, define the goals of the research areas established in the agreement with industry and identify potential research topics; two, serve as a guide to CARP program managers as they prepare to define research projects; and, three, be widely circulated to help research scientists and engineers begin to prepare proposals to CARP participants.

The process to establish the technical framework involves the active participation of the research community through working groups formed in the nine areas in which we are now developing research topics. Approximately 100 leading researchers from both the public and private sectors are currently involved in this proc-

ess. The deliberations of these working groups should be completed during the next few weeks.

Some of these groups have already submitted their findings to the planning staff. The reports are being reviewed by the planning staff according to the criteria of the program and made available as an intermediate product of the process. The reports of the aerodynamics, controls, and combustion groups, which we will submit for the record, provide examples of the type of research to be included in the program.

Because the Department has virtually no prior experience in the management of a program of basic research, Secretary Goldschmidt requested Dr. Press, director, Office of Science and Technology Policy, to convene a panel of technical experts to advise him on appropriate procedures to carry out an extramural program of basic automotive research. This panel, chaired by Dr. H. Guyford Stever, was composed of recognized scientific experts representing the academic and industrial research community.

The panel made substantive and sensible recommendations concerning the management of CARP and, in addition, addressed the broader questions of R. & D. management and scientific and technical decisionmaking in the DOT. These recommendations were reviewed by Dr. Press, who provided additional comments to the Secretary regarding the potential alternatives for management of R. & D. in the Department.

The Department generally endorses the thrust of the panel's report, both as it applies to the auto research program and to the Department overall. The need clearly exists for improvement in the organization and management of DOT's research and development activities, and in our general procedures for dealing with scientific and technical issues.

Secretary Goldschmidt agrees with the panel's view that an improvement is needed in the capacity within the Office of the Secretary for providing scientific and technological advice on matters related to research and development programing, the technical aspects of regulatory proposals, liaison with scientific and technological functions at the secretarial level.

To meet these defined needs, we have initiated a comprehensive review and analysis of the Department's organizational structure for research and development and a set of alternative approaches is being developed. It is our intention and commitment to develop an extramural basic research program that will earn the respect and recognition of the scientific community and others who have entrusted this responsibility to the Department. We do not underestimate the task.

I would like to personally endorse the panel's recommendation regarding the need for strengthening the expertise of the Office of the Secretary in the general area of science and technology. This recommendation is completely consistent with my experience as to the highly technical nature of many of the most critical issues facing the Department. I am announcing here our intention to appoint a senior adviser to the Secretary for matters of science and technology as expeditiously as possible.

Our research efforts are aimed at different time scales. It is not necessary to detail the relationship of our domestic auto industry

to the economic fiber of the Nation. In fact, it would be difficult to overdramatize the influence the auto industry exerts on the economic course of the Nation.

It was precisely in recognition of these far-reaching relationships that Congress, as part of the Chrysler legislation, directed the Department of Transportation to examine the future of the auto industry. Specifically, under the terms of the Chrysler Loan Guarantee Act of 1979, Secretary Goldschmidt is required to make an assessment of the impact of likely energy trends and events on the auto industry. The Secretary is required to include information on long-term capital requirements, rates of technological change, shifting market characteristics, and the capability of the industry as a whole to respond to the requirements of the 1980's. This study, which is due in January 1981, is to be followed by annual reports on the state of the auto industry and its interaction with the economy.

This administration study will examine the auto industry and the broad industrial network which touches and is touched by that industry. Our task is to describe choices to assure the future health of those industries and the means to reinvigorate an American industrial base that has reached the cycle of maturity.

It will require a restructuring of the industrial base if we are to answer the long-range questions about mobility in America and the role of the auto beyond the year 2000, and if we are to emerge from this period of change secure in our role in the world and the world's economy. The cooperative approach evidenced in CARP is an initial effort to help restore the American automotive industry to a position of undisputed leadership worldwide. Cooperation rather than confrontation will be the hallmark of our approach toward basic research in the automotive technologies.

Let me conclude by summarizing the Department's position. The cooperative automotive research program is a long-range program. The implications for the Nation's personal transportation system and the economic viability of the industry which supports it are clear. This program must be part of a balanced effort to provide for future mobility consistent with the Nation's economic, energy, environmental, and social goals. As the mission agency charged with the responsibility for transportation, we accept the challenge of providing the necessary Government leadership and support for the research required to assure adequate mobility in the future.

This completes my statement. We are prepared to answer any questions the committee may have. Thank you.

Senator STEVENSON. Thank you, Mr. Secretary.

You say the reports of the aerodynamics, controls, and combustion groups are staffed?

Mr. BECKHAM. No. I say they will be.

Senator STEVENSON. We would appreciate having those reports when they're available.

Now, you acknowledge, in your statement that, "The Department has virtually no prior experience in the management of a program of basic research."

Why should we repose this authority or funding in a Department with no prior experience, instead of an agency with such experi-

ence, including experience in transportation research, such as NASA?

Mr. BECKHAM. Well, first of all, we acknowledge our lack of experience, but we also recognize our obligation in the field of transportation to begin to develop that expertise.

We recognize NASA has a history in this area, but it is our opinion that if we develop within the area of transportation the ability to do basic research not just in the automobile industry, but in all other modes of transportation where there might be a similar application of that research. We must also develop the ability to make trade-offs, if in fact it is determined that, based upon the set of analyses and our involvement in transportation, that it is more prudent for the Nation in its long-term interest to, in fact, do basic research in another mode of transportation, be it air, marine, or auto. We are able to make those trade-offs in the Department of Transportation and reflect the long-term national interest through our basic research approach.

And we think the Department of Transportation, regardless of where else it might be, ought to have the capacity to perform basic research to relate the results of that basic research to our ongoing program so as to make judgment trade-offs as to how we should apply our research.

Senator STEVENSON. Is that the purpose of CARP: to develop and implement a capability within the Department of Transportation for basic research in all modes of transportation?

Mr. BECKHAM. No. We look upon CARP as an opportunity to, first of all, get ourselves in a position to begin to be experienced and respected in the area, but then to use that as a model to do what we think should be done beyond just automotive research in the transportation field.

So, it is not the sole purpose of CARP, but it is clearly an opportunity and one we think that we ought not miss to develop the broader capability.

Senator STEVENSON. You mentioned aeronautics. Is it the Department's intention, then, to get involved in basic research for aeronautics?

Mr. BECKHAM. Not in that sense. I would be thinking more in terms of our Federal Aviation Administration responsibility that relates to safety and other kinds of technology used in our air safety mission. Our mission as a Federal agency is not in aerodynamics as much as it is safety in the air, so we would not get into that.

Senator STEVENSON. Well, then, I misunderstood you earlier. I had understood you to say that you wanted to develop the capability of basic research in all modes. Now you are suggesting that it would be confined to safety with respect to certain modes?

Mr. BECKHAM. I would not think we would want to get into an area such as that currently pursued by NASA. Mr. Dugoff might want to be more specific.

Mr. DUGOFF. Well, Mr. Chairman, as I think you were suggesting in discussions earlier with Dr. Sternlicht, the substantive character of the subject matter that would be pursued under the current CARP program is of an extremely general aspect, and much of the

work product, if not all, would indeed be applicable to other transportation sectors.

We don't see this program as a substitution for other ongoing research activities. It's really an augmentation. We have identified particular applications in which the Federal Government is not supporting basic research. That's the application. By all means, the research which NASA has developed in connection with the air transportation industry is an example to be emulated, and it's just not appropriate or necessary for us to do anything extra in that field.

On the other hand, there certainly are common research subjects.

Senator STEVENSON. You have heard Dr. Sternlicht's comments about the need for applied research. Do you want to respond to those comments?

Mr. DUGOFF. Yes, Mr. Chairman. As I understood Dr. Sternlicht's thesis, it was to suggest that the Nation needs to undertake a far more substantial effort in applied research and development in order to enhance our position vis-a-vis the foreign competitors who are doing us in so badly in the marketplace.

That view is not consonant with our understanding of what the problem really is. It is our judgment that the reason why the Japanese automobile industry is succeeding so admirably in the United States is not that it is privy to more advanced technology than we can provide in the United States, but rather that it has made a commitment to the application of very well-known technology at an earlier point in time and faces the present market with a manufacturing basis that matches the market. The U.S. auto industry is unfortunately in a position of holding a manufacturing capability to a market that has passed them by.

Mr. Beckham has just finished testifying before Senator Jackson's subcommitttee on the Department's views as to the very real organic troubles the automobile industry faces. And if I can go over and simplify, we see it not as a technology problem, but rather as an economic problem, a problem of generating and mobilizing the capital necessary to transform the industrial plant of the U.S. manufacturers so they can produce the kind of cars that technology will enable them to produce.

We testified in the previous hearing that fuel economies in the range of 40–50 miles per gallon are entirely within reach, given a well-established, existing technology. But in order to achieve those, it will require vast and potentially devastating economic actions. And that's what the real problem is.

Senator STEVENSON. Thank you.

Senator Schmitt.

Senator SCHMITT. So it's a local problem and not a research problem. Is that what you're saying?

Mr. DUGOFF. Yes. We think the technology is there to in fact meet the requirements of the marketplace. It is the capital and times that are causing the problem.

Senator SCHMITT. Why do you think that others disagree with you? Do they have a vested interest, or are they after Federal dollars to do more research just for the sake of research—more

applied research for the sake of applied research? New technology just for the sake of new technology?

Mr. DUGOFF. I don't think we're suggesting there is not a need for more research, but what we are suggesting is: Given what we can see in the present in terms of the problem, the technology is there. We think, in terms of looking 10 to 20 years down the road, we ought not rest on what we know now; that we think clearly there is a need to, in fact, build on the present technology and be prepared for a future that we think will require a substantially enlarged commitment toward energy conservation, productivity, and efficiency.

Senator SCHMITT. There is an inherent theoretical advantage to external combustion versus internal combustion. There are many new, innovative alternatives, some of them already developed, for energy transfer systems, once you have a maximum propulsion system.

Now, those external combustion technologies are not present. They're not developed to the point where they can be put in automobiles. Isn't that something that needs to be developed?

Mr. DUGOFF. Yes. We think that kind of research is appropriate. That's why we made the point that there are certain technologies available now.

Senator SCHMITT. But then you would advocate the technology base that's already here and retool while we come along with new technology that will require another retooling.

Mr. DUGOFF. I think we almost have to do something now. I think we're being driven. If the Government were not involved at all, I think the marketplace is driving the private enterprise to do something anyway. They're going to retool and respond to the best of their ability based on the resources, regardless of what the Government does at this point, given the market realities.

Senator SCHMITT. You think they're going to retool in the pattern of the past?

Mr. DUGOFF. Well, for those who hope to remain in business, the prudent man in the auto industry is going to retool and respond to the competition internationally and in the domestic marketplace, planning fuel-efficient cars, and safe ones.

Senator SCHMITT. Does that mean they're going to automate manufacturing technology?

Mr. DUGOFF. I think they're doing some of it. At this point, we don't see total automation but we do see it growing.

Senator SCHMITT. You think you're going to see them automate to the level technology permits?

Mr. BECKHAM. I might ask Mr. Dugoff to speculate on that.

Mr. DUGOFF. Well, I think they are highly motivated to do so. I think, generally, yes, I would answer in the affirmative.

Senator SCHMITT. Are the United Auto Workers motivated to do so?

Mr. DUGOFF. United Auto Workers are facing a very serious issue. As I understand it, they recognize that unless something is done in Detroit to make U.S. manufacturing become more competitive, the U.S. auto manufacturing industry is going to be hurt or tend to be hurt and suffer vis-a-vis its foreign competition. And I am of the impression that the union takes a quite progressive view

of understanding the need to make perhaps some short-term concessions to assure that the companies that provide their long-term security will be competitive.

Could I perhaps elaborate a bit in connection with the question you asked a moment ago concerning the nature of retooling for the 1980's? As best we can judge, the major improvements in efficiency that are achieveable in that decade will come from weight reduction associated with strong, light-weight materials, but significant combinations of improvements in the efficiency of the spark-ignition engine, but especially application of electronic control to the spark improvement of the engine and into a variety of other smaller improvements associated with the lubricants, reducing inefficiency, and accessories. An aggregation of this set of improvements plus one other big one, which is somewhat questionable because of concern over unresolved concerns over health effects; namely, widespread application of the diesel likely in combination with supercharging, will bring us to a fuel efficiency on an average, in the main, of 40 to 50 miles per gallon.

This suggests that the new powerplants, new propulsion systems, particularly external systems, such as you were suggesting, we would be looking for applications perhaps in the 1990's decade, a challenge to demonstrate that they can beat the conventional spark ignition, and particularly the diesel engine, on economic terms.

And in my judgment, the ongoing programs that the Federal Government is sponsoring through the Department of Energy in support of R. & D., in connection with Stirling and the gas turbine engine are appropriate Federal initiatives in support of more advanced technology.

Senator SCHMITT. Isn't that all a self-fulfilling prophecy, assuming the administration program and therefore this is all you can do?

You're talking about taking 15 years to develop a new propulsion system. My goodness gracious, this country has done better than that. We have developed new rocket propulsion systems in a few years. They are as complex and certainly involve more energy, than anything we're talking about here.

Mr. DUGOFF. I certainly acknowledge the validity of the Senator's argument on the part of the administration, that there does not exist a technology sufficiently promising compared to——

Senator SCHMITT. At a price you're willing to pay.

Mr. DUGOFF. At a price we're willing to pay.

Senator SCHMITT. Or an effort you're willing to make or an organizational restructure you're willing to make, or a combination of the two.

Mr. DUGOFF. I don't think the list of considerations has affected it.

Senator SCHMITT. Of course, the administration has sent us an innovation policy without any tax policy. We're immediately constrained in what it's possible to accomplish. Why should we—you, I understand propose that the Department of Transportation take over the management of the various research efforts in transportation technology? Why in the world would we want to do that with the Department of Transportation?

Mr. DUGOFF. We made no such proposal. The proposal that we have been discussing is an extremely limited one. It is to vest in DOT the responsibility of coordinating a new program in basic research, a very small program which would not——

Senator SCHMITT. What do you know about basic research in DOT?

Mr. DUGOFF. We know very little. And one of the principal considerations in the Department's perspective here is the conviction that it's wrong for an agency like DOT not to have competence in basic research, and we are very anxious to build such competence.

Senator SCHMITT. I heard people in the Department say that in 1974, and the man that said it eventually left and took over the Caltech engineering department. There is a very difficult inertia in DOT and to my knowledge, it hasn't changed since 1974. There just isn't the base of people.

Mr. DUGOFF. In 1974, the Deputy Secretary would never have come to a hearing like this to evidence the Department's degree of commitment to this new initiative.

Senator SCHMITT. That's why he left. They wouldn't let him.

Mr. DUGOFF. I think Secretary Goldschmidt has a very strong spirit of developing the capacity in the Office of the Secretary and throughout the Department for a basic research program.

You're right about the inertia. That does not mitigate the fact that we cannot now, based on the administration's commitment, based on the Department's commitment and the Secretary's commitment, in fact turn it around. We think the Department has to have that basic research.

We think the problems in transportation—not just the automobile industry but all the other modes—dictate that the Department get into basic research, and that is the commitment we are willing to make and to bring on board the necessary talents and structure, the institution in the Department to—as Secretary Goldschmidt said, a structure that will survive him, me, and any other Secretaries.

When he goes, I go, and the next Secretary goes, the commitments and the programs of basic research are not terminated and we go on to something different, and it's a question of how you structure it at the front end and what the commitment is and how you institutionalize it, and, quite frankly, what cooperation we have between the industries affected, be it the auto industry, bus, be it train, et cetera, in that effort.

And at this point on CARP, we think the auto industry is cooperating with us and we think we've got a relationship to build on that will allow this program to succeed.

Senator SCHMITT. Well, I don't think there's much confidence out there that the Department of Transportation knows how to manage basic research, applied research, or any other type of research, except perhaps some mobile analysis research, which they have done fairly well.

Mr. BECKHAM. I guess our challenge is to disprove that concern.

Senator SCHMITT. Why should we go through that exercise of proving or disproving it when we already know what kind of structures work in these kinds of areas? We know those structures don't

exist in the Department of Transportation. We could transfer them all to DOT, but then you have done exactly what we hope we have learned not to do with the dissolution of the Atomic Energy Commission, which that is to combine research with regulation in the same Department.

We didn't learn that lesson. We created the Department of Energy, in which clearly basic research takes a back seat to regulation. And in the Department of Transportation, won't they take a back seat there, as well?

Mr. DUGOFF. Senator Schmitt, we now have an unprecedented situation of a Secretary who seeks to alter that situation.

Senator SCHMITT. But name me one example in the history of the U.S. Government where regulatory responsibility and basic research have coexisted and prospered? You can't.

Mr. DUGOFF. The only prosperous programs of the basic research that come to my mind in the Federal Government generally are those sponsored by the National Science Foundation.

Senator SCHMITT. But they're not a regulatory agency.

Mr. DUGOFF. That's correct.

Senator SCHMITT. We had it in the AEC and we found that it just wasn't working, so what we did, has to create ERDA and the NRC and it started to work. So what did we do? We put a lot of those responsibilities back together again in the Department of Energy, and again it's not working.

Basic research and applied research in the Department of Energy is a shambles, because management attention is largely occupied with the regulatory responsibilities of that agency. And I don't see how Secretary Goldschmidt, no matter what his motivations are, is going to be diverted away from your ultimate goal into worrying about how to regulate the transportation industry. That's my concern. It has nothing to do with your motivation. It has to do with the realities of the bureaucracy, the way it works.

Thank you.

Senator STEVENSON. Well, I have some difficulty, thinking that NASA, for example, would have been as effective a research development organization if its responsibilities had been diffused throughout a large Department of Transportation. Therefore, again, I wonder whether this large effort which could go well beyond automotive research, if it were applied, shouldn't be organized along similar lines with a clear mission and perhaps much stronger appeal to the kind of qualified people required.

And if it was a secondary mission of the Department of Transportation, an agency with no prior experience in basic research, I ask the same question. I find that a very troubling position.

Conversely, it troubles me to think we might be proliferating the capability for basic or applied research instead of centralizing it in order to facilitate the kind of intermodal efforts which we all have recognized are possible and desirable.

Any further questions?

Thank you very much.

[The statement follows:]

STATEMENT OF WILLIAM BECKHAM, DEPUTY SECRETARY, DEPARTMENT OF TRANSPORTATION

Mr. Chairman and Members of the Subcommittee, I am pleased to appear before this subcommittee today to discuss the proposed Cooperative Automotive Research Program (CARP) and strongly request your support for the continuation of this effort. I am accompanied by Howard Dugoff, the Administrator of the Department's Research and Special Programs Administration.

Title III of the Transportation Energy Efficiency Act of 1979, as originally proposed by the Administration, dealt with the necessary authorization to carry out a cooperative basic automotive research program. This legislation was contingent upon the establishment of the Energy Security Trust Fund and since this feature did not become law we no longer seek this legislation. The existing legislative authorities of the participating agencies are sufficient to conduct the program and we will request the necessary funding through the appropriations process.

We in the Department of Transportation have expended substantial effort on the development of this major new program of basic research related to automotive technology. As you may recall, former Secretary Adams first urged the automobile industry to join with the Government in a mutually-supported program of research in December 1978. The auto industry responded constructively to this challenge and on May 18, 1979, President Carter met with the leaders of the American automobile industry at the White House. There was agreement on a set of guiding principles for a cooperative program and the decision was made to enter into further discussions aimed at defining a formal agreement between industry and Government.

Continuing discussions have been carried on by the Office of Science and Technology Policy and the Department of Transportation for the Government and the five domestic automobile manufacturers. These discussions have proven fruitful. A detailed administrative framework which documents the terms of agreement is essentially complete and awaiting formal endorsement by the participants.

The Department of Transportation is identified as the lead Federal agency with responsibility for coordinating the efforts of the Federal participants and serving as a central point of contact for the program. This responsibility has been actively sought by the Department and is one we take seriously and intend to satisfy fully. The other participant in fiscal year 1981 will be the National Science Foundation.

Preliminary planning for the cooperative program has been the responsibility of an Interagency Planning Staff under the direction of Mr. Dugoff. The Planning Staff includes representatives from the National Science Foundation, the Departments of Energy and Transportation, and the Office of Science and Technology Policy. In addition, our Transportation Systems Center has been an active member and the major technical and staff resource for several of the activities of the Planning Staff.

The Planning Staff developed information on a number of important issues which influenced and shaped the discussion between the industry and the Government and the nature of the organization proposed for the Government share of the program. Issues such as the institutional alternatives for the program within the Federal agencies, the capacity of the nation's research establishment to respond to this new initiative, and the need for new specialized research facilities. All of these issues have been answered positively and have encouraged us to proceed with this new undertaking.

In addition, the Planning Staff, on behalf of the Government, undertook the development of an Inventory of Government-supported Basic Research Related to Automotive Technology. This inventory was required both to identify the relevant on-going Government research and to effectively define the research areas and thrusts of the program. This proved to be a difficult and time consuming effort. The research activities of each agency contacted had to be screened and judgments made concerning the relationship of particular projects to automotive technology and to distinguish between basic and applied research. By this process some $35 million in Federal research in fiscal year 1979 in six different agencies was identified and cataloged in the inventory.

The activities of the Planning Staff are now focused on the development of the technical framework of the program. The technical framework will be the most important of the programmatic guidance documents produced for CARP. It will: (1) define the goals of the research areas established in the agreement with industry and identify potential research topics, (2) serve as a guide to CARP Program Managers as they prepare to define research projects, and (3) be widely circulated to help research scientists and engineers begin to prepare proposals to CARP participants.

The research areas of the program are: Combustion, thermal and fluid sciences; Structural mechanics; Electrochemistry; Aerodynamics; Materials science and proc-

essing; Control systems; Tribology; Acoustics and vibration; Surface science and catalysis; Environmental science; Biomedical science; and Behavioral science.

The process to establish the technical framework involves the active participtation of the research community through Working Groups formed in the nine areas in which we are now developing research topics. The Working Groups are composed of respected researchers in the field under the direction of a leader approved by both the Government and industry participants. Approximately 100 leading researchers from both the public and private sectors are currently involved in this process. The deliberations of these Working Groups should be completed during the next few weeks.

Some of the groups have already submitted their findings to the Planning Staff. The reports are being reviewed by the Planning Staff according to the criteria of the program and made available as an intermediate product of the process. The reports of the Aerodynamics, Controls, and Combustion groups which have been made available to your staff provide examples of the type of research to be included in the program. Their recommendations include: research to understand the fluid mechanic of three-dimensional bluff bodies, research on multivariable control systems with widely varying time constraints, and research to understand time-varying turbulent reacting flows.

Because the Department has virtually no prior experience in the management of a program of basic research, Secretary Goldschmidt requested Dr. Press, Director, Office of Science and Technology Policy, to convene a panel of technical experts to advise him on appropriate procedures to carry out an extramural program of basic automotive research. This panel chaired by Dr. H. Guyford Sever, was composed of recognized scientific experts representing the academic and industrial research community.

The panel made substantive and sensible recommendations concerning the management of CARP but, in addition, addressed the broader questions of R&D management and scientific and technical decision-making in the DOT. These recommendations were reviewed by Dr. Press, who who provided additional comments to the Secretary regarding the potential alternatives for management of R&D in the Department.

The Department generally endorses the thrust of the panel's report both as it applies to the auto research program and to the Department overall. The need clearly exists for improvement in the organization and management of DOT's research and development activities, and in our general procedures for dealing with scientific and technical issues.

Secretary Goldschmidt agrees with the panel's view that an improvement is needed in the capacity within the Office of the Secretary for providing scientific and technological advice on matters related to research and development programming, the technical aspects of regulatory proposals, liaison with scientific and technological functions at the Secretarial level.

To meet these defined needs, we have initiated a comprehensive review and analysis of the Department's organizational structure for research and development and a set of alternative approaches is being developed. It is our intention and commitment to develop an extramural basic research program that will earn the respect and recognition of the scientific community and others who have entrusted this responsibility to the Department. We do not underestimate the task.

I would like to personally endorse the panel's recommendation regarding the need for strengthening the expertise of the Office of the Secretary in the general area of science and technology. This recommendation is completely consistent with my experience as to the highly technical nature of many of the most critical issues facing the Department. I am announcing here our intention to appoint a senior advisor to the Secretary for matters of science and technology as expeditiously as possible.

I would like to make a few comments concerning the substantial difference between the cooperative automotive research program and ongoing DOT automotive R&D activities which support regulatory decisionmaking. The cooperative automotive research program is intended to increase or enhance the fundamental scientific knowledge underpinning automotive technology. It provides for no explicit linkage to its ultimate application in the product.

The ongoing program, by contrast, assesses and evaluates existing and emerging technology in order to determine if it is possible to design and produce vehicles which are more socially desirable (more fuel efficient, safer, cleaner, etc.) than the present marketplace provides. This activity is not directed toward the creation of new technology, but rather tries to understand the implications of available technology on the design of new vehicles.

The programs are aimed at different time scales. The regulatory support activity is concerned with product improvements which can be introduced into the product stream within the next 5 to 10 years. The cooperative automotive research program is intended to fund the basic research required to make possible the development of even better vehicles in the longer range future—beyond ten years.

It is not necessary to detail the relationship of our domestic auto industry to the economic fiber of the Nation. In fact, it would be difficult to overdramatize the influence the auto industry exerts on the economic course of the Nation.

It was precisely in recognition of these far-reaching relationships that the Congress, as part of the Chrysler legislation, directed the Department of Transportation to examine the future of the auto industry. Specifically, under the terms of the Chrysler Loan Guarantee Act of 1979, Secretary Goldschmidt is required to make an assessment of the impact of likely energy trends and events on the auto industry. The Secretary is required to include information on long-term capital requirements, rates of technological change, shifting market characteristics, and the capability of the industry as a whole to respond to the requirements of the 1980's. The study, which is due in January, 1981, is to be followed by annual reports on the state of the auto industry and its interaction with the economy.

In addition, we received direction from the White House Domestic Policy office to examine this set of issues of its broadest context—looking at issues of the industrial base, trade, productivity, employment and more—to develop policy choices for the government which could assure the future health of the auto industry and our manufacturing base and to report back within roughly the same time period.

This Administration study will examine the auto industry and the broad industrial network which touches and is touched by that industry. Our task is to describe choices to assure the future health of those industries and the means to reinvigorate an American industrial base that has reached the cycle of maturity.

In this effort we have the assistance and cooperation of the appropriate federal agencies whose work bears directly on these issues. These include the Departments of Treasury, Commerce, Labor, Energy, Justice and Interior, the Council of Economic Advisors, the Council on Wage and Price Stability, the Environmental Protection Agency, the Special Trade Representative, and the Office of Science and Technology Policy. Moreover, as we work, we will seek the views of our private partners in enterprise—industry, labor, consumers, environmentalists—all those who share the serious concern over the economic future of this country. We believe this effort can begin to define a new era of public-private cooperation.

It will require a re-structuring of this relationship if we are to answer the long-range questions about mobility in America and the role of the auto beyond the year 2000, and if we are to emerge from this period of change secure in our role in the world and the world's economy. The cooperative approach evidenced in CARP is an initial effort to help restore the American automotive industry to a position of leadership worldwide. Cooperation rather than confrontation will be the hallmark of our approach toward basic research in the automotive technologies.

Let me conclude by summarizing the Department's position. The cooperative automotive research program is a long range program, the implications of the Nation's personal transportation system and the economic viability of the industry which supports it are clear. This program must be part of a balanced effort to provide for future mobility consistent with the Nation's economic, energy, environmental and social goals. As the mission agency charged with the responsibility for transportation, we accept the challenge of providing the necessary government leadership and support for the research required to assure adequate mobility in the future.

This completes my statement. We are prepared to answer any questions the Committee may have. Thank you.

Senator STEVENSON. I invite our next witnesses, Brian Ketcham, vice president and chief engineer, Citizens for Clean Air, Inc., and Robert Showalter, president, Automotive Engineering Associates. Mr. Ketcham.

STATEMENTS OF BRIAN KETCHAM, VICE PRESIDENT AND CHIEF ENGINEER, CITIZENS FOR CLEAN AIR, INC.; ACCOMPANIED BY STEPHEN WILDER; AND ROBERT SHOWALTER, PRESIDENT, AUTOMOTIVE ENGINEERING ASSOCIATES

Mr. KETCHAM. Thank you, Mr. Chairman and Senator Schmitt.

With me today are Stephen Wilder and Mr. Robert Showalter, from Automotive Engineering Associates. I am vice president and chief engineer of Citizens for Clean Air, which is a nonprofit public interest organization that specializes in issues related to transportation and air quality.

I think it's important to summarize our expertise in this area. I have had 20 years of experience in automotive engineering, in engineering alternative power systems for passenger cars, and in transportation planning on a regional and national level.

Mr. Wilder has some 30 years of experience in automotive work, including research, design, assembly and marketing. Mr. Wilder is also chairman of the New York City Group of the Sierra Club.

The American auto industry today is in serious trouble. It is suffering from the consequences of both a recession and poor corporate judgment. Indeed, the current recession is partly a result of the auto industry's unwillingness to face a world that is rapidly changing in character. Gone are the days of cheap energy. We no longer have the fiscal resources to pay the real costs of our dependence on autos. The age of limitless personal mobility is ending—and will do so tragically unless we act now.

The auto industry has operated for decades on the premise that there is no alternative to automobiles: That mobility based on this one mode of transport is practical; that some form of liquid hydrocarbon fuel will always be available at a reasonable cost; that there are no desirable alternatives to the auto-dependent sprawls that crisscross the country; that car sales measure the health of our economy; and that people will always have enough money to support their own personal mobility but that motorists will never have to pay for all the costs that they impose on society.

These assumptions are no longer valid. Automakers who continue to pursue policies rooted in the past do so at great risk. Unfortunately, this problem is not being addressed by Government or by industry, and this committee's proposals to establish a Federal program financing basic research that supports automotive technology will not truly help automakers—not now and not 10 years from now.

Technical innovation is not the issue. We already know plenty about the physical sciences that automakers can use to make their products more competitive. What is missing is the motivation to apply this information effectively. Corporations today are so obsessed with earning short-term profits that, coupled with the high cost of capital financing and with the magnitude of their existing investments, they are paralyzed by the prospect of risk. And since innovation entails risk-taking, there is precious little of it to be found in America's automobile industry today.

We oppose your proposal to establish a program of automotive technology development because we do not believe it will help the industry, particularly at this time of crisis. We oppose it because it ignores critical social and economic issues that are at the heart of the industry's problems.

There is one ray of governmental enlightenment in this dilemma. It is in a just released report by the Department of Transportation entitled "Draft Transportation Agenda for the 1980's." I'd like to quote from that document:

We are entering a period of far-reaching change. The assumption that the future is going to be a continuation of the past is invalid. Large national economic problems will change radically over the next several years and will provide a very different context for transportation policy.

Existing transportation planning is based upon assumptions about our economic viability, resource availability, population distribution and behavior that are unlikely to remain valid over the next decade.

We can no longer afford to base our planning processes solely on the extrapolation of trends. That practice reinforces existing trends, promotes self-fulfilling prophecies of conditions no longer deemed desirable. Rather, government needs to be more aggressive in predicting some basis of change; postulating alternative scenarios; and developing convictions about where policy decisions ought to be leading us. In other words, design a better future and determine the logic switches and routes to get there.

Seven years ago OPEC nations sent us the first of several messages. It was not heeded. As a result, today more than a quarter of the work force in the auto industry has been laid off and Chrysler is battling bankruptcy. On a broader scale, every citizen is burdened by the resulting costs of unemployment, welfare, food stamps, and programs like the one you are considering.

The one bright spot is this committee. Five years ago you set fuel economy standards despite the industry's protests. If you hadn't, the industry and the Nation would be in a lot worse shape than they are in now. Congress displayed a sense of vision then and it should do so again.

The need to consider the larger picture was one of the unheeded conclusions reached at last year's conference at MIT on basic research directions for advanced automotive technology. Many of the ideas reflected in the legislation before us today were launched at that meeting. Although there was an overall capitulation to the myth of ongoing personal automobility, the conference's participants did state that there is a need to assess the social, economic and political components of the Nation's automotive problems and the tradeoffs in these areas that any basic research program would create.

But these bills ignore the problems of a society grown embarrassingly dependent on automobiles and trucks. Americans already drive more than 150 million autos and trucks, more than one vehicle for every licensed driver.

In recent decades, highways and parking lots have come to determine the shape of our cities and towns, the places where people live, how they commute, where they will work, while subways and railroads have atrophied.

More than 200 communities have abandoned public transit. Hundreds of other neighborhoods have been ruined by unwanted roads. Tailpipe exhaust causes most of our urban air pollution and the manufacture of vehicles and the materials they're made of contribute much of the rest.

Traffic accidents kill more people under 35 than any disease and, of course, the mileage we drive costs us all the oil we import.

Last year, the cash bill for our automotive mobility was about $400 billion—that's for cars, parts, fuel, maintenance, highways and the movement of freight by truck—these are direct, out-of-pocket user payments.

Another $100 billion should be added to represent the societal costs of auto-induced pollution, congestion, accidents, lost wages,

medical expenses, and existing subsidies—costs borne by nonusers as well as motorists.

Before you channel large sums of money into basic automotive research programs, Government must begin to consider these factors in its planning. We heard Mr. Philip Smith this morning admit this fact.

We must know where we are going. The status quo is no longer enough. For a start, we must question the value of our addiction to automobiles and trucks as the primary means of transportation in an increasingly resource-scarce world.

Before Congress acts to prop up the American automobile industry, we must organize to answer the questions we have raised today regarding the future of the industry and its role in America's economy. Should we continue to use auto sales as the barometer of the Nation's economic health? Or does the pursuit of sales aggravate a dependency which is really part of the cause of our economic sickness?

Should we be trying to bootstrap an industry by pumping dollars into its technology, or should we first examine the industry itself and its impact on society?

Is preserving the auto industry as we know it the real point of these hearings? Shouldn't we really be exploring how Americans can enjoy a quality lifestyle that does not depend on the universal use of automobiles?

We must look at what we will do in future years when resources and economic constraints force us to change our lifestyles and goals. As DOT's transportation agenda suggests, we must develop alternative ways of looking at how and where we live, the economy, and the role of transportation in satisfying human needs.

For example, if we can reduce travel by 25 percent, we can reduce oil imports by 2 million barrels a day. We must look beyond auto dependence. Perhaps DOT can do this by adopting a more liberal approach to the policy analyses suggested in its agenda for the 1980's.

But our own experience suggests that biases inherent in DOT and external pressures from the transportation industry will prohibit meaningful, timely results.

What is needed is a permanent research institute, independent of short-term political and corporate pressures, that can focus on the forces changing this Nation, many of which have been largely ignored in transportation policy circles.

Such an organization would be free to investigate the social, economic, environmental, and institutional factors affecting the future of the auto industry and present these facts with a range of possible solutions for public debate.

One of the many structural problems facing this country is our inability to assess our problems rigorously, to inform the public, debate issues and arrive at solutions that are truly in the public's interest. Until we can do this, we shall continue to govern from one crisis to the next.

Such crisis management rarely, if ever, produces long lasting solutions to anything.

In seeking to reorganize the way we approach the problems posed by Detroit, we might do well to take a page from our tough-

est automotive competitor—Japan. The Japanese support a national system of think tanks, pursue the best experts on any subject anywhere in the world, use an interdisciplinary methodology that includes social scientists, determine what policies will be in their best national self-interest and then vigorously apply them.

For example, in 1958, Japan barely had an auto industry. Its total production was less than 100,000 cars. In 1977, Japan exported 4.5 million cars and trucks, half of them to this country. Today, Japanese manufacturers have about 20 percent of the American market. Studies show that their auto plants are more modern, their workers are more productive and, most important, they have a superior system for gathering, evaluating, and applying economic and technical information.

The system has worked not only for autos, but for cameras, televisions, radios, stereo and video equipment, watches, sporting goods and a host of other products and services.

There is much we can learn from their approach. The first step that an independent research institute should take is to find out what works best for the Japanese and see how it applies here.

At the same time, such a body should initiate a long-range, indepth assessment of the future of the automotive industry and related industries and their impact on all aspects of our society.

Past efforts have failed because they were narrowly conceived. If the investigations to come are not to be equally narrow, they must include participation by all affected interests, including technically expert representatives of the public interest—engineers and social scientists who are independent of the auto industry and who are not afraid to raise the tough questions we have outlined today.

Within this framework, we can begin developing the kind of technical effort these hearings seek, the kind of effort this Nation needs.

I'd like to conclude my remarks by just repeating a statement made by the Deputy Secretary of Transportation, William Beckham, this morning.

He said this program must be part of a balanced effort to provide for future mobility consistent with the Nation's economic, energy, environmental, and social goals.

We certainly agree with that. Unfortunately, we see no evidence of this objective at any level of Government today. We hope this committee can close this gap.

That concludes my remarks. Mr. Wilder and I will be happy to answer any questions you might have.

Senator STEVENSON. Thank you. We will proceed with Mr. Showalter and then come back to you.

[The statement follows:]

STATEMENT OF BRIAN KETCHAM, VICE PRESIDENT AND CHIEF ENGINEER, CITIZENS FOR CLEAN AIR, INC.

My name is Brian Ketcham. I am vice president and chief engineer of Citizens for Clean Air, which is a non-profit public interest organization that specializes in issues relating to transportation and air quality. In 1970 I directed New York City's Bureau of Motor Vehicle Pollution Control where I designed and outfitted a vehicle emissions test facility. As part of that work, I introduced the first testing program to investigate sub-compact passenger cars as an energy and cost saving measure. While with New York, I also authored the City's Transportation Control Plan, the first in the nation. I have also designed and tested Wankel Rotary Engines for

Curtiss-Wright Corporation, gas turbine engines for General Electric, and high performance piston engines for racing teams. With Clean Air, I have participated in many federal regulatory proceedings, including those relating to the Clean Air Act and fuel economy and emissions requirements.

With me is Stephen Wilder, and engineering manager with nearly three decades of experience in automotive work, including research, design, assembly and marketing. Mr. Wilder is also Chairman of the New York City Group of the Sierra Club.

The American auto industry is in serious trouble. It is suffering from the consequences of both a recession and poor corporate judgment. Indeed, the current recession is partly a result of the auto industry's unwillingness to face a world that is rapidly changing in character. Gone are the days of cheap gasoline. We no longer have the fiscal resources to pay the real costs of our dependence on autos. The age of limitless personal mobility is ending—and will do so tragically unless we act now.

The auto industry has operated for decades on the premise that there is no alternative to automobiles: that mobility based on this one mode of transport is practical, that some form of liquid hydrocarbon fuel will always be available at reasonable cost, that there are no desirable alternatives to the auto dependent sprawls that criss-cross the country, that car sales measure the health of our economy, and that people will always have enough money to support their own personal mobility but that motorists will never have to pay for all the costs they impose on society.

These assumptions are no longer valid. Automakers who continue to pursue policies rooted in a time when these assumptions were easier to defend do so at great risk. Unfortunately, this problem is not being addressed by government or by industry and this Committee's proposals to establish a Federal program financing basic research that supports automotive technology will not truly help automakers—not now and not ten years from now.

Technical innovation is not the issue. We already know plenty about the physical sciences that automakers can use to make their products more competitive. What is missing is the motivation to apply this information effectively. Corporations today are so obsessed with earning short-term profits that—with the high cost of capital financing and with the magnitude of their existing investments—they are paralyzed by the prospect of risk. And since innovation entails risk-taking, there is precious little of it to be found in America's automobile industry.

The auto industry's failure to innovate is complicated by the fact that automaking is a mature industry: its market in this country is limited largely to replacing existing fleets, its growth potential is limited to about one percent a year, its assembly lines are increasingly automated, and its products last longer (yes, they are getting better). Meanwhile, the industry's labor force is shrinking. To put it bluntly, the U.S. auto industry is in decline and will continue to decline as an industrial power. Unless it diversifies, and soon, it will wither and it may die. If it does, a large chunk of America's economy will go with it. These are the real issues. They are social and economic in nature and they will never be solved by throwing money and technology at them.

We oppose your proposals to establish a program of automotive technology development because we do not believe it will help the industry, particularly at this time of crisis. We oppose it because it ignores the cricital social and economic issues that are at the heart of the industry's problems.

There is one ray of governmental enlightment in this dilemma. It is in a just released report by the Department of Transportation entitled "Draft Transportation Agenda for the 1980's." I quote:

"We are entering a period of far-reaching change. The assumption that the future is going to be a continuation of the past is invalid. Large national economic problems will change radically over next several years and will provide a very different context for transportation policy.

"Existing transportation planning is based upon assumptions about our economic viability, resource availability, population distribution and behavior that are unlikely to remain valid over the next decade.

"We can no longer afford to base our planning processes solely on the extrapolation of trends. That practice reinforces existing trends, promotes self-fulfilling prophesies of conditions no longer deemed desirable. Rather, government needs to be more aggressive in predicting some basis of change; postulating alternative scenarios; and developing convictions about where policy decisions ought to be leading us. In other words, design a better future and determine the logic switches and routes to get there."[1]

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[1] "Draft Transportation Agenda for the 1980's: The Issues," U.S. Department of Transportation, March 25, 1980, pp. 38-39.

Seven years ago OPEC nations sent us the first of several messages. It was not heeded. As a result, today more than one-quarter of the work force in the auto industry has been laid off, and Chrysler is battling bankruptcy. On a broader scale, every citizen is burdened by the resulting costs of unemployment, welfare, food stamps, and programs like the ones you are considering. The one bright spot is this Committee. Five years ago you set fuel economy standards despite the industry's protests. If you hadn't, the industry and the nation would be in a lot worse shape than it is in now. Congress displayed a sense of vision then and it should do so again.

The need to consider the larger picture was one of the less-heeded conclusions reached at last year's Conference at MIT on Basic Research Directions for Advanced Automotive Technology. Many of the ideas reflected in the legislation before us today were launched at that meeting. Despite and overall capitulation to the myth of ongoing personal automobility, the Conference's participants stated that there is a need to assess the "social, economic and political components" [2] of the nation's automotive problems and the trade-offs in these areas that any basic research program would create.

But these bills ignore the problems of a society grown embarrassingly dependent on automobiles and trucks. Americans already drive more than 150 million autos and trucks, or more than one vehicle for every licensed driver. In recent decades, highways and parking lots have come to determine the shape of our cities and towns, the places where people live, how they commute, where they will work, while subways and railroads have atrophied. More than 200 communities have abandoned public transit. Hundreds of other neighborhoods have been ruined by unwanted roads. Tailpipe exhaust causes most of our urban air pollution and the manufacture of vehicles and the materials they're made of contributes much of the rest. Traffic accidents kill more people under thirty-five than any disease, and, of course, the mileage we drive costs us all the oil we import.

Last year, the cash bill for our automotive mobility was about $390 billion—that's for cars, parts, fuel, maintenance, highways and the movement of freight by truck—these are direct, out-of-pocket user payments. Another $100 billion should be added to represent the societal costs of auto-induced pollution, congestion, accidents, lost wages, medical expenses, and existing subsidies—costs borne by non-users as well as motorists.

Before you channel large sums of money into basic automotive research programs, government must begin to consider these factors in its planning and decision-making processes. It must know where we are going. The status quo is no longer enough. For a start, we must question the value of our addiction to automobiles and trucks as our primary means of transportation in an increasing resource scarce world.

To some degree, foreign automakers have more accurately gauged and responded to world conditions and the American market. As a result manufacturers such as Nissan, Toyota, Honda and Volkswagen build more attractive, more sellable cars. Many are more fuel efficient and more carefully engineered than comparable domestic models.

Before Congress acts to prop up the American auto industry, we must organize to answer the questions we have raised today regarding the future of the industry and its role in America's economy. Should we continue to use auto sales as the barometer of the nation's economic health? Or does the pursuit of sales fuel a dependency which is really part of the cause of our economic sickness? Should we be trying to bootstrap an industry by pumping dollars into its technology or should we first examine the industry itself and its impacts on society? Is preserving the auto industry as we know it today the real point of these hearings? Shouldn't we really be exploring how Americans can enjoy a quality life style that does not depend totally on universal use of automobiles?

We must look at what we will do in future years when resource and economic constraints force us to change our lifestyles and goals. As the DOT Draft Transportation Agenda for the Eighties I quoted from earlier suggests, we must develop contingency plans with alternative ways of looking at how and where we live, the conomy, and the role of transportation in satisfying travel needs. For example, if we can reduce travel by 25 percent, we can reduce oil imports by 2 million barrels a day. We must look beyond auto dependence. Perhaps DOT can do this by adopting a more liberal approach to the policy analyses suggested in its Agenda for the Eighties. But our own experience suggests that inherent biases and external pressures will prohibit meaningful, timely results.

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[2] "A Research Blueprint for Future Automobile Technology," April 6, 1979, p. 5.

What is needed is a permanent research institute—independent of short-term political and corporate pressures—that can focus on the forces changing this nation, many of which have been largely ignored in transportation policy circles. Such an organization would be free to investigate the social, economic, environmental and institutional factors affecting the future of the auto industry, and present these facts with a range of possible solutions for public debate. One of the many structural problems is our inability to assess our problems rigorously, to inform the public, debate issues and arrive at solutions that are truly in the public's interest. Until we can do this, we shall continue to govern from one crisis to the next. Such crisis management rarely, if ever, produces long lasting solutions to anything.

In seeking to reorganize the way we approach the problems posed by Detroit, we might do well to take a page from our toughest automotive competitor—Japan. The Japanese support a national system of think tanks, pursue the best experts (including our own) on any subject anywhere in the world, use an interdisciplinary methodology that includes social scientists, determine what policies will be in their best national self-interest and then rigorously apply them.

For example, in 1958, Japan barely had an auto industry. Its total production was less than 100,000 cars. In 1977, Japan exported 4.5 million cars and trucks, half of them to this country. Today, Japanese manufacturers have about 20 percent of the American market. Studies show that their auto plants are more modern, their workers are more productive, and—most important—they have a superior system for gathering, evaluating and applying economic and technical information. [3] The system has worked not only for autos but for cameras, televisions, radios, stereo and video equipment, watches, sporting goods, and a host of other products and services. There is much we can learn from their approach to research and application that can be adopted for our own lagging auto industry.

The first step that an independent research institute should take is to find out what worked best for the Japanese and begin applying it here. At the same time, such a body should initiate a long range, intense assessment of the future of automotive and related industries and of their impacts on all aspects of our society. Past efforts failed because they were narrowly conceived. If the investigations to come are not to be equally narrow, they must include participation by all affected interests including technically expert representatives of the public interest—engineers and social scientists who are independent of the auto industry and who are not afraid to raise the tough questions we have outlined today. Within this framework, we can begin developing the kind of technical effort these hearings seek, the kind of effort this nation needs.

Mr. SHOWALTER. Mr. Chairman, Senator Schmitt, it is an honor and a pleasure for me to appear before you. I feel more than a little fear as I sit here.

As an inventor, I cannot survive without the protection of patent laws under your jurisdiction. Laws passed by you have the most direct possible effect on my life and livelihood.

As I sit before you, I am, to borrow a term from the lawyers, a creature of statute.

Last year I testified before a DOT meeting calling for reinvention of the car. At that conference, despite its title, the idea that a lack of invention was responsible for significant technical problems was all but ignored. I think the conference made a bad mistake.

I am convinced that this Nation is badly in need of first-rate inventive work in the automotive field, that first-rate inventive work is our Nation's best hope for efficient promotion of energy conservation, exports, safety, and environmental protection.

I believe that this subcommittee could take practical steps which would substantially increase the amount of first-rate automotive inventive work in America, and these steps would be strongly in the interest of both the public at large and the auto industry.

I feel it is important for me to explain, as carefully as I can, the sort of inventive work which I think the country needs. The very

[3] Japan As Number One, Ezra F. Vogel, Harvard University Press, 1979.

word "inventor" has acquired clownish connotations in our time, but our need for practically effective inventiveness is very real.

In most people's minds, invention—particularly mechanical invention—is a 19th century activity.

In the popular mind, the ideal type of the inventor is Thomas Edison. Here was a man of incomplete education, with considerable scorn of theoretical work and for book learning, proceeding on technical work largely on the basis of intuition and faith.

Much of Edison's work was done blind, by a process of trial and error. The man spent only a little time perfecting his ideas. He was terrifically prolific and productive, but he spent years and millions of dollars pursuing efforts which could have been shown to be impossible with information available in his own time.

When people think of invention, they think of function in the Edisonian manner—unless they think of invention as something done by wild-eyed men in messy workshops.

This sort of inventive work cannot compete in well worked out heavy industrial areas in the second half of the 20th century. The technical problems in need of solution are too logically complicated and precise to yield to this sort of attack. Too much has already been done.

In this sense, people are right when they discount inventors. When they think of inventors, they are thinking of obsolete people.

The contemporary barriers to successful invention are much more formidable than the ones Edison confronted. The enforceability of patent is at a discount in the investment community, and a serious inventor must be sure he has at least $1 million available for patent defense if his patents are to be meaningfully enforced.

The level of technical performance an invention must meet is much higher than it was a century ago. Edison could sell products which were still rough prototypes.

Now, a new product must be very well developed in order to be acceptable—this is very expensive. Edison's old comment that invention is 1 percent inspiration and 99 percent perspiration still holds good, but the costs in both inspiration and hard work have gone up since Edison's time.

Moreover, early inventors were generally pioneering, inventing first-of-a-kind pieces. At AEA our job is "First principle redesign of piston engine components for optimization of emissions and economy."

We are redesigning and reinventing components—in every case we are confronting technical individuals and groups in the auto industry with a vested interest in the old component design. These are people who generally wish for us to fail, often with a passionate desire to see our efforts die.

These people have real power to set the rules by which we must prove our products—they stack the cards against us as much as they can, even though the technical success of our products might serve the real economic interest of their company.

As U.S. Senators, you are surely aware that anyone wishing to change something defended by vested interests faces significant problems. For our work to succeed, we need something more than technical correctness—we need economic power on a scale Edison did not require.

The barriers to inventive success are now so high that few scientifically competent and able people go into the business.

This Nation has many first-rate minds doing significant science throughout the country, and for this we should all be proud. I find it a personal inspiration to read scientific literature and consult with scientists.

Nonetheless, the number of able and scientifically literate people who function as mechanical inventors in this country is pitifully small. Since only inventive work can practically apply our scientific knowledge, the dividends to this Nation from its mechanical science have been disappointing.

In my judgment as a private citizen, this Nation's energy problems are mostly attributable to a shortage of first-rate inventive effort.

It is my considered judgment, after much thought, that it would be technically possible, with no new scientific knowledge for U.S. energy consumption—automobile and otherwise—to be vastly less than if is if adequate inventive effort by first-rate minds was devoted to the problem.

It is also my judgment that additional money for basic research, as basic research is generally understood, will be a serious misallocation of scarce national resources and will not do much to solve our automotive needs.

For very much less money than the $800 million proposed for basic research, the Government could radically increase the inventive productivity of our Nation. For this to happen, a situation must be set up where first-rate minds—the sort of people who now go to medical school—can find support for sustained and disciplined inventive work in the automotive industry.

For me to ask for this, as an inventor, is obviously self-serving. Like the rest of us, I want to survive. Nonetheless, the Nation needs innovative solutions.

Please let me take a moment to describe the sort of inventive work which is needed, and my tentative suggestions on how this work can be supported with a minimum of duplication and waste.

These ideas are based on more than 10 years of study and very hard work in the inventive business, and are the result of much practical and sometimes bitter experience.

Although the 20th century confronts the inventor with obstacles, it also offers the inventor significant advantages. Anyone working now has a tremendous body of certain scientific knowledge and experimental precedent to work from and to reason with—if he is willing to go to the very considerable intellectual trouble of integrating it all.

In the mechanical sciences, the basic scientific laws are already known and expressible as exact equations. In addition, our technical culture now has a very sophisticated body of applied mathematics—with good applied mathematicians available for hire.

We have computers make problems which were previously insurmountable subject to attack.

Now, because of the very great amount of knowledge, it is possible to make great progress without need for discovering any new physical laws, by careful application of known established scientific principles.

This work requires an extremely high level of intellectual flexibility, honesty, and intellectural discipline. Also, the work requires significant theoretical insight, since one is navigating in a field involving virtually infinite numbers of possible combinations, so that anything but a disciplined and theoretically based approach has essentially no practical chance of success.

At this point, I would like to emphasize the point the late economist Jacob Schmookler established well in his work in the 1960's: The number of potential inventions in any field is virtually infinite; only a tiny fraction of all possible inventions are actually made. The widespread assumption that all scientifically possible technical advances will automatically be made is absurd, and resource commitments based on this assumption will be very unproductive.

Today the scientific laws relevant to automobiles are already known. A sufficiently careful person working in an area where all the physical laws are known can reliably develop his ideas on paper and pretty well predict how a machine built according to the paper plans will function.

This ability to rely on known physical laws involves dramatic economies of time and effort. Paper computations go faster and are much cheaper than experimental results. Any given paper calculation is suspect.

However, if the work has been checked by many computational tests and rigorously checked against many pieces of relevant and statistically independent information, then the paper computations can probably be trusted.

The great risk in this process is usually not some new physical law; rather it is the risk that the person who is doing the work has forgotten something.

It is my judgment, based on practical experience—some of it painful—that no invention or technical development is worthy of serious experimental support unless it has passed through this stage of careful and complete computational study.

It is also my conviction that an invention which passes through this computational study—referred carefully by the best scientific experts available—and emerges looking like a breakthrough invention very likely is a breakthrough invention, and is worthy of economically significant levels of support. In this business, economically significant levels of support are expensive.

I do not mean to suggest that experimental results are not necessary—it is obviously true that inventions can only be proven by extensive and expensive experiments. The extent of the experimental results required to get action from an auto company would appall most ordinary people.

But unless very good analysis is done, the time and money for experimentation should not be expended— experimental costs are too high, and the chance of an undisciplined idea being successful is too slim.

On the other hand, if good analysis is done, the experimental work is relatively simple—although still expensive—and the solutions are rather sure.

Even when something has been forgotten in the conceptual design, the rigorous conceptual discipline expended in the analysis

make the inventor well prepared to field and solve unanticipated problems.

In short, I believe that breakthrough inventions can be identified and evaluated on the basis of scientifically disciplined and careful analysis, and can be evaluated through a process not much different from that used by the National Institutes of Health and the National Science Foundation to evaluate research proposals.

The inventions which passed the selection process would be few enough that each could receive adequate support—enough for practical results.

Nowhere in the country, in either the public or the private sector, is there any mechanism for evaluating inventions in this way—the NBS Office of Energy Related Inventions is not organized for this purpose, and lacks the resources to support large-scale inventive efforts.

Nowhere in the auto industry is there any evaluation mechanism remotely approaching the sophistication needed.

If the mechanism could be set up, it would be a great boon to practical innovation in this country.

Personally, it would make my task as an inventor much easier. But it would serve a more public purpose—it would set up conditions which would attract many first-rate minds to inventive work in the automotive field.

I sincerely believe that this would be a service to our Nation, and serve the real interests of the auto industry, although many in the industry would not appreciate the changes admission of so many boat rockers would bring.

On the basis of a great deal of experience as an inventor, I have prepared answers to the five questions submitted to me by the committee, and submit in addition chapter III from Jacob Schmookler's "Invention and Economic Growth," addressing the relation between science and invention—invention does not follow automatically from scientific knowledge.

I would like to summarize my answers here:

First, without a sophisticated mechanism for supporting real practical innovation, the proposal for basic automotive research funding is not justified.

Second, any research program must include full-size component and vehicle tests if its results are to be practically useful in the automotive business.

Third, any program should involve well organized cooperation between Government, industry, and the academic community, with significant market disciplines applied, if the program results are to be practically useful.

Fourth, a program to promote breakthrough innovation with rigid controls on waste is needed. The program must give substantial support to inventions having the potential for breakthrough results, and still be able to weed out the far more numerous ideas which are unsound or lack the potential to substantially improve automotive economy and cleanliness.

The support of the solid work must be ample and available at an early stage. For this to be possible, the standards the work must meet must be set very high—without asking the verification process prior to support to be impossibly expensive.

The filtering process is the most important part of the proposal, and is necessary to any practical program to support innovation. I suggest requiring prospective breakthrough inventions to be criticized by expert individuals at the level of members of the National Academy of Sciences, the National Academy of Engineering, and the Fellow level of the Society of Automotive Engineers.

Most of this effort and expense of soliciting this criticism should be imposed on the inventor. Compared to other obstacles a serious inventor faces, the cost of soliciting expert criticism is a minor matter.

Innovations which can pass this filtering process deserve support. I suggest a mechanism utlizing the incentives of the entrepreneurial, capitalistic system at minor cost to the Government. Other support mechanisms could be devised.

The main points are: One, good work needs substantial and reasonably long-term support; and, two, it should be assured that proven breakthrough technology has a reasonable chance of being adopted at a fair price, even in the face of industry opposition.

Fifth, in my judgment, the program required to promote breakthrough innovation could be set up and administered at the National Bureau of Standards for less than $5 million cost to the Government.

If breakthrough results were not forthcoming, there would be no further expense to the program. If breakthrough results did result and were proved, the Government might need to commit up to several hundred million dollars to loan guarantees, but it should be possible to arrange the program so that it is a moneymaker for the Government.

I would like to thank the committee for giving me an opportunity to appear before you today.

I would be honored to answer any questions you have as carefully and honestly as I can.

[The statement and attachments follow:]

STATEMENT OF M. ROBERT SHOWALTER, PRESIDENT, AUTOMOTIVE ENGINE ASSOCIATES

Mr. Chairman, it is both an honor and a pleasure for me to appear before you and the members of the Science, Technology and Space Subcommittee. I feel more than a little fear as I sit before you. As an inventor I cannot survive without the protection of patent laws under your jurisdiction. Laws passed by you have the most direct possible effect on my life and livelihood. As I sit before you I am, to borrow a term from the lawyers, a creature of statute.

Last year I testified before a D.O.T. meeting calling for "reinvention of the car". At that conference, despite its title, the idea that a lack of invention was responsible for significant technical problems was all but ignored. I think the conference made a bad mistake—the very idea of invention was without credibility at that conference. As an inventor I surely have a bias (conventional research scientists have biases too). Still, I am convinced that this Nation is badly in need of first rate inventive work in the automotive field, that first-rate inventive work is our Nation's best hope for efficient promotion of energy conservation, exports, safety, and environmental protection. I believe that this Subcommittee could take practical steps which would substantially increase the amount of first-rate automotive inventive work in America, and these steps would be strongly in the interest of both the public at large and the auto industry.

I feel it it important for me to explain, as carefully as I can, the sort of inventive work which I think the country needs. The very word "inventor" has acquired clownish connotations in our time—but our need for practically effective inventiveness is very real. In most people's minds invention (particularly mechanical invention) is a nineteenth century activity.

In the popular mind, the ideal type of the inventor is Thomas Edison. Here was a man of incomplete education, with considerable scorn of theoretical work and for book learning, proceeding on technical work largely on the basis of intuition and a (in Edison's case, quite justified) faith in his own brillance. A great deal of the work was done blind by a process of trial and error. The man spent only a little time perfecting his ideas. Edison was a terrifically prolific and productive man, but he spent years and millions of dollars pursuing efforts which could have been shown to be impossible with information available in his own time.

When people think of invention they think of function in the Edisonian manner (unless they think of invention as something done by wild eyed men in messy workshops). This sort of inventive work cannot compete in well worked out heavy industrial areas in the second half of the twentieth century. The technical problems in need of solution are too logically complicated and precise to yield to this sort of attack. Too much has already been done. In this sense people are right when they discount inventors. When they think of inventors, they are thinking of obsolete men.

The contemporary barriers to successful invention are much more formidable than the ones Edison confronted. The enforceability of patents is at a discount in the investment community, and a serious inventor must be sure he has at least a million dollars available for patent defense if his patents are to be meaningfully enforced. The level of technical performance an invention must meet is much higher than it was a century ago. Edison could sell products which were still rough prototypes. Now, a new product must be very well developed in order to be acceptable—this is very expensive. Edison's old comment that invention is 1 percent inspiration and 99 percent perspiration still holds good, but the man-hour costs in both inspiration and hard work have gone up since Edison's time.

Moreover, early inventors were generally pioneering, inventing first-of-a-kind pieces. At A.E.A. our job is "First principle based *redesign* of piston engine components for optimization of emissions and economy." We are redesigning and reinventing components—in every case we are confronting technical individuals and groups in the auto industry with a vested interest in the old component design. These are people who generally wish for us to fail, often with a passionate desire to see our technical efforts die. These men have real power to set out the rules by which we must prove our products—they stack the cards against us as much as they can, even though the technical success of our products might serve the real economic interest of their company. As U.S. Senators you are surely aware that anyone wishing to change something defended by vested interests faces similar problems. For our work to succeed, we need something more than technical correctness—we need economic power on a scale Edison did not require.

The barriers to inventive success are now so high that few scientifically competent and able men devote enough attention to inventive work to do anything significant. This nation has many first-rate minds doing significant science throughout the country, and for this we should all be proud. I find it a personal inspiration to read scientific literature and consult with scientists. Nonetheless, the number of able and adequately educated men devoting full time effort to mechanical invention in this country is pitifully small. Since only inventive work can practically apply our scientific knowledge, the dividends to this nation from its mechanical science have been disappointing. In my judgement as a private citizen, this Nation's energy problems are mostly attributable to a shortage of first-rate inventive effort.

It is my considered judgement, after much thought, that it would be technically possible, with no new scientific knowledge for U.S. energy consumption (automobile and otherwise) to be vastly less than it is if adequate inventive effort by first-rate minds was devoted to the problem. It is also my judgement that additional money for basic research, as basic research is generally understood, will be a serious misallocation of scarce national resources and will not do much to solve our automotive problems.

For very much less money than the 800 million dollars proposed for basic research, the government could radically increase the inventive productivity of our nation. For this to happen a situation must be set up where first-rate minds can find support for sustained and disciplined inventive work in the automotive industry. For me to ask for this, as an inventor, is obviously self serving. Like the rest of us, I want to survive. Nonetheless, the Nation needs innovative solutions. Please let me take a moment to describe the sort of inventive work which is needed, and my tentative suggestions on how this work can be supported with a minimum of duplication and waste. These ideas are based on more than ten years of study and very hard work in the inventive business, and are the result of much practical and sometimes bitter experience.

Although the twentieth century confronts the inventor with obstacles, it also offers the inventor significant advantages. A man working now has a tremendous body of certain scientific knowledge and experimental precedent to work from and to reason with (if he is willing to go to the very considerable intellectual trouble of integrating it all). In the mechanical sciences, the basic scientific laws are already known and expressible as exact equations. In addition, our technical culture now has a very sophisticated body of applied mathematics (with good applied mathematicians available for hire) and computers make problems which were previously insurmountable subject to attack. Now, because of the very great amount of knowledge available, it is possible to make great progress without need for discovering any new physical laws, by careful application of known scientific principles.

This work requires an extremely high level of intellectual flexibility, honesty and intellectual discipline. Also, the work requires significant theoretical insight, since one is navigating in a field involving virtually infinite numbers of possible combinations, so that anything but a disciplined and theoretically based approach has essentially no practical chance of success. [At this point I would like to emphasize the point the economist Jacob Schmookler established well: the number of potential inventions in any field is virtually infinite; only a tiny fraction of all possible inventions are actually made. The widespread assumption that all scientifically possible technical advances will automatically be made is absurd, and resource commitments based on this assumption will be very unproductive.]

Today the scientific laws relevant to automobiles are already known. A sufficiently careful man working in an area where all the physical laws are known can reliably develop his ideas on paper and pretty well predict how a machine built according to the paper plans will function. This ability to rely on known physical laws involves dramatic economies of time and effort. Paper computations go faster and are much cheaper than experimental results. Any given paper calculation is suspect. However, if the work has been checked by many computational tests and rigorously checked against many pieces of relevant and statistically independent information, then the paper computations can probably be trusted.

The great risk in this process is usually not some new physical law; rather it is the risk that the man who is doing the work has forgotten something. It is my judgement, based on practical experience (some of it painful) that no invention is worthy of serious experimental support unless it has passed through this stage of careful and complete computational study. It is also my conviction that an invention which passes through this computational study (refereed carefully by the best scientific experts available) and emerges looking like a breakthrough invention very likely is a breakthrough invention, and is worthy of economically significant levels of support.

I do not mean to suggest that experimental results are not necessary—it is obviously true that inventions can only be proven by extensive and expensive experiments. The extent of the experimental results required to get action from an auto company would appall most scientists and would appall most ordinary people. But unless very good analysis is done, the time and money for experimentation should not be expended—experimental costs are too high and the chance of an undisciplined idea being successful is too slim. On the other hand, if good analysis is done the experimental work is relatively simple (although still expensive) and the solutions are rather sure. Even when something has been forgotten in the conceptual design, the rigorous conceptual discipline expended in the analysis makes the inventor well prepared to field and solve unanticipated problems.

In short, I believe that breakthrough inventions can be identified and evaluated on the basis of scientifically disciplined and careful analysis, and can be evaluated through a process not much different from that used by the National Institutes of Health and the National Science Foundation to evaluate research proposals. The inventions which passed the selection process would be few enough that each could receive substantial support—enough for practical results.

Nowhere in the country, in either the public or the private sector is there any mechanism for evaluating inventions in this way. (The N.B.S. Office of Energy Related Inventions is not organized for this purpose, and lacks the resources to support large scale inventive efforts.) Nowhere in the auto industry is there any evaluation mechanism remotely approaching the sophistication needed. If the mechanism could be set up it would be a great boon to practical innovation in this country. Personally, it would make my task as an inventor much easier. But it would serve a more public purpose—it would set up conditions which would attract many first rate minds to inventive work in the automotive field. I sincerely believe that this would be a service to our nation, and serve the real interests of the auto industry, although many in the industry would not appreciate the changes admission of so many "boat rockers" would bring.

On the basis of a great deal of experience as an inventor I have prepared answers to the five questions submitted to me by the committee, and submit in addition chapter III from Jacob Schmookler's "Invention and Economic Growth" (Harvard University Press, 1966) addressing the relation between science and invention (invention does not follow automatically from scientific knowledge). I would like to summarize my answers here:

1. Without a sophisticated mechanism for supporting real practical innovation, the proposal for basic automotive research funding is not justified.

2. Any research program must include full size component and vehicle tests if its results are to be practically useful in the automotive business.

3. Any program should involve well organized cooperation between government, industry and the academic community, with significant market disciplines applied, if the program results are to be practically useful.

4. A program to promote breakthrough innovation with rigid controls on waste is needed. The program must give substantial support to inventions having the potential for breakthrough results, and still be able to weed out the far more numerous ideas which are unsound or lack the potential to substantially improve automotive economy and cleanliness. The support of the solid work must be ample and available at an early stage. For this to be possible the standards the work must meet must be set very high (without asking the verification process prior to support to be impossibly expensive).

The filtering process is the most important part of the proposal, and is necessary to any practical program to support innovation. I suggest requiring prospective "breakthrough inventions" to be criticized by expert individuals at the level of members of the National Academy of Sciences, the National Academy of Engineering, and the Fellow level of the Society of Automotive Engineers. Most of the effort and expense of soliciting this criticism should be imposed on the inventor himself (or on the inventive group). Compared to other obstacles a serious inventor faces, the cost of soliciting expert criticism is a minor matter.

Innovations which can pass this filtering process deserve support. I suggest a mechanism utilizing the incentives of the capitalistic system at minor cost to the government. Other support mechanisms could be devised. The main points are: (1) good work needs substantial and reasonably long term support and (2) it should be assured that proven breakthrough technology has a reasonable chance of being adopted at a fair price, even in the face of industry opposition.

5. In my judgement the program required to promote breakthrough innovation could be set up and administered at the National Bureau of Standards for less than five million dollars cost to the government. If breakthrough results were not forthcoming, there would be no further expense to the program. If breakthrough results did result and were proved, the government might need to commit up to several hundred million dollars to loan guarantees, but it should be possible to arrange the program so that it is a moneymaker for the government.

I would like to thank the committee for giving me an opportunity to appear before you today. I would be honored to answer any questions you may have, as carefully and as honestly as I can.

Attachments.

Attachment 1

PREHEARING QUESTIONS AND THE ANSWERS THERETO

Question 1. Is a Federally-funded basic research program necessary for the development and application of automotive technology in order to promote energy conservation, exports, safety, and environmental protection? (Title III S2015 proposes such a program).

Answer. The Title III S2015 language proposes to appropriate up to $800,000,000 to "advance the state of knowledge underlying automotive technology." Implicit in the language is the assumption that improvements in automotive performance await increases in scientific knowledge. I am certain, on the basis of personal experience and much careful throught, that this basic assumption is false and dangerously misleading for our Nation.

We already know a great deal about the scientific laws underlying automotive technology. We know much more about these things than we are effectively using at present. The scientific-technical culture is already rich in knowledge of thermal and fluid sciences; structural mechanics; electrochemistry; aerodynamics; materials science and processing; control systems; tribology; surface science and catalysis; and acoustics and vibrations. The basic laws in these fields are known. When the technical solutions to automotive fuel consumption and emissions come, it is most

unlikely that they will involve scientific knowledge or scientific laws discovered after 1970.

What is needed is science based invention which applies scientific knowledge rigorously to achieve practical and cost effective solutions to energy and emission problems. There is no shortage of good science in this country. There is a shortage of disciplined and scientifically sophisticated invention applying the scientific knowledge we already have.

The barriers to acceptance of serious inventive work are so high now, in both the public and the private sector, that able men are most unlikely to become serious inventors. Presently, effective mechanisms for nurturing breakthrough advances in automotive design once they are invented do not exist in either the public or the private sector. Consequently, few able men become inventors, and even an able man has great difficulty finding enough support to work effectively.

Until we have a mechanism for nurturing inventive breakthroughs based on knowledge we already have, the knowledge we already have is almost useless for producing the technical advances we need. Scientific knowledge does not spontaneously produce technological progress—almost invariably the process of application involves a difficult and disciplined process of invention.

Unless an effective mechanism for nurturing inventive breakthroughs and bringing them to fruition can be developed, new scientific knowledge is almost certain to be unused, however potentially useful it might be. A disciplied and adequately funded mechanism for nurturing innovation must exist before (in my opinion as a private citizen) additional funded for basic automotive research can be justified.

For much less than $800,000,000 suggested in Title III S2015 a mechanism could be set up and funded effectively nurturing automotive innovation. In my judgement the mechanism described later in this submission could greatly enhance U.S. innovation and be a moneymaker for the Government.

Question 2. Should such a program be restricted to basic research or extended to experimental components and vehicles to verify the feasibility of newly developed technology? H.R. 4678 includes such extension.

Answer. The auto industry is basically risk averse and rigidly empirical. An antitheoretical bias permeates auto company decision making, so that scientific results are generally discounted within the industry to a degree which would astonish most scientists.

Unless research results from the program are extended to fully acceptable working units (preferably in vehicles) the chances are overwhelming that the research results will not be used and the money spent on the research will be wasted.

Working full size models, well tested, are expensive. Nonetheless, they are indispensible in this industry.

For this reason, only work with real breakthrough potential (assessed by tough standards) should be funded. The work which is funded should be supported (in one way or another) well enough to bring the breakthroughs to practical fruition.

Question 3. a. Should such a program be funded and carried out through government facilities and educational and other non-profit institutions without direct involvement of the auto industry?

Answer. Not if practical results are wanted. Results will only be practically useful if the practical requirements of industrial use in an imperfect world are adequately considered. For this to happen, the auto industry must be involved, at least in an important consultative role where the industry gives detailed comments on issues of practical application. Without the discipline provided by industrial viewpoints, research efforts in government, educational and non-profit institutions are likely to become "academic" in the pejorative sense of the world.

b. Alternatively, should it involve a cooperative government/industry relationship for funding, project selection, and program management?

There should be a cooperative relationship between government and the private sector, involving firms which wish to enter the auto industry, and not just the auto industry as it is currently established. For optimal function government, the academic community, the auto industry and the financial community would each have an important role to play. The disciplines of the capitalistic system should be brought to bear for efficient funding and project management.

Question 4. Should such a program (a) be structured and administered within a Federal department or agency, (b) be structured as a multi-agency activity, or (c) be carried out in some newly established institutional framework?

Answer. Support for practical innovative work in the automotive field will require complex cooperation between the federal government and the private sector. The government part of the institutional framework could be handled well by the National Bureau of Standards, perhaps as an outgrowth of the Office of Energy Related Inventions (Mr. George Lewett, Chief) already at N.B.S. Mr. Lewett should

in any event be consulted for advice on the organization of the project. Men in charge of resource allocation at the National Institutes of Health should also be consulted.

What is needed is an organized mechanism for giving substantial support and incentives to work having the potential for breakthrough advance which is also capable of rejecting the far more numerous ideas which are unsound or which lack the potential to substantially improve automotive performance. The support for the work must be ample and available at an early stage, and for this to be possible the scientific and engineering standards the work must meet to merit support must be set very high (without asking the verification process prior to support to be impossibly expensive). Because the natural laws relevant to automobiles are already known (in the scientific sense) it is possible to evaluate the potential of an invention on paper by consultation with scientific experts, so long as extremely high standards of scientific expertise are used and the work is thoroughly studied.

I. INITIAL EVALUATION BURDEN TO REST ON INVENTOR

To keep the system from being inundated with half baked or inadequately conceived inventions, the bulk of the effort and expense of verifying the scientific validity of an invention should be imposed on the inventor or inventive group itself.

Prior to submission to the government the inventor should have fully set out his idea in fully defined and scientifically disciplined terms, with the scientific principles governing the function of the proposed device clearly stated. Technical issues involving the invention should be broken down to well defined fields of expertise. The inventor will then have to provide evidence that top level experts (members of the National Academy of Sciences, the National Academy of Engineering, and Fellow grade members of the Society of Automotive Engineers) in each of the relevant fields of expertise consider the proposed invention scientifically sound. (If no N.A.S., N.A.E. or S.A.E. Fellow level expert can be found in a particular field of expertise an expert acceptable to an N.A.S. or N.A.E. member can be substituted in that particular field of expertise.) The inventor will be responsible for finding the required experts, will have to persuade the experts to spend their time judging his work, will have to compensate these experts himself, and will be expected to travel anywhere within the United States to consult with the needed experts. As a matter of law, the inventor will be required to include in his submission any negative comments from such consultants, and will be required to explicitly address any such negative comments.

These requirements may seem onerous and unreasonable, but they are not. Inventions with breakthrough results will function on the basis of well understood scientific principles if they function at all. Well understood scientific laws are not violated in the real world. If the function of a proposed invention cannot stand up to scientific scrutiny, the invention does not merit further effort unless the problem identified can be corrected. The sooner inadequate ideas can be weeded out, the better for all concerned (particularly, the better for the inventor: a life is a terrible thing to waste). Moreover, and invention is likely to be improved by the advice and comments of the top level scientists called upon to evaluate the idea. The inventor will learn valuable things in his interaction with these distinguished men.

The cost of the evaluation process to the inventor would not be unreasonably high. The consulting fees and travel expenses would typically cost only a few thousand dollars—only very rarely would a competently handled evaluation process cost the inventor more than $15,000. In terms of the other costs and barriers a serious inventive effort faces, this is very little money. As a practicing inventor, I find it inconceivable that any inventor with a real breakthrough idea would be deterred by this expense. Casual and ill educated inventors would be deterred, but this is desirable: major practical breakthroughs in automotive design cannot, as a practical matter, be achieved by casual and ill educated efforts. Also, an inventor forced into contact with first rate scientific experts has the best possible chance of learning what he needs to know to make his ideas work.

An objection may be raised that the major scientists whose approval would be required would not be willing to consult with inventors. Although the scientists might require proposals to be filtered through someone prior to giving the work attention, members of the N.A.S., N.A.E., and Fellows of the S.A.E. are secure men at the pinnacle of these professions. These are able, tough mined and public spirited men, open to good ideas from any source and much less prone to jealousy than their scientific juniors. They would deal with the work honestly, and for consulting fees no worse than those charged by good lawyers. Scientists at this rank are, within the human limits, incorruptable. They would offer good advice. Moreover, it would benefit the country to have these men involved in attempts to solve the energy problems which threaten our nation.

II. ACCEPTANCE BY THE GOVERNMENT

Once an inventor or inventive group had approval from the requisite top-level experts, the inventor would submit his proposal to the government. There would be few enough such proposals that each proposal could be carefully handled by the government. First, government scientists would check the proposal to be sure that every field of scientific expertise relevant to the work had in fact been adequately treated in the submission. The inventor would be required, again at his own expense, to remedy any oversights and resubmit his proposal. At this point the proposal would be accepted by the government.

The government would be required to determine whether, in light of the information submitted by the inventor and other available information it was reasonable to estimate that the invention, fully developed and disseminated throughout the U.S. economy, would result in a real total saving to the U.S. economy in excess of 200 million dollars/year in comparison to hardware currently in place. Social costs of the invention should be considered in this determination and estimates of costs involved in tooling changeovers should be explicitly considered. Most inventions worthy of the name "breakthrough" would clearly save the economy more than 200 million/year if they were fully successful—it should be possible for the government to make this "breakthrough potential" determination quickly. If the invention was judged to have "breakthrough potential" the invention would be accepted by the government, and action would be taken to get the invention the support required to bring it to practical fruition.

III. NURTURING AND PROMOTION OF INVENTIONS—A COMBINED GOVERNMENT AND PRIVATE SECTOR ACTIVITY

A. Early steps for initial support of the invention

Once an invention was accepted into the support program, certain legal steps would be taken immediately by the government to assure that the invention would be adequately funded and assure that the disciplines of the capitalistic system were brought to bear on the inventive development process to assure minimum standards of project selection and program management:

1. The inventor or owner of the invention would be exempted from the S.E.C. limitation of 35 offerees in private placements. This exemption would dramatically ease the task of raising investment money for the invention.

2. Investors in the inventive project would be assured that the invention would not be reduced to practice for tax purposes until the invention was actually being sold on a full scale commercial basis.

3. The inventive project would be specifically permitted to pay sales commissions of up to 10 percent to facilitate the selling of its equity.

4. The government would invest in the inventive project on a dollar-for-dollar matching basis. The government would get the same percentage of the venture as a private investor, except that the government's share would return to the inventive project after the government received five times its investment in inflation-adjusted dollars.

These steps would assure that the inventor or inventive group could secure enough money to proceed with development of the invention for the proof-of-principle and early engineering stages. The project would be set on its legs as a capitalistic enterprise. A condition for the above exemptions should be that the inventor or inventive group satisfy the government that the invention-supporting organization, however formed, will not pay excessive salaries or otherwise enrich the principals in the organization until the invention achieves actual commercial success. There should be no government-imposed limits on the payments to the principals in the event that the invention achieves actual commercial success.

The four government assistances described in this section would make sufficient resources available to the inventive venture to fund the proof of principle and early engineering development.

B. Cooperative government, auto industry, private sector steps to assure that a technically successful invention has a fair chance of large scale commercial success

One of the major deterrents to inventive effort in the automotive field is the practical fact that the automotive industry capital requirements are so large. There is a real question whether a small firm, untested in the market place, can ever enter the auto industry without help. Market disciplines need to be maintained to assure good resource allocation decisions, but the barriers to entry ought not be impossibly difficult for hardware which meets very high technical standards. Bootstrap operations building business from a marginal capital base are not practical in this industry.

It cannot be assumed that a breakthrough innovation will be quickly embraced by the automotive industry as it is presently constituted, even though it may appear that open-mindedness would be in the companies' own interest.

The auto industry is very risk averse and requires a completeness of test data on any innovation which imposes large costs on the innovative organization. The data requirements of the auto industry are based on real organizational needs, and are very much more extensive than people outside the industry can readily understand. Anyone who has been close to the manufacturing coordination problems which auto companies must face every day knows that risk taking has such a high chance of causing problems in the production process that is must, as a practical matter, be rigidly suppressed in the production line organization. If one tolerates risk in a process involving coordinated sequential assembly of more than fifteen thousand parts, production is actuarily certain to involve intolerable error and failure rates. Moreover, changes which look small to an outside observer may seem, often rightly, to be risks to the auto companies. The disciplines of risk avoidance permeate the automotive engineering profession, and it will never be possible for an innovation to be accepted commercially unless it has successfully passed an extensive list of tests.

Passing these tests is likely to be a matter of several million dollars. Unless the tests required are clearly set out so that they can be attacked in a coordinated fashion, the chances of getting an innovative product accepted for production may be vanishingly small. By way of illustration of the tests which must be passed, a list of "Suggested Topics of Specification" which formed part of a recent A.E.A. proposal to a major auto company is submitted. The list of topics of specification runs for more than four pages. The specifications requested, had they been granted, would have taken about twenty five carefully written (and carefully negotiated) pages to set down.

Anyone with engineering experience will know that designing equipment capable of meeting so many specifications is no casual or inexpensive exercise. Testing the equipment to see that it meets standards after it is designed is a major undertaking in itself.

One may argue that the burden of designing an innovative component to meet all these tests should properly fall on the auto companies themselves. In a perfect world it might be safe to assume that the auto companies would carefully and competently do this design and testing. In the imperfect world in which we actually live it is only prudent to assume that the innovative group will have to do the requisite design and testing itself. An innovation is a fragile thing, and is not likely to prosper at the hands of men who do not wish it to succeed.

These barriers to entry are major obstacles to innovation—the innovative group could use judicious federal assistance. An innovation which has passed so far into the program offers substantial advantage to the national interest—it is appropriate that at least one competent man be assigned by the program (perhaps by D.O.E. if the innovation program is an extension of the NBS–D.O.E. Office of Energy Related Inventions) who is assigned to advocate the innovation and assist in its coming to fruition. An appropriate government role would involve two stages.

1. Assistance in determining the actual detailed specifications the innovative component would have to meet to be fully acceptable in the technical sense (getting a realistic set of specifications on the level described in the "Selected Topics of Specification" example submission). Every effort should be made to secure the comments of the auto industry, and to secure their cooperation and technical input, although the program should be prepared to proceed without industry cooperation if necessary. Sectors of the industry which take an adversarial stance to the innovation should be carefully noted, and inability to understand the invention by industry people should be carefully recorded for potential use in patent defense.

In any event, the best set of practically obtainable specifications for a complete, practical vehicle demonstration should be set out. The specifications should be tough but reasonable. The auto companies should be given a chance to comment on the proposed specifications before they are settled.

2. If the innovative group can successfully meet the above specifications, it will have been held to have given commercially relevant practical proof of its innovative component. After this is done, the innovative group will be eligible for *substantial* government loan guarantees (up to 100 million dollars per project) subject to the requirement that 10¢ in private risk capital be secured for each $1.00 of federal loan guarantee. It should be emphasized that these loan guarantees would only be offered to innovations capable of saving the economy more than 200 million dollars/year, and would only be offered after the innovation was proven according to a tough set of standards. The availability of the loan guarantee, even if it was not in fact used, would greatly enhance the inventive group's ability to get its innovation in full scale production at a fair price.

The proposal advocated here would greatly enhance the effective incentives for innovation within the automotive industry. Perhaps the most important part of the program is the initial analytical filtering process using members of the National Academy of Sciences, the National Academy of Engineering and Fellow level members of the Society of Automotive Engineers, since this process will both refine and identify first-rate inventions. The process for nurturing inventions proposed here involves complex cooperation between the highest levels of academia, government, the auto industry and the private sector and would make practical automotive innovation a reasonable human possibility a degree that it has never been before. The proposal uses the incentives and disciplines of the capitalistic system, the most flexible and powerful incentives the American economic system offers.

It is also hoped that this proposal will clarify to the Committee the barriers to practical innovation which exist in the auto industry, and help explain why this Nation's technical progress in automotive matters has been disappointing to many people.

Question 5. What Federal funding level would be required for optimal results in the decade of the nineties?

Answer. I can only competently address a part of this question. Some university research support is needed for the explicit purpose of training graduate students. Some basic research may also be justified, although there should be a strong effort to assure that the "basic research" is not rehashing something already known, and that the research logic is held to high standards of scientific and analytical discipline.

For the innovation support mechanism I have been advocating, costs would break down roughly as follows: The administrative part of the program itself could be set up and administered (perhaps as an offshoot of the Office of Energy Related Inventions) for less than five milion dollars cost to the government. If breakthrough results were not forthcoming, there would be no further government expense connected with the program. If breakthrough results did result and were proved, the government might need to commit up to several hundred million dollars to loan guarantees. Given the very tough standards hardware would have to meet, these loan guarantees would be an excellent investment risk for both the Nation and the federal government. Because the government will partly function as an investor under the suggested program, it should be possible for the program as a whole to be a net moneymaker for the government.

Attachment 2

SUGGESTED TOPICS OF SPECIFICATION

Fuel economy advantage compared to a completely defined and representative current production—

3-way catalyst or duel catalyst vehicle;
CVS advantage 20 percent +;
Highway cycle 20 percent +;
Cold driving advantage 20 percent +;
Hot weather advantage 20 percent +; and
High altitude advantage 20 percent +.

Need to specify number of vehicles, tires, transmission, rear end differential, auxiliaries.

Emissions

Must pass any E.P.A. tests in force at deadline of contract: CVS cycle; cold weather; evaporative; and high altitude.

Must pass tests in force in California.

Need to specify:

1. Details of vehicles (same as for fuel economy tests)
2. Tolerance bands for ignition, fuel-air metering, fuel variation
3. factors of safety for emissions
4. Durability tests relevant to contract.

Power and Torque

Peak Power more than 30 percent greater than baseline engine.

Torque at all RPM equal to or greater than torque of baseline engine.

Drivability

All well defined drivability characteristics equal to or superior to baseline vehicle.

General:

1. Subjective smoothness under all conditions

2. Throttle responsiveness: fast transient response and acceptable steady state power vs. foot pedal position
3. Excellent startup and driveaway at all temperatures.
High temperature—freedom from vapor lock and overheating.
Low temperature—specific cold start standards at various temperatures.
Smooth performance and optimized economy regardless of altitude.
Octane requirement:
(a) New
(b) Octane requirement increase tests (A.E.A. wants the right to filter oil aerosol from PCV line, specify improved valve stem seals).
Drivability with fuels other than indolene:
(a) Specify range of gasoline volatility system must tolerate
(b) Specify degree of alcohol tolerance required of system
(c) Other fuel tolerance specifications.

Interface Specifications

Engine compartment packaging; Exhaust system compatability.
Compatability with other engine components:
(a) Mounting, including accessory mountings
(b) Engine component drawings with dimensions and tolerances
(c) PCV interface (oil aerosol filter permitted?)
(d) Electrical interface specifications.

Safety

No throttle sticking—fail safe linkages
Safety in the event of backfires
Engine fire prevention under all conditions (including crash conditions).

Noise and Vibration Standards

Exhaust noise—external and in-vehicle
Mechanical noise—external and in-vehicle

Durability

The unit will have to pass numerous standard durability tests for fatigue, deposits, corrosion, calibration drift, damage in assembly, and miscellaneous wear-and-tear. Tests the induction package will have to pass should be *specifically* defined.
The package involves changed camshaft specifications and increased engine power—what specific engine durability tests will these changes entail?
How much vehicle testing is required?
What oils are permissible during the testing?

Maintainability

Induction package components should not malfunction. But if parts do fail, how easy is the unit to service? A panel of independent servicemen might be used to judge maintainability.

Electromagnetic Compatibility

Any electronic components of the induction system should be immune to electromagnetic environment in which the system will have to operate. Components themselves should not generate electromagnetic noise above a specified level.

Head Casting Issues

Modified intake ports will require modified head castings. (A.E.A. and SWRI will require head casting cores to work with.)
Specifications on tolerable port shape variation, other issues, will have to be worked out.
Will A.E.A. have to supply new production cores?
With any modified head casting, value seat distortion is a problem. Can A.E.A.-SWRI use insulated and cooled flexible intake and exhaust valves on prototypes to compensate for seat distortion?

Other Manufacturing and Assembly Issues

Costs

Maximum tolerable cost of the entire system (including credits for the components the system replaces) needs to be specified in inflation-adjusted dollars.
Whenever possible, costs of components and assemblies should be determined by multiple bids from outside suppliers of proven automotive production ability.
Overhead charge procedures should be clear.

Time

A deadline for meeting specifications should be specified. The time frame will have to depend on the testing and specifications required.

Attachment 3

INVENTION AND ECONOMIC GROWTH

(By Jacob Schmookler, Harvard University Press, 1966)

III

THE ROLE OF INTELLECTUAL STIMULI

1. TWO HYPOTHESES AND RELATED MATTERS

We have much to learn about the inventive process. Yet, because invention is important in economic and social change and therefore in public policy, men have speculated and developed strong beliefs about the factors which control it.

Unfortunately, such speculations usually appear as "obvious" propositions preliminary to the analysis of some other problem or to the presentation of some policy recommendation. In either context, while widely believed, they have not been rigorously set forth. When examined they reveal logical gaps. Even their very meaning is sometimes unclear.

The speculations referred to concern the relation of scientific discovery to invention, and of one invention to another. Knowledge obviously builds on knowledge. The question is how. If invention *B* is based on the knowledge provided by invention *A*, does the inventor think of *B* because he learned of *A*? Or did he think of *B* because of the changing technical-economic features of life, including but by no means limited to changes brought about by the use of *A*? This second causal pattern is more complex, and the role of the growth of knowledge itself quite different. Here, knowledge *as knowledge,* new or old, plays a permissive role, like books in a reference library, taken down when needed in order to make an effective response to a stimulus provided by features of daily existence.

This chapter is devoted entirely to throwing light on the first of these views of the relation of the growth of knowledge to the inventive process. Specifically, we shall consider two hypotheses: (1) Im-

portant inventions are typically induced by scientific discoveries. (2) Inventions are typically induced by the intellectual stimuli provided by earlier inventions. The evidence we shall consider is far from direct, but its bearing on the tenability of these two hypotheses is unmistakable, and no better evidence is available.

Both hypotheses seem to have considerable popularity in their own right, particularly the first.[1] They are seldom if ever stated in these terms, however. Instead, we more often hear that a scientific discovery "led to" an invention, or one invention "led to" another. In such statements "led to" is ambiguous. Sometimes it means that the act of learning about the discovery or first invention was the event that led the inventor to make the invention in question, *and* that the inventor was not already trying to accomplish the functional equivalent of the invention he ultimately produced. This interpretation of "led to" is the equivalent of our two hypotheses. It suggests a completely psychological interpretation of the inventive process, in which, under the stimulus of a new idea, the inventor's unconscious mind presumably goes to work unbidden and produces the root idea for a new invention. Thereafter, the inventor is presumably gripped by the idea until he perfects it.

"Led to" can signify a great deal less, however. It may mean merely that while other events already had set the inventor in search of an invention, he used the knowledge embodied in the discovery or earlier invention to make it. Since any invention necessarily depends on pre-existing knowledge, "led to" is always justified in this sense. All that matters in any given instance is whether the facts are as stated. On the other hand, "led to" seems too strong a phrase if only this is meant.

Still another interpretation of "led to" is possible, as implied above, when the phrase relates to the connection between one invention and another. The use of the first invention may change conditions in industry, the home, and so on, and these changes may provide the stimulus which prompts someone to make the second invention. (Such an interpretation of the phrase cannot apply when we speak of a scientific discovery as having led to an invention.) Provided the facts

[1] However, as noted in the text below, statements from which the second hypothesis might be inferred can often be interpreted to signify the second kind of causal pattern described above, in which an invention changes technical-economic conditions and these changes themselves prompt invention.

in the case warrant the statement, the latter may provide a convenient, partial perspective for thinking about part of the chain of events. Here, we need merely note that our second hypothesis, that inventions are typically induced by the *intellectual* stimulus provided by earlier inventions, assumes a different causal pattern.

Our hypotheses also have a possible bearing on the validity of the common belief that knowledge, in particular technology or invention, tends to grow at an exponential rate. Few ideas have proved so intuitively attractive with so little foundation in either logic or evidence. While it must have a long history, the earliest expression I have found of it occurs in a short story by A. Conan Doyle called, interestingly enough, "The Great Keinplatz Experiment." Doyle writes, "Knowledge begets knowledge as money bears interest."

In more recent times, the idea was popularized by William F. Ogburn in a very stimulating and influential book, *Social Change*, first published in 1922. Whatever its other merits, the work illustrates the quality of the logic commonly used to support the argument. As set forth in the supplementary chapter added to the 1950 edition:

> This accumulation tends to be exponential because an invention is a combination of existing elements, and these elements are accumulative. As the amount of interest paid an investor is a function of the size of the capital he has invested, so the number of inventions is a function of the size of the cultural base; that is, the number of existing elements in the culture. In compound interest the principal accumulates, as does the "principal" of culture. . . .
>
> Put in figures, this argument would mean that if a cultural base of a hundred thousand elements yielded one invention, then a cultural base of a million elements would yield a thousand inventions (*sic*), even if the inherent mental ability of the peoples of the two cultural bases were the same. But in reality the yield of the second cultural base would be more than a thousand inventions. The reason lies in the definition of an invention as a combination of existing elements; and as the existing elements increase, the number of combinations increases faster than by a fixed ratio. Thus three elements can be combined by two's in three different ways, four elements in six different ways, and five elements in ten different ways. Even though only a microscopic fraction of combinations will result in a useful invention, the principle of an increasing rate holds.
>
> So exponential accumulation means acceleration. . . .
>
> Exponential growth seldom exists for long in reality for the increments quickly become too large for reality. . . .[2]

[2] William F. Ogburn, *Social Change* (New York: Viking Press, 1950) pp. 381–383. Quoted with permission.

In the first paragraph Ogburn states that invention tends to grow at a constant percentage, or exponential, rate. In the second paragraph he suggests that the number of inventions realized in one period is a fraction of some "combinatorial" function of the number in existence in the previous period. Finally, he states that "exponential growth seldom exists for long in reality."

Two interpretations of Ogburn's argument should be considered. In the first, assume that the fraction of combinations that will result in a useful invention is constant throughout time. In this case, the implied acceleration in the rate of growth exceeds that of exponential growth. Ogburn excludes this by implication as unrealistic. In the second interpretation, assume that the fraction of combinations that results in a useful invention varies over time. In this case, it is clearly the question of how that fraction varies over time that is of interest, and Ogburn's theory, whatever it is, obviously throws no light on why or how it varies.[3]

Chapter I suggested that the possible causes of invention are implied by the fact that an invention is a novel, useful combination of pre-existing elements. A theory like Ogburn's that seeks the causes of invention exclusively in the latter fact faces three difficulties:

[3] Since it is not our purpose to assess the validity of the exponential growth hypothesis, the empirical evidence adduced in its behalf need not be considered in the text. However, the popularity of the idea suggests that a comment on a recent effort to document it would be in order. Derek J. deSolla Price in *Science Since Babylon* (New Haven: Yale University Press, 1961) makes very strong claims to having established "accurately exponential proliferation" (p. 110) in the growth of scientific discovery. He presents no data but publishes four charts dealing with the subject. One, on p. 97, on a semi-logarithmic scale, is of the number of different scientific journals published from 1665 to about 1950. The rate of growth from 1665 to about 1750 shows distinct retardation, followed by a period of more rapid growth but still characterized internally during the period by retardation until about 1800. From 1800 to about 1880, there appear four observations, two very near 1800, one about 1850, and one at 1880. Only this phase fails to exhibit retardation. Thereafter, the rate of growth is markedly slower than that for 1800–1880, except for a strange segment in which time actually seems to reverse itself. Another graph on the same page provides eight observations on the number of abstract journals from about 1835 to about 1950 with three observations clustered at the very beginning and two at the very end. On p. 103 he presents a continuous curve described as giving the number of physical abstracts published since 1900. This graph is on an arithmetic scale, and, while much of it looks as if it might involve exponential growth, calculations based on readings from the graph indicate that the series is generally characterized by growth at a declining percentage rate. Another graph, again on a semi-logarithmic scale, presented on p. 105, of the number of papers published in the theory of determinants and matrices from about 1745 to shortly after 1920, shows generally retarded growth from 1745 to about 1800, growth at a constant rate until about 1880, and at a declining rate thereafter. Anyone who would accept such evi-

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(1) We know very little about what constitutes an "element" in this context. How many elements, for example, are present in a U-shaped strip of metal alloy with, say, six holes in each of the three sections? Is the shape one element or three or five? Is each edge a separate element? Each hole? Each chemical element in the alloy? Is a locomotive one element or several hundred thousand? To what extent does the inventor's contribution consist of recognizing as divisible what others regarded as an element, or of treating as an element what others regarded as a combination of elements? These questions seem so important that it is difficult to treat seriously hypotheses about the rate of technological progress which presuppose unsupported and indeed unstated answers to them.

(2) Even if we assume the foregoing questions to be answered, another unsolved problem immediately arises: we know literally nothing about general rules governing the combination of elements to produce useful inventions. An element may be combined with itself, for example. A straight line can be combined with itself an infinity of times to produce novel and interesting geometric figures. Carbon can be combined with itself and a few other elements hundreds of thousands of times to yield different chemicals, some of great interest. Silicon is only somewhat less versatile, but helium and iron are not nearly so. Two different elements can be combined in many different ways, nor is there any rule limiting the number of elements entering an invention to some specified number. On the other hand, a cross between a television set and an automobile may spell disaster, while the combination of a locomotive and hybrid corn is just nonsense. While some kind of statistical generalizations may prove possible, their basis is yet to be laid.

(3) Whatever the rules governing the production of useful combinations from pre-existing knowledge may be, they relate only to what *could* be done. *What is done may be a good deal less.*

It is in connection with this last point that our hypotheses have a possible bearing on the belief that invention, or technological progress generally, tends to grow at any rate, exponential or otherwise, which increases because the inventive potential increases. Hypotheses of this sort appear to imply that what can be invented will

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dence as proof that the number of scientific journals and the number of papers in them obey "the law of exponential increase" (*ibid.*, p. 101) is easily satisfied.

be. Why should it? What kind of event will make the inventor think of the invention and want to make it? Ogburn, seeking to combat "great man" theories of history, virtually denied to the individual any significant influence on social change. Hence, he neither asked nor answered the question.

One answer which, if true, would provide modest support for the hypothesis that the increase in the inventive potential causes an increase in invention would be that the same events which increase the potential cause men to think of the inventions which those events make objectively possible. That is to say, scientific discoveries and important inventions, for example, would cause men to think of the inventions that they make objectively possible. Thus, if the evidence supports the two hypotheses to be examined in this chapter, then the premise that increases in the inventive potential tend to be realized in practice would gain some support.

Even then, the support would be weak. To suggest either that all possible inventions are made, or that the proportion made changes systematically over time strains one's credulity. If N is the number of possible inventions in any period, then the number of conceivable outcomes in that period is $N + 1$, since one possible outcome is that no inventions will be made. To suggest that virtually all N will be made calls for more proof than the statement that they somehow could be.

Similarly, to assert instead that the fraction m of those possible that are made in any given period is so related to the m of other periods as to yield exponential growth surely demands something by way of proof that has not been forthcoming. Only when we know much more than we do about the circumstances governing inventive activity can such assertions be even tentatively assessed. If N is the number of possible inventions in a period, the number of different *sets* of inventions which might actually be made during the period is 2^N. The probability that, in any given period, any given invention will be made will vary between zero and one, depending on the invention and the circumstances; and the probability distribution for the m of one period can vary greatly from that relating to the m of some other period. There is no a priori reason for supposing that m is constant over time, or changes systematically.

The possibility that m may vary randomly arises from the fact that the number of inventions that are made in a period depends not

only on the number made in the previous period but also, among other things, on which ones were made then. If m is much less than unity, the number of combinations of possible inventions leading to any given number of actual inventions is likely to be astronomical. Thus, if N is the number of possible inventions in a period, and n is the number actually made in that period, n could consist of any one of $\frac{N!}{n!(N-n)!}$ different sets or combinations. For example, if $N = 100$ and $n = 50$, these 50 can consist of approximately 10^{28} different combinations (taken without regard to order) of the N possible inventions. If the order of appearance is also relevant, the number of possibilities is far greater. It seems reasonable to suppose that the number of inventions made in the next period will be affected — although in unknown ways — by which of the 10^{28} combinations consisting of n specific inventions actually occurred.

If, instead of accepting the causal mechanism suggested above, one seeks to support the Ogburnian hypothesis by arguing that the stimulus to invent comes not from intellectual events but from the changed conditions that result from using whatever inventions are made, the hypothesis appears even less tenable. For then conditions would always have to change in such a manner as to induce either all, or the right fraction of all the new inventions that the earlier inventions made possible, and this would seem to require divine assistance; and no mechanism exists which would induce men to make those inventions that prior scientific discoveries made possible.

One final, perhaps obvious, comment seems in order before we turn to the evidence. The belief that scientific discoveries and major inventions *cum* intellectual stimuli are the prime determinants of technological progress seems to underlie the conviction of many economists that such progress is essentially a noneconomic phenomenon and of noneconomic origin.

2. SCIENTIFIC DISCOVERIES AS STIMULI

To ascertain the relative frequency with which scientific discoveries or major inventions not only permit but indeed directly induce the inventions which follow and build on them, chronologies of important inventions, regardless of country of origin, were compiled

for four important industries — petroleum refining, paper making, railroading, and farming. Each chronology, shown in Appendices C-F, was prepared by a research assistant with special competence in the field and then revised to secure as much uniformity of treatment among the industries as possible. These industries were chosen because of their importance, the diversity of potentially relevant conditions, and the comparative ease with which patent statistics could be compiled for comparison with the chronologies. Thus, in terms of size of firm, petroleum and railroading are large-scale, paper making is medium-sized, and farming is small-scale. Railroading and, more recently and in other ways, farming have been regulated. Petroleum and railroading are relatively modern whereas the other two are ancient. While none of them owes its origin especially to antecedent scientific discoveries — as do, for example, the electric industry, plastics, nuclear energy, and electronics — petroleum and paper (and to a lesser but increasing extent the other two) rely considerably on science. Hence, the hypothesis that scientific discoveries direct the course of invention would seem to have a fair chance of surviving if it is true.

Inventions were included in the chronologies if they were important either economically or "technologically." An invention was considered economically important if its commercial use had an economically "significant" effect on the industry.[4] It was considered technologically important if, with subsequent improvements and modifications of its essential idea, it led to one or more economically important inventions.

It is interesting and important, and not wholly digressive, to note that lists of important inventions, when used as a point of departure for assessing the impact of individual inventions on economic development, may lead to grossly erroneous inferences. An invention derives its importance partly from the way it fits into its environment, not from its technical attributes alone. For this reason an important invention in the United States is likely to be an unimportant

[4] Theoretically the economic importance of an invention could be measured by the percentage increase in output per unit of composite input that it made possible, weighted by the commodity's share in national product, or by the share of resources using the invention in the industry's total output. (As noted shortly, for some purposes one would prefer the inventions unweighted but ranked according to percentage cut in unit cost.) Lacking anything approaching such data, our researchers had to evaluate inventions subjectively, keeping these criteria in mind, in the light of the comments made about the inventions in the technical and economic literature.

one in India, and an important invention in the twentieth century is likely to be an unimportant one in the nineteeth — and the converse of these propositions is true. Thus, our chronology of important railroad inventions omits one made in the late 1920's which solved a problem that had plagued designers of steam locomotives for decades: The big depression and the advent of the diesel locomotive made it a nullity; had it occurred a decade or two sooner, we would have included it. Since an invention is major or minor only with respect to a defined set of circumstances, and since we are dealing with hosts of important inventions made under *changing* circumstances, we cannot tell, without far more information than is available, whether their changing relative frequency over time reflects changes in the technological attributes of the inventions themselves or changes in the environment.[5] Consequently, while we shall usually treat our important inventions as though they derive their significance from their own technological characteristics, it is desirable to bear this ambiguity in mind.

Applying the aforementioned criteria as well as could be to the inventions recorded in the literature, the research assistants ultimately recorded, for the period 1800–1957, 235 important inventions in agriculture, 284 in petroleum refining, 185 in paper making, and 230 in railroading — 934 in all. While there is a presumption that every invention included is more important than any invention knowingly excluded with respect to each industry considered singly, differences in the amount of published material on each industry make it probable that the "importance" of the least significant invention in each chronology differs considerably among the four industries.

Moreover, the individual chronologies may be subject to biases of unknown character and magnitude. In general, the entries derive from technical and trade journals and from technological and economic histories. The number of inventions reported in a given period by trade and technical journals may be affected by such extraneous factors as the amount of advertising and the number of subscriptions, and the number reported in histories is likely to be affected not

[5] Because of this consideration, a chronology of inventions which decreased cost per unit of output by a given percentage, unweighted by the amount of output or input involved, would be better for our purposes than the chronologies we compiled. Unfortunately the sources available appear to reflect weights, albeit only implicitly and perhaps inconsistently, of the sort indicated in the text which relate somehow to the magnitude of the total effect on the industry. Hence the decision to use as consistently as possible the criteria stated.

only by biases in the journals which the historians may have used as sources but also by the difference between the historian's needs and ours.[6]

To test the potency of scientific discoveries as stimuli of inventive activity, the four researchers were instructed to record any suggestion in the literature that a particular scientific discovery (or any other event) led to the making of an important invention. For *most* of the roughly one thousand inventions in our four chronologies the literature available unfortunately fails to identify the initiating stimuli. On the other hand, for a significant minority of cases, the stimulus is identified, and for *almost all of these* that stimulus *is a technical problem or opportunity conceived by the inventor largely in economic terms,* that is, in terms of costs and revenues. This may be illustrated by four among many possible examples drawn from the two industries, paper and petroleum, most dependent on scientific discovery. Thus, in the paper industry, the famous Fourdrinier continuous paper-making machine was invented in 1798 by N. L. Robert to solve labor difficulties in a mill producing assignats for the French revolutionary government. In the same industry, in 1942, J. B. Butler, Professor of Zoology at University College, Dublin, invented wet-strength paper after noticing the need for waterproofed maps during war games of the Irish Local Defense Forces, in which he served as adjutant. In the petroleum industry, Everest's invention of the vacuum still in 1866 (which provided the foundation for what later became Socony-Vacuum) was prompted by the impairment of the color and odor of the distillate by existing stills. In the same industry Houdry's fixed-bed, catalytic cracking process, patented in 1931, was pursued, as were later catalytic processes, with the declared goal of increasing the yield of gasoline per barrel of crude under the spur of rising gasoline consumption.

[6] For example, our chronology of important petroleum refining inventions shows a rapid rise until about 1870 *followed by a plateau* until the end of the century, while a similar chronology compiled from H. F. Williamson and A. R. Daum, *The American Petroleum Industry* (Evanston: Northwestern University Press, 1959), Vol. I, shows the rise to 1870 followed by a decline to the end of the century. Yet, the items in our chronology omitted by Williamson and Daum are no less important than those they included. (I was informally advised that Williamson and Daum also reached this conclusion.) The difference in behavior of the two series is simply the result of a difference in purpose. We sought to include all items meeting a minimum level of significance, whereas the central purpose of Williamson and Daum was to account for the rise of the industry's technological base. Once they had accomplished this, they devoted relatively more of their resources to other purposes.

In those few instances where the literature identifies a stimulus which is not an economically significant technical problem per se, that stimulus is an accident. Thus, thermal cracking of petroleum was discovered in 1861 when the still operator, having left his post, found on his return that the heavier vapors had recondensed and returned to the overheated still where they were redistilled, with the result that the yield of kerosene increased by 20 percent.

In contrast to the many accounts identifying economic problems as the immediate stimulus, *in no single instance is a scientific discovery specified as the factor initiating an important invention in any of these four industries*. There are, to be sure, a few instances in which one suspects that such discoveries may have led directly to the inventions concerned. Thus, Paul A. Sabatier's Nobel Prize-winning work on hydrogenation in 1896 was followed by V. N. Ipatieff's work in the same field after the turn of the century, and by others later. What is not clear is whether Ipatieff's researches were stimulated by Sabatier's discovery (which was a necessary precondition for it), by the rising demand for gasoline, or both, and if the latter, in what proportions. (Certainly subsequent research in the hydrogenation field was markedly influenced by demand.) Again, Tennants' invention in 1799 of dry chlorine bleaching powder, later used in bleaching wood pulp for the paper industry, may have been stimulated directly by Scheele's discovery of chlorine in 1774. Yet the twenty-five year interval suggests that it was probably evoked by other influences and that Scheele's discovery was only a necessary condition. The record simply fails to provide the fine detail in these cases needed to permit certainty.

The credibility of the evidence is of course open to question. When information is available the inventor himself is generally the source. Emphasizing the problem that he solved rather than a discovery that might have made him recognize it is perhaps more ego-gratifying.

Nonetheless, the internal evidence suggests that the accounts are probably accurate enough on this score. When the inventions themselves are examined in their historical context, in most instances either the inventions contain no identifiable scientific component, or the science that they embody is at least twenty years old. In the first case, obviously no scientific discovery could have stimulated the inventor to make it. In the second, it seems much more likely that the inventor either knew about the discovery for a long time and called

upon his knowledge when he found a use for it, or that, seeking the solution to a problem, he examined the literature for knowledge that might bear on it. While it undoubtedly happens sometimes, the probability seems small that, reading a paper or book that discusses a discovery made years ago, an inventor is brought to think of an invention that he has no prior intention of creating.

Thus the evidence suggests that, while many important inventions in the four fields depended on science, few if any were directly stimulated by specific scientific discoveries. Moreover, given the highly diversified character of the four industries covered, it seems probable that studies of most industries would yield a similar conclusion.

On the other hand, the relevance of this conclusion to important inventions in the electrical, electronics, nuclear, chemical, drug, and pharmaceutical industries requires comment, for the first three of these originated directly in scientific discoveries; invention and research in all of them is heavily dependent on scientific knowledge; and unquestionably instances of important inventions directly induced by scientific discoveries dot their development.

Nonetheless, several considerations suggest that the conclusion would probably need only to be qualified, not reversed, in the case of these heavily science-based fields. In the first place, none of the studies that I know of reports antecedent scientific discoveries as an important determinant of corporate research expenditures.[7] Rather, the factors listed are more consistent with the hypothesis that, as in the industries studied here, economically evaluated technical problems and opportunities arising in the normal conduct of business are dominant. Since 30 to 40 percent of the research and development funds spent in American industry goes to these science-based industries,[8] one would expect scientific discovery to appear on such lists if it were indeed a major factor in them.

There is an even more persuasive reason for supposing that our findings are also pertinent to most of the important inventions in science-based fields. Even if one made the unwarranted assumption

[7] See National Science Foundation, *Science and Engineering in American Industry: Final Report on a 1953–1954 Survey* (Washington, D.C., 1956), pp. 41 *et seq.*; C. G. Harrel, "Selecting Projects for Research," in C. C. Furnas, ed., *Research in Industry* (New York: D. Van Nostrand Co., 1948); and C. F. Kettering, "Trouble as an Approach to Research," in Malcolm Ross, ed., *Profitable Practice in Industry Research* (New York: Harper and Brothers, 1932).

[8] See *Research and Development in Industry, 1961*, NSF 64-9, Table XVI, p. 35.

that every radically new invention made in these fields was directly stimulated by some particular scientific discovery, most of the ultimate social and economic significance of the line of development which such inventions open up can seldom be ascribed to that alone. On the contrary, most of the effect derives usually from a host of inventions, some very important, which improve and adapt the basic one. Once introduced, a basic invention, regardless of the stimulus which produced it, becomes much like any other item of commerce, with shortcomings that creative men will seek to remedy and latent possibilities that they will try to tap. Thus the important inventions in a field which follow the basic one are likely to arise from the exposure of creative minds to technical-economic phenomena, just as with most of the important inventions in the field studied here. Moreover, it is probable that many, if not most, of the basic inventions in the science-based fields had a similar origin. And it is certain that most of those that did not, because of the cost entailed in making them, were evaluated in essentially economic terms before they were made.

Thus it is true that the discoveries of Franklin, Faraday, and Henry "led to" the electrical industry, and those of Chadwick, Fermi, Hahn, Meitner, and Strassmann, to the atomic age. Yet decades were required to develop electrical technology before the industry amounted to much. And the more rapid realization of some of the possibilities opened up by the discoveries in nuclear physics required the largest collection of high-level scientific manpower ever assembled and a greater expenditure of funds on a single project than had ever been made before. Hence, even when the idea for the invention is suggested by scientific discovery, the commitment to make it is generally an investment decision. This implies that even in such cases the invention is not an automatic outgrowth of the discovery. It is made only after estimating its value in the context of the times.[9]

If what has been said above is correct, the kind of role played by individual discoveries in pure science in leading to the electrical and atomic industries is uncommon. Insight-yielding accidents and dis-

[9] It is also worth noting, although the point should not be pushed far, that scientists were interested in the research leading to electricity and the breaking of the nucleus partly because in each instance the possibility existed that a revolutionary source of power would be uncovered. To be sure, this possibility was often denied, and in any case the motives of pure science were, so far as the scientists themselves were concerned, evidently paramount.

covery within industrial research operations are probably more frequent, but more frequent still is the production of inventions that are sought because problems and opportunities have been initially identified.

The implication of this is obviously not that science is unimportant to invention but merely that its role is often misconceived. Most inventions, including most of the important ones, are made by men more attuned to events in the workaday world than to the latest issue of the *Physical Review*. Under these circumstances, the effect on invention of scientific discoveries taken individually is smaller than their collective effect. The progress of science means that, at successive points in time, creative and educated technology-producers view the changing processes and products of industry and other aspects of life with deepening understanding. They can sense problems and opportunities that their predecessors could not and imagine previously unimaginable inventions relating to them. But this is more a matter of changes from generation to generation than from day to day. In short, vital though it is, scientific discovery is far more a permissive than an active factor in the inventive process.

Two readers of earlier versions of this book independently argued that the foregoing is consistent with the conventional view of the effect of scientific discovery on invention and economic growth, since economic growth is basically a matter of centuries whereas the preceding discussion is in terms of decades. If by the conventional view is meant the proposition that a given scientific discovery is not only a necessary but also ordinarily a sufficient condition for the occurrence of the later invention based on it, I cannot agree. To state the issue as I now see it: (1) If some omniscient being were to list all the inventions that could have been made in the twentieth century on the basis of the scientific discoveries made in the nineteenth, his list would greatly exceed the list of inventions actually made in this century. In short, scientific discovery is seldom a sufficient condition for invention, either in the short run or the long. To account for the inventions actually made, we would have to bring into prominence the factors which emerge later in the book. (2) If somehow we were able to eradicate from history a scientific discovery required for some important invention, then perhaps more often than not some other invention would have been made, or taken off the shelf and used, to do roughly the same thing. In brief, particular scientific dis-

coveries are seldom even necessary conditions for later inventions if we think of the latter in terms of rough substitutes.

In the long run scientific progress opens up a wide variety of alternative paths for invention and economic development. The choice of path depends largely on extrascientific factors. Moreover, the choice of one path often forestalls the development of another, and even the growth of basic science also reflects the forces that condition the course of invention and economic development. Partly for these reasons, it seems an error to suppose that the course of technological and economic progress could, in principle, be predicted from the progress of science. Another important reason, of course, is that many important inventions of even the recent past have not depended on scientific knowledge in the proper sense of the term.

One possibility suggested by the foregoing analysis is that many inventions made possible by the great growth of science in modern times are not made. Those who know the problems or opportunities may not know the science, and those who know the science may not know the problems or opportunities. By the time either group learns what it lacks, the problems or opportunities may have vanished.

[The following information was subsequently received for the record:]

ADDITIONAL QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question 1. Several symposia and workshops conducted last year by government agencies and by academic institutions, participated in by a wide range of experts in most all the disciplines of auto technology, reflected a pronounced consensus in support of the need for basic research in most of the fields identified by the Administration. Would you explain more fully the basis for your apparently isolated conviction that most of those judgments are wrong—that what is really needed is more use, through innovation and invention, of the scientific base already available.

Answer. I. First of all, I agree with the "pronounced consensus" that it would be nice to have more basic research in automotive areas. A.E.A., my operation, is a heavy user of research results, and we are conscious of working on the basis of intellectual tradition, basing our own efforts on the contributions of many people (mostly engineering scholars and scientists). It is a strange world when I, a very academic person, am forced into what seems an anti-research position. I love research, and feel the country would be better off if basic automotive research of decent scientific discipline were more heavily funded than it is. More knowledge will offer new technical options. University research has the very important additional function of training people this country needs badly.

Engineering research is a good thing. In our country, engineering research results in many areas have more than justified the research cost. However, in the automotive field the application of research results has been much less than it could or should have been. This is not the fault of the researchers, and is not entirely the fault of industry. It is generally difficult to apply research results in heavy industries. This problem is not confined to the automotive field.

II. I am trying to make a point about priorities. This country could use more engineering science applied to automobiles and other things. As an inventor who uses research results, I would benefit directly from the fruits of new research, as I benefit from old research results. But it is important to recognize that we already know a great deal of engineering science applicable to automobiles, and that much of this science is not used. I have sent copies of a number of engineering textbooks and handbooks in the technical fields identified by the administration to the sub-

committee staffs,[1] in the hope of showing that much which has not been applied is well enough established to be set down in handbooks and textbooks. Particularly if one looks at the bibliographical sections of these books, one begins to sense how rich our scientific-technical heritage is right now. New knowledge would be nice, but we already know a lot. One can reasonably argue that this nation would benefit from increased support for basic engineering research for automotive purposes and other purposes. But we are not desperately short of basic research results.

We are desperately short of innovation and invention applied to heavy industrial problems (including but not limited to automotive problems). Applying research results to the practical and dirty world of mass produced automobiles is no trivial job; to get results applied takes great intellectual effort, hard work, a long time, and significant amounts of money. Without this effort, work, time, and money research results are not applied.

Where are the capable people working to apply research results in innovative and inventive ways to the basic parts of the automobile? There is much small scale ingenuity, but where is the large scale ingenuity?

Counting noses, I do not believe that there is one inventor with enough academic ability to get into engineering graduate school for every fifty researchers in the areas of engineering applicable to the automobile. With so little innovative and inventive work going on, many research results (including some very important and some very old ones) are never applied.

Many of this nation's basic technical problems could be solved if much more effective support were given to science-based invention. It takes inventive effort to apply scientific knowledge rigorously to solve practical problems.

III. This nation needs a mechanism to bring forth this inventive effort and a mechanism to see that there is a fair chance that the products of first-rate inventive effort can be practically applied. I do not believe these mechanisms would be either difficult or expensive to set up. The National Innovation Centers suggested in S. 1250 are a part of the solution, and I strongly support them, although they do not solve the problems confronting a serious inventor in a heavy industrial field. My own suggestions would help in the automotive field and could be extended to other energy-related and heavy industrial fields with little change. Basically, any workable system for bringing forth a renaissance of inventive effort in America has to do two things to attract the able and ambitious people needed. First, the economic inventives must be shifted to attract the economic support serious invention needs, and make the hard work of invention attractive to enough first-rate people. Secondly, the stigma which now goes with being an inventor should be replaced with a certain amount of recognition for first-rate work. The government has it in its power to do both of these things. If they were done, the supply of first-rate inventive work in this country would greatly increase. I feel a factor of ten increase in inventive output applicable to our most pressing technical problems (energy, the environment) would be a reasonable thing to shoot for.

If the supply of high quality inventive output increased, the value of new research results (as well as old ones) would increase in proportion, since results would have an increased chance of being practically applied.

IV. A. So far my answer has been somewhat abstract. It is time for a specific example to illustrate what I mean. Tribology is a field identified by the administration; roughly, tribolgy is the study of bearings and other sliding surfaces. Work in tribology has been going on for a long time. How have the many exact, beautiful, and useful results which have been built up in tribology (bearing theory) over the last century been applied to the design of the automobile engines we all use?

That is an important question. Under characteristic driving conditions, at least a third of all the mechanical work combustion gases do on the pistons of automobile engines is dissipated in friction between sliding parts within the engine. Making reasonable assumptions about design, this means that at least a third of automobile fuel consumption is attributable to internal engine friction. This figure corresponds to roughly twenty billion dollars a year worth of oil imports. If application of bearing theory to engine design could reduce this figure it would be practically important. I chose the example because I personally believe, on the basis of calculations, that inventive application of the research results of tribology could reduce friction between sliding parts by at least a factor of five. The example of tribology is also useful because many of its basic results are quite old and expressible in terms which are mathematically beautiful, very clear, and scientifically certain. A vitally

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[1] *Shock and Vibration Handbook* by Cyril M. Harris & Charles E. Crede; *Handbook of Heat Transfer* edited by W.M. Rohsenow & J.P. Hartnett; *Standard Handbook of Lubrication Engineering*, O'Connor & Boyd, editors; *Theory and Practice of Lubrication for Engineers* by Dudley Fuller: *Formulas for Stress & Strain* by Raymond Roark & Warren Young; *The Internal Combustion Engine in Theory and Practice* by C.F. Taylor.

important part of tribology, full film bearing theory,[2] is now completely understood in the scientific sense, and is exact. All the basic results of full film bearing theory can be derived mathematically from Newton's law of viscosity (in some cases with corrections for temperature and pressure effects on viscosity). The math in this field can be complicated, but the physics is basic and clear. This is the part of tribology which concerns this example.

Three of the books submitted to the subcommittee staff are relevant to tribology and its application in engines. There are two handbooks: "Standard Handbook of Lubrication Engineering," edited by James O'Connor and John Boyd; and "Formulas for Stress and Strain," by Raymond Roark and Warren Young. (Strain deformations greatly affect geometries which determine real bearing performance.) These books put much practically useful information into compact form, and, through their excellent bibliographies, put one in touch with a rich technical heritage. [The basic ideas and fundamental equations of hydrodynamic lubrication are explained compactly in Chapter 3 of O'Connor and Boyd, although this chapter need not be read to understand the current discussion.] The third book is "Theory and Practice of Lubrication for Engineers" by Dudley D. Fuller, published in 1956 and still a standard text. Those who read this book should understand bearing theory well enough to use it. The book should be clearly within the grasp of any competent undergraduate engineer. [Incidentally, Beno Sternlicht is one of Fuller's graduate students. Fuller has also helped me as a consultant.] Fuller's book has the merit, too rare in engineering texts, of giving the reader a sense of the practical power of its subject. For example, one learns of huge telescopes supported on hydrostatic bearings so the many tons of apparatus can be moved smoothly by an electric motor no bigger than a man's fist; one sees a heavy steel ball spinning with practically no friction on a film of air; one learns of full film bearings which smoothly support the huge loads generated in steel rolling mills; one learns the theory of the pivoted plane slider bearing and is immediately shown how pivoted sliders are used in electric power plants, where some pivoted plane sliders have operated for more than a quarter of a century with negligible wear and very low friction. Here is rigorous and clearly applicable engineering science made accessible to every literate technical person. Nowhere in engineering science have I seen basic research results made more accessible than in this book.

Because the practical application of research results is central to this discussion, a short history of the research results of full film bearing theory is useful here. Isaac Newton published his law of viscosity in the seventeenth century; a mathematical purist would dismiss most of the developments in full film lubrication since as "mere application" since they can almost all be derived mathematically from Newton's law of viscosity. More than a century and a half later, with the coming of railroads, Beauchamp Tower performed experiments on railroad bearings and discovered the fluid pressures generated in hydrodynamic bearings in 1883. In 1886, Osbourne Reynolds explained the hydrodynamic action in journal and other bearings, clearly showing how the wedging of a viscous fluid between the sliding surfaces of a bearing would develop the pressures observed by Tower three years before, and deriving Reynold's equation [3] directly from Newton's law of viscosity. From here on full film bearing theory's development has been a classic example of applied mathematics generating practically useful and clear results from fundamentally understood physics. Some of the greats of late nineteenth century physics worked in hydrodynamic bearing theory (there is, for example, a Raleigh step bearing). By 1900 a great deal was already known about full film bearings. In 1905, A.G.M. Mitchell of Australia and A. Kingsbury of the United States independently invented the pivoted plane slider bearing, each working from published results.[4] The pivoted plane slider bearing can be shown mathematically to be the minimum friction hydrodynamic bearing, and the mathematics works in real industrial application. By the First World War, pivoted plane sliders were in practical use—combat ships using pivoted plane sliders fought in the battle of Jutland (also, on the German side). Today, the thrust of all ship propeller shafts is bourne by pivoted plane sliders, and pivoted plane slider bearings are standard in the bearings of electrical power plants, and standard in some other heavy industrial applications. (Even now, only a tiny fraction of our hydrodynamic bearings are pivoted plane sliders: in the real sense, there are no pivoted plane slider bearings in automobiles.

In the 1920s and 1930s, bearing theory was applied to a number of industrial jobs. The hydrostatic hearing, where a pumped volume of pressurized fluid separates the sliding surfaces, was developed. (New applications of hydrostatic bearings to indus-

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[2] Hydrodynamic bearing theory, hydrostatic bearing theory, and the theory of squeeze films.
[3] Equation (3) of Chapter 3 of O'Connor and Boyd, op. cit.
[4] The pivoted plane bearing is explained on pages 3–6 and 3–7 of O'Connor and Boyd, op.cit.

try are still being found today.) In the late thirties and forties, it was finally noticed that journal and wrist pin bearings in engines were operating and had been operating for forty years under loads much heavier than could be readily explained by steady state hydrodynamic bearing theory. In 1947, Dudley Fuller explained the fact by showing the important effect of squeeze film fluid mechanics on bearings subject to fluctuating loads. Fuller, with his graduate student, Frank Archibald, developed the mathematics of squeeze films (which is derivable from Newton's law of viscosity) very thoroughly in the 1950s.[5]

During this period, many other practical and mathematically sophisticated people contributed to full film bearing theory. Chapter 5 of O'Connor and Boyd, "Analysis and Design of Sliding Bearings" by A.A. Raimondi, J. Boyd, and H.N. Kaufman includes over a hundred pages of very useful design information, developed by many able research people. The work continues. In short, full film bearing theory is very well developed.

Now how have the many useful results which have been built up in full film bearing theory been applied to the design of automobile engines? That is an important issue: engine friction consumes a lot of fuel. To make sure of the answer, I refreshed my memory about full film bearing theory and, with my references beside me, took a current production engine, quite representative of standard engine practice, apart piece by piece. I could find plenty of examples of mechanical ingenuity, plenty of evidence that the engine was a highly evolved device built with reasonable knowledge of the loads to which it is subjected. The materials in bearing shells were used with economy and sophistication. Still, looking carefully, I could find no instance where it was reasonable to believe that full film bearing theory had been used. There were plenty of places where it should have been. The engine components were highly evolved, but they had evolved by an arduous process of trial and error, quite independent of any discernable bearing theory.

For the purposes of engine design, the corpus of full film bearing theory might just as well not have existed. Important and intellectually clear research results were applicable, but they were not applied.

This is not an academic issue. Huge amounts of fuel would have been saved if the results of bearing theory had been inventively applied to engine design when they were available. Huge amounts of fuel could be saved if inventive work could apply bearing theory now. The engine friction of a current production engine is about ten times higher than the friction values one expects when one designs a machine carefully using full film bearing theory.

Invention is needed to practically apply bearing theory to engines. The inventive work must be done by able and scientifically competent people. Without the efforts of competent inventors, the research results of full film bearing theory cannot be applied. It takes invention to apply most research results. With a desperate shortage of competent inventors, adequately funded and working as inventors, most potentially useful research results are never practically applied, and results which could have had great usefulness to our nation and the world are wasted so far as practical application goes. Productivity is much less than it could have been. Our world is poorer than it needs to be.

IV. B. The idea of science-based invention as a fulltime job worthy of an able person seems foreign enough that an example seems necessary. A.E.A. is working to apply full film bearing theory to automobile engines. It is not our main business (which is control of all the fluid mechanical details governing homogeneous charge engine combustion and emissions), but the opportunities in engine friction were irresistible. Since the work is difficult and expensive (and since our work must be very well demonstrated to convince an auto company), we are a long way from finished. Even if the "inspiration" work was complete (and it probably isn't), we still have a lot of "perspiration" work to do. Given more funding, I would immediately hire several competent engineers to help the work along. But we are far enough into it to give an example without upsetting our patent lawyers too much. The example is one chosen from a number of others. It will be specific, but will involve the sorts of problems involved in the great majority of tasks a competent inventor faces, and will therefore have general value.

Engines have main journal bearings, which fix the axis of rotation of the crankshaft with respect to the engine block, and the rotation of the crankshaft is converted to reciprocation of the pistons through wrist pin bearings and connected to the crankshaft through bearings called con rod bearings (or con rod big end bearings). Wrist pin bearings work so well and consume so little energy that it is doubtful that the current design will ever be significantly improved. Main bearings and con rod

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[5] See Chapter 7 of O'Connor and Boyd, op.cit., written by Archibald.

bearings still cause trouble, and limit engine performance in several ways. We are trying to improve them.

Energy consumption in these bearings, *per se,* isn't a particularly bad problem (usually main and con rod bearing friction is less than 20 percent of total engine friction), but if these bearings could safely take high loads at low engine speeds, total engine friction under many power outputs of practical significance might be cut in half, since the engine could make its power at a lower RPM and a higher torque load. It would also be nice to cut the friction of these bearings, and to cut their wear rates. Main and con rod bearings are still limiting in many racing engines, and we wanted a shot at that problem, too.

Looking at standard bearing design charts derived from theory and proven in practice, con rod and main bearings look terrible. For the same bearing area, bearing diameter should be less and the bearing should be longer axially. There can be no doubt of this, and it is certain that engine designers know that their heavily loaded con rod and main journals are badly designed as journal bearings. The difficulty is that structural requirements of the crankshaft are in direct conflict with the dictates of good journal bearing design, and some nasty tradeoffs are involved. For strength of the crankshaft, which is a very highly stressed part, one wants maximized journal diameters and minimized axial bearing length—just the opposite of what the journal bearing designer would want. Considerations of part deformation and alignments also tend to conflict with the design dictates of conventional journal bearing theory.

The response of engineers designing engines has been to ignore bearing theory and cope with their tradeoffs as best they can. Different engines show somewhat different tradeoff decisions. Within the context of conventional journal bearings, they all look like reasonably good compromises. In every case, bearing performance at low speeds and high loads still leaves much to be desired. In the engines where low speed high load bearing capacity is highest, great penalties have been paid in friction to buy this capacity.

Designers are still fighting with this problem, and progress is being made. But this is a problem designers have been consciously dealing with for at least sixty years, and it is unlikely that there are any big breakthroughs to be had within the contest of conventional journal bearing design for the con rod and main bearings.

To get out of this box will require invention. A new kind of bearing, cheap and durable enough to be practical, needs to be invented and developed. The new design has to have greatly increased load capacity. It must be manufacturable at a reasonable price. It should have significantly lower friction under all conditions than the bearing it replaces. It must fit in the available space. If it is to replace the old and established con rod and main bearing designs, it will have to be much better on most counts.

At A.E.A. we are working to invent and develop such a bearing. Whether we succeed commercially or not, the process we have to go through to do this inventive work is worth explaining. Problems in the example are typical of the problems a serious inventor faces.

Looking at the loading conditions to which the main bearings and con rod bearings are subjected, we decided to try to apply the pivoted plane slider bearing for both these bearings. The pivoted plane slider bearing, in itself, is old, well understood, and thoroughly proven. Calculating bearing performance with a hypothetical infinitely stiff and strong pivoted plane slider arrangement, bearing characteristics would be very attractive in terms of load bearing capacity, friction, and wear. The problem was that real pivoted plane slider bearings are made of real materials, and are neither infinitely stiff nor infinitely strong. Conventional pivoted plane slider bearings operate at about one twentieth the load which would be required in main or con rod bearings. Present art pivoted slider bearings are too weak and too flexible to work in con rods or main bearings. They also take up too much space. All these problems relate not to the mathematical ideas of a pivoted plane slider, but to the practical problem of providing a strong bearing supporting structure which also pivots. The inventive problem quickly reduced to the problem of producing a strong, stiff and compact pivoting structure.

Here is a typical example of why inventive work is important and necessary to the practical application of research results. There are usually technical, nuts and bolts problems standing in the way of application of research results to a practical case. Unless the inventive work to solve these nuts and bolts problems is done, the research results cannot be applied to practical hardware, no matter how "theoretically useful" these results may be.

To apply an old and proven kind of bearing arrangement to the new context of the con rod and main bearings, we had to come up with a new kind of pad bearing pivot structure. We weren't going at the problem blind. We had the corpus of full

film bearing theory available for use. We also had a tremendous amount of practical research work, much of it summarized in the Roark and Young handbook, to apply to our pivot support structure problem. Because the technical culture in which we live is so rich, we also knew that we had able and specialized consultants available to use at reasonable prices. Nonetheless, we weren't smart enough to figure out the solution to our pivot support structure problem right off-the-bat; the process of getting our solution involved a combination of scholarship, and analytical facility, much directed searching behavior, many false starts, and stubbornness. In the course of this work we think we have come up with two independent and adequate solutions to the bearing pad pivot support structure problem. Neither one is far enough along in demonstration to convince the risk-averse people who make decisions in auto companies. Still, the history of the development of these solutions is a simple and clear example of inventive work.

When we first faced up to our pivot support structure problem, we started making sketches with out handbooks before us (and with occasional trips to technical libraries). We used up a lot of paper quickly in this initial focusing process. We came up with many different approaches which were unsatisfactory for one reason or another before we got to any that look like they had a real chance.

We settled on a particular approach after a little time. It wasn't very well focused, and involved mathematical problems which we could not solve. I asked my friend, Professor Bela Sandor of the University of Wisconsin Engineering Mechanics Department to help me as a consultant and he agreed to do so. Bela's help was inventive enough that his name will be going on one of our patents in this field. There were still mathematical aspects of the design which needed work, and Bela suggested another consultant in the department. This man did mathematical work on the support which we could not have done, and solved part of our mathematical problem in analyzing the structure. Working from his output, I solved the other part. At this point we were confident enough about the structual aspects (and of course the full film bearing theory aspects) to be essentially certain that we could produce a very heavily loaded pivoted plane slider bearing which would function well, if we had the money and time to work the approach through teething problems. We did not know precisely what these teething problems might be, but could assume, from long and sad experience, that there would be some expensive and frustrating difficulties along the way.

Our first pivot support structure looked good in a number of ways, but it took up too much space to fit in the connecting rod, although it would fit in the main bearing caps which are the only parts of the main bearings requiring change. The structural equations of the bearing pad and pivot structure made it absolutely certain that we could never shoehorn this first pivot support structure into the space required for a connecting rod bearing.

It was time to do more thinking, and read over the textbooks once again. On doing so, I found that an idea in a textbook, with a few straightforward modifications, could be applied to make one of the ideas which we had rejected in our first stage of sketching useful, and that this approach might well be compact enough and yet stiff enough to support a pivoted pad bearing in the connecting rod. Working from handbooks, I set out the best design I knew how to make. There were substantial questions about its mass producability and durability. At this point I needed a bearing consultant. I got on the telephone and started asking the question, "Who would be the best person in the country to help with this problem?" Several people mentioned Dudley Fuller, and commented that he might not have time for me. Professor Fuller kindly agreed to work with me as a consultant. Since consulting fees and plane tickets are very much cheaper than experimental mistakes, I flew to New York to see him.

Fuller was very helpful. He checked my work, found most of all right and solved the biggest durability and manufacturing problems with my approach by throwing out pieces which I had though were necessary. He knew what one could practically get away with in a sense which I did not. I thought the contribution important enough to include Professor Fuller as a co-inventor, but he disagreed. Fuller told me of important references I had not known about, and put me in touch with much research experience I could have contacted in no other way. He gave me a list of problems to check out which I would not have known to worry about otherwise. Fuller also helped me greatly by telling me he thought my work worth doing, and practically promising.

My relation with Professor Fuller is not atypical of my relation with a number of able and senior engineering scientists. The relationship between science-based invention and engineering research and science per se is potentially very close. Research scientists are aware their research results are not applied, and are disappointed by the fact.

It would benefit the country if there were more able and disciplined inventors around working to apply research results. If my experience is any guide, tolerably able and disciplined inventors would be welcomed by the most able people in the research community.

Referring back to the specific example, we at A.E.A. now know enough to be certain that we have two pivoted pad support structures capable of taking very heavy loads, and that one of them is compact enough to fit in the connecting rod bearing. We face manufacturing problems and experimental problems, but we know enough to be certain of the endpoint which awaits us with full development of these pieces. They form only a part of our friction reduction efforts.

We have work to do on both these pivot supporting structures. Nonetheless, quite a significant amount of inventive work on pivoted plane slider bearing support structures has been done already. When we do more experiments, problems may arise and it will likely require ingenuity to solve these problems. The technology for manufacturing the pieces at an attractive cost may require invention too. We are a long way from finished.

A point of importance, based on my previous experience, deserves to be emphasized. So far as I can tell, no auto company is willing to devote anything but dilatory resources to any device which is not well proven, and generally the level of proof required involves full size vehicle buildups proving out the function and durability of the device. Auto companies don't want inventions (at least they don't want them enough to pay for them). They want finished products. If my past experience is any guide, it is a waste of time to show our pivoted plane slider bearing inventions to auto companies unless we are really there to use the automotive engineers as consultants. If past experience is a guide, they will have kind things to say but they will be absolutely unwilling (perhaps in fact unable) to commit any significant resources to any device which is not fully proven. To prove our pivoted plane slider bearing connecting rods and main bearing caps, we expect to have to spend at least several hundred thousand dollars. These ugly realities do not correspond to the average person's sense of invention as a casual enterprise.

To do the science-based invention that is required to practically apply research results to the dirty and practical world of automotive engineering requires serious commitments of able manpower, significant support, a good deal of time, and a rather significant amount of well-motivated persistence. One has to be an able person to have much chance in the field. My judgment is that the intellectual requirements for first-rate invention about match the intellectual requirements needed to do first-rate scientific or engineering research. In my judgment, people capable of doing good scientific research would also be capable of doing good inventive work if they set their mind to the task and were supported. The United States has a good number of people able enough and well enough trained to do excellent scientific and engineering research. They are not presently employed as inventors. Many of them should be.

If human abilities applied to the field of invention are to bear fruit, the work needs significant amounts of reasonably long-term economic support. If inventors were smarter they could get by with less support, but a precisely analogous argument can be made in any research field. Much of the money any inventor spends will be spent making mistakes, but it is important that his expenditure levels and efforts be under reasonable mechanisms of control if scarce resources are not to be squandered. There is virtually no limit to the amount of money which can be wasted in attempts to perfect ill-conceived inventions. For this reason I suggested that a process analogous to the peer review process used to allocate research resources be applied to heavy industrial inventive work. The process suggested would go a long way to remove the stigma which now makes inventive work artificially unattractive, and would also serve the extremely valuable function of inventor education. It would also make less likely the personal tragedy, which I have seen more than once, of a person wasting his life on the basis of scientifically unsupportable obsessions. A caption in a cartoon I saw years ago still haunts me and should haunt anyone trying to do serious and responsible invention. The caption read, "Smith gave up his whole life for his music. And he didn't play very well, either." A good selection process, by bringing inventors face to face with technical realities, would make such tragedies much less likely. The process itself would also go a long way to assure that inventors were aware of technical traditions, and were working in close contact with able people in the research community.

I also think that the flexibilities and disciplines of the capitalistic system have an important role to play.

Science-based inventive work is a serious business. Referring back to the specific case of application of full film bearing theory to internal combusion engines, we at A.E.A. are working on each of the bearing interactions in an engine which involves

significant friction. We hope to cut total engine friction for a given engine speed by at least a factor of five. Computations suggest that a factor of ten reduction should be possible although practical compromises are likely to make a factor of ten difficult to achieve. In every case of bearing interaction that we look at in the engine, we found that full film bearing theory could not be applied without a difficult and reasonably extended process of invention. The challenges we have faced on the connecting rods and main bearings are typical and representative of the problems which we are facing in the other areas. The inventive work that is required to surmount these problems requires significant amounts of effort and money, and could never happen unless someone set out, with both funding and determination, to solve these problems. The enterprise, by its very nature, requires a willingness to risk significant amounts of time, money and effort on the strength of theoretical arguments. There are gambling aspects at the core of the game.

V. Heavy industrial science-based invention is not an easy thing to do. It doesn't happen by accident, and it doesn't happen casually. The work requires scientific sophistication and discipline, and a willingness to *bet* on the basis of sophisticated theoretical arguments. For fundamental reasons, science-based heavy industrial invention must be an adventurous business if it is to be any business at all.

It is a great misfortune that the fundamental requirements of science-based inventiveness are in basic conflict with the most central doctrines and traditions of automotive engineering and automobile industry management. In my judgment this conflict, more than any other thing, explains the almost astonishing inability of the auto industry to change itself quickly and in the basic ways which are required for its own prosperity. To clarify the issue I would like to quote from my testimony at the Boston D.O.T. Conference of last year:

"The disciplines of risk avoidance are central to the auto industry, and risk avoidance must stay central in automotive management doctrine for fundamental organizational reasons. Anyone who has been close to the manufacturing coordination problems which auto companies must face every day knows that risk taking has such a high chance of causing problems in the production process that it must, as a practical matter, be rigidly suppressed in the production line organization. Moreover, changes which look small to an outside observer appear, often rightly, to be risks to the auto companies.

The disciplines of riks avoidance permeate the automotive engineering profession much more strongly than they do the other engineering professions, although all engineering professions appear to outsiders to be conservative. The disciplines of risk avoidance are but little relaxed for the automotive engineering men working research departments, particularly since these men, if they are ambitious, wish to be transferable to other places in the company where risk is absolutely unacceptable.

"Because they must be risk avoiders, auto companies are ill-suited to support any fundamental breakthrough developments, even when the developments are totally within the context of the reciprocating piston spark fire engine. If a man were to present any United States auto company with an idea, only on paper, which was in fact capable of radically improving automotive fuel consumption, performance, and emissions, the auto company would not support the work without a great deal of expensive and time consuming data regardless of the merits or correctness of the idea. Support would be withheld no matter how compatible the idea was with existing production arrangements, no matter how much money the idea might save the company, and no matter who the proposer was, if the proposer was from outside the company. Even inside the company, support for any such idea would be hard to come by if significant amounts of resources would have to be committed to bring the idea to fruition."

I should still stand by every word of that. It is hard to imagine a set of management patterns more in conflict with the needs of basic innovation. For this reason, I do not believe that basic science-based invention is possible for anyone working in an American auto company or in the basic industries which supply the auto companies. I'm sure this sounds like an extreme statement, and I do not make it lightly. Nonetheless, I've given the matter thought for easy-to-understand personal reasons. If my operation fails, where do I go to get a job? There are a number of places in the auto industry where I could get a good salary (or could have before this testimony, anyway). In none of them would I be permitted to function as an inventor. I would not be given resources enough, nor time enough. Automotive organizations do not trust any of their employees enough to give them the resources and discretion needed to do fundamental science-based invention. They do not trust scientific arguments enough to support science-based invention. To support science-based invention or be open to fundamental change requires that the auto industry gamble, something which it will not do.

The irony is that, although the industry may not have to gamble to survive, it will certainly have to gamble in order to prosper. Left to itself, there is not much reason to be heopeful that it will.

Specifically, there is no evidence that I know of which leads me to believe that there is any chance that significant progress in production automobile design will be made simply because the scientific base on which vehicle design proceeds is increased. Applying science-based information to practical vehicles requires, except in very rare cases involving extraordinary luck (I can think of no such cases), a process of invention. Where are the capable people, working as inventors, to apply this research information? When, with names and dates, was scientific information ever applied in a sophisticated way to vehicle design? A complete list of examples, collected with very permissive standards on what constitutes scientific sophistication, would still be a sorry thing when the list was set beside the needs of the industry, and its central place in the United States and world economy. Single companies involved with computers and electronics could compose a more impressive list than the list which could be put together for all of the innovations in the entire auto industry in the last sixty years. Science-based invention goes on in the electronics business and it pays dividends. It does not go on in the automotive industry.

Our nation and the automotive industry would be better off if it did go on. The capital needs of the industry would be drastically less if the industry were inventive. Also, with inventiveness, we might be able to have an industry which had an advantage with respect to the Europeans and the Japanese. If you apply the standards of inventiveness we've become used to in electronics to the European or Japanese auto makers, they don't look very innovative. But compared to the U.S. auto industry, the Europeans and Japanese are very innovative indeed, and that is why they are beating us.

Congress has it in its power to drastically increase the supply of science-based inventive work in the auto industry, and if it did so, I think American creativity and entrepreneurial spirit would have a good chance of turning our domestic industry around. People of first-rate ability (people capable of doing good scientific or medical research) would have to be attracted to the industry. They would have to be funded and brought into contact with first-rate scientists. The stigma which now goes with the title "inventor" would have to be removed for these people. The inventors and their investors would have to know that if the inventive work performed well enough, the inventors would have access to enough power to enter the industry in a solid way. My proposal would do this; there are probably a number of alternatives which would achieve the same purpose.

If this were done, there would be a great flowering of innovation and invention in the automotive field. If the program were extended to energy related inventions, there would be a great flowering of science-based inventive work in all of the energy related fields. There are plenty of very able and scientifically trained people in this country who would be capable of doing first-rate science-based inventive work. These people, particularly when they are young, are attracted by money and glory. The program I suggest would provide both. In our country today, power, money and glory are all hard enough to come by that the program would be attractive to very good people. There would be a big response. People who now dream of Nobel prizes would dream of taking a slice out of the auto industry. If the program were instituted it would be a good thing for me, but I suspect that I would be up to my neck in competition very quickly. I'm also sure that the great increase in science-based invention would bring results. It would be a good thing for the country.

It is worth mentioning that, if my suggestion was instituted, it would cost the government very little unless the innovative work was forthcoming. If innovative work did come, it is likely that the program would end up as a net moneymaker for the government. The program would also reinforce the entrepreneurial free enterprise spirit in America, something which could use some help. The bureaucratic problems with the proposal are minimal.

SUMMARY OF QUESTION 1

I would like to apologize for the length of this response, but Mr. Smick's question was a very tough one. I was asked to explain more fully the basis for my apparently isolated conviction that what this country really needs in the automotive field is more use, through innovation and invention, of the scientific base already available, rather than increased support for basic scientific research itself. My position is this: additional automotive research support would be nice, and would widen the sphere of technical possibilities, but without science-based invention there is no reason to expect that this research information would ever be applied. We need first rate science-based inventive work if the scientific information we already know is to be

applied, and if new research results are to be practically applied to production vehicles. Basic research is a national good, but increasing the national supply of first rate science-based inventive work is a far more pressing need. It is in Congress' power to meet this need. If it does so, the practical value of research, old as well as new, could be greatly increased.

SUMMARY OF ANSWER TO QUESTION 1

I. Research is admirable and widens the sphere of technical possibilities, but research per se cannot convert possibilities to technically useful actualities—applying research results to practical cases almost invariably involves a disciplined and reasonably difficult inventive effort.

II. The number of able, scientifically trained, disciplined and funded inventors and innovators is now so small that most research results are not applied (even if they have great practical potential) for want of inventive work to apply them. The shortage of inventiveness is notable in the auto industry, for reasons which will be explained. With much increased inventive work the practical value of research results (old and new) would be much increased, and the public justification for funding automobile realted engineering research would increase as well. My private judgment is that auto research support, without more inventiveness, is probably not justified; but that research support combined with effective efforts to radically increase inventiveness, would be well justified.

III. Congress has it in its power to radically increase the supply of inventive work in automotive and other areas by changing the economic and social incentives to invent. The country is well supplied with able and scientifically trained people, now otherwise engaged, who could and would become effective inventors if the social and economic incentives to invent were large enough. For want of these inventors our nation is much poorer than it needs to be.

Two things, both in the power of Congress, would be required to greatly increase the inventive output of this country. First, the economic payoff from invention must increase for inventors and their investors. Secondly, the stigma now associated with invention should be removed for people doing first-rate work. My proposal would do both these things. If it was enacted, the supply of first-rate inventive work applicable to automobiles would greatly increase in a reasonably short time. With more inventive work, the practical value of research results would be much increased.

IV. A. Because the idea of science-based inventive work seems unfamiliar, a specific explanatory example is offered. Research results from the field of full film bearing theory (a subset of tribology) are discussed. These results, if applied, would significantly reduce automobile fuel consumption. For want of inventive work, research results have not been applied to auto engines, even though many of the research results are quite old.

IV. B. To explain clearly what is meant by inventive work, some of A.E.A.'s work to invent and develop main bearings and con rod bearings which use full film bearing theory is discussed. Whether A.E.A.'s efforts are successful or not, the efforts offer a good example of what science-based inventive work is, and the manpower, support, and time required for practically useful inventive work.

V. In light of the example, the difficulty of producing significant innovation in the auto industry is discussed. Practical government steps which could improve this situation are discussed in light of the specific example.

VI. In a short summary, my position is restated: additional automotive research would be nice, but increasing the national supply of first-rate science-based inventive work is a far more pressing need. If inventive output is increased, the practical value of research, old as well as new, would be greatly increased.

Question 2. You define a breakthrough or meritorious invention worthy of government support as one promising substantial economic savings. Why do you appear thus to reject inventions whose benefits in terms of safety, the environment, preservation of limited resources or other societal goals may not be readily measurable in dollars?

Answer. I never intended to reject societal goals. I was involved in air pollution research in 1967 (as a 19 year old economic consultant for a President's Council of Economic Advisors project for N.A.P.C.A., E.P.A.'s predecessor) and have been working to solve air pollution problems continuously since. The great bulk of my own inventive work has been directed at eliminating trade-offs between emission control and fuel economy. I would be the last person to reject the societal goals you speak of.

Still, as an inventor in the automotive field, it is terribly difficult to survive on any terms at all. As an inventor I have enough problems finding support on issues with clear money pay-offs. I can't even think about committing the resources of investors to "societal goals which may not be readily measurable in dollars."

Let me give you a specific and personal example. Some time ago I invented, with a couple of my engineers, a device which we are sure would substantially improve passenger car safety by making it easier for drivers to control their cars in accident avoidance situations. The invention would not have affected vehicle ride quality. We looked at it enough to feel that the invention, fully disseminated in the vehicle population, would save several thousand lives a year. We consulted with some experts to reach this judgment. Our tentative estimates were that our invention, well designed, would add less than ten dollars to the price of a vehicle (my judgment would be that it would cost five dollars). We checked around. There was no way to support the work, and no reason to believe we had any real chance of selling it. We didn't even talk to the auto companies, since we were absolutely certain they would turn us down. The government had nothing to offer which had any promise of getting our invention into production cars.

I would be happy to show you or the Office of Technology Assessment the invention, but it would have to be done on a confidential basis. My operation is too poor to pay for patent applications on "frills" like this.

Of course I would be very proud to help save many thousands of lives, and would risk a good deal to do it. But at A.E.A. we live in a resource poor and very brutal world. My engineers and I stay near the edge of exhaustion most of the time because there is so much to do on emissions and fuel economy. My operation is, by far, the richest independent inventive shop I know of in the United States. As an American, I'd feel much safer with more competition. We are very poor now, and in the past my inventive operation has been desperately poor. The total amount of money I have spent on inventive work over ten years is less than two million—less than eleven minutes of oil imports at current rates. None of this money came from government. A fundamental moral principle was expressed by Immanual Kant. Translated freely from the German it reads, "My duty ends where my strength ends."

I've stayed in the business because I was pretty sure it was possible to improve fuel economy by at least a factor of 1.5 (the difference between 30 mpg and 20 mpg), applying basic scientific principles to engine design. If you have A.E.A.'s work evaluated by the Office of Technology Assessment you will find this estimate reasonable (although not yet proved; it takes time to do these things). Working with this almost astronomically large financial incentive, it has been very hard to support the work. Much of my difficulty in finding support has been due to aspects of patent law and tax law under the direct control of Congress. I am very happy that this Committee and others in both branches of Congress are considering the role of the government in nurturing innovation, and are working to promote innovation with a level of attention and concern not found for many years. As a private inventor, I am personally grateful for this. Reading recent testimony before this Committee, particularly the perceptive and attentive questions of Senators Stevenson and Schmitt, has given me a hope for the future I have not had for many years. Still, although the U.S. rate of innovation might be greatly increased, I think economic action will still be controlled by the signals generated by money.

The private enterprise system allocates scarce resources by money accounting. Many would wish it otherwise. (I am one.) But it is idle to expect private enterprise to respond efficiently to incentives not expressible in money. An inventor, to survive at all, must justify his actions to investors who think in terms of profit and loss. Consideration of profit and loss is a valuable discipline.

In the question posed there is the phrase, "meritorious invention worthy of government support." Although I respect the motivation behind the phrasing, the language still needs to be brought down to earth. I would be happy to be supported because my work is meritorious on aesthetic of other grounds. But I respectfully suggest that, to be "worthy of government support," an invention must have a real chance of going into production or leading to something which does go into production. Unless the invention has a money pay-off, I do not see how this can happen.

Question 3. How did you happen to pick the value of $200 million per year as the criterion for economically meritorious inventions?

Answer. The number was picked arbitrarily, but seems to me, on the basis of my studies and experiences, to be in the right ballpark. I should not object if the cutoff point were placed at either the 100 million dollars per year or 300 million dollars per year. It seems to me that most of the potential inventions which would justify the label "breakthrough" in the automotive field would save the economy considerably more than a billion dollars per year if they were fully disseminated through the economy. In my considered judgment there are inventions based on scientific knowledge already available which would, if they were reduced to practice and widely applied commercially, save tens or even hundreds of billions of dollars over a reasonable period of time. Given the rigidities and risk aversions in the auto

industry, it seems to me that a cutoff around 200 million dollars a year of net economic saving to the economy is about right because it would be hard for an invention with less economic value than this to overcome the rigidities of the auto industry as it currently exists.

In chemistry there are reactions with very high energies of reaction which do not go under conventional circumstances because they also have high energies of activation. Certain military explosives are excellent examples. When they go, a great deal of energy is liberated. But unless the explosive is hit very hard, it is essentially inert. The auto industry has a high activation energy with respect to change in an analogous sense.

Most people find it difficult to conceive how large and lumbering heavy industries are. I recall very clearly sitting in the MIT faculty diningroom with Professor Jack Longwell, a man of long experience in the oil industry. Crunching on his salad, Jack commented, "Any innovation of any importance at all in the oil industry saves a hundred million dollars." The comment was made casually, but in the tone of a man absolutely sure of his ground. Jack clearly felt, on the basis of his industrial experience, that any innovation worth less than $100 million wasn't worth the industry's worrying about. The comment was something of a shock to me. However, thought and interaction with heavy industry has convinced me that Jack was wise in what he said. Marginal optimization processes go on every day within industry. But the big steps, the things which can be called breakthrough innovations or inventions, are discrete steps and the difficulty of introducing such an innovation is large indeed. Given their organizational circumstances, it is *rational* for the oil industry not to worry about innovations which would save less than $100 million if implementing these innovations would involve any significant inconvenience.

Anyone who has worked with both groups knows that the auto industry is more risk-averse and less flexible than the oil industry. To get the auto industry to move requires a big incentive.

All private inventors would wish that the barriers to change were not so great. Nonethless, talking about the sort of heavy industrial innovative work in which I have specialized, the payoffs must be very high in order to justify commitment of resources to an invention.

Question 4. You suggest that Government guaranteed loan support be provided sufficient to enable an inventor to proceed, if necessary, with substantial production independent of established industry. What then happens if that industry rejects the product based on its value judgements which are dominated by marketing considerations—at times admittedly faulty?

Answer. The central core of your question, paraphrased, is "what happens to the Government's loan guarantee if the industry rejects the invention, for whatever reason?" The short answer, pretty clearly, is that the Government loses its money alongside of the money private investors lose. I will come back to the issue of these risks, and the reason why I think these risks can be easily overstated.

Other parts of the question make me want to apologize for my inadequate explanation of the context between the companies of industry and an inventor or inventive group. The automotive industry is not a monolith, and it would not be necessary (or indeed possible) to proceed with substantial production independent of "established industry". The inventor would be, in the natural order of things, in a cooperative relation with several companies in the industry, and perhaps in a competitive relationship with a number of others. The inventive group would have to have, for fundamental reasons, a close cooperative relation with several automotive suppliers capable of substantial production of his product, since any part which goes on an automobile must be available from several independent sources of supply.

The question I am being asked also includes embedded in it a strong implication that an invention would be rejected based on value judgements which are dominated by marketing considerations. Marketing considerations work for an inventor's hopes, not against him. Marketing considerations are generally the greatest source of hope for success the inventor has. An invention must be justified on the basis of market considerations, its ability to enhance the sales of the automobile makers or its ability to increase their profits by reducing their costs. The invention will have been developed, from the first, with marketing considerations in mind. Unless it is attractive from an economic and marketing point of view, the invention has no chance at all. Every competent inventor knows that.

In an auto company, the marketing people and the dealers are the inventor's natural allies. Marketing people like to sell things that are exciting, new, and better. Marketing people have very pure motivation: they want to sell automobiles. These are the most adventurous and flexible people in an auto company's hierarchy,

and if an inventor cannot attract the support of a number of marketing people in an auto company, his cause is almost lost.

The biggest difficulties in getting an invention accepted were mentioned in the answer to my previous question. It takes an extremely strong incentive and extraordinarily complete levels of proof, in order to get the engineering and production parts of the company to accept an innovation. Because of the job they have to do, these parts of an auto company are much more conservative than the marketing parts. They present by far the largest challenge and barrier to acceptance of an invention. The primary requirement for the loan guarantee is to give the innovative group, once it is proven the merits of its work beyond reasonable doubt, the ability to surmount this challenge.

To put the loan guarantee in context, I feel it would be useful to work through some of the economic aspects of the inventive work in the context in which it would exist if my proposal were to be adopted.

First of all, the inventor would have had his work favorably evaluated in an extremely rigorous scientific adjudication process before his proposal was even submitted to the government. The government would check this process and make sure that it was a complete one. The government would judge the potential economic value of the invention to the economy to be large, in excess of some reasonable cut-off such as $200,000,000 per year. Once the government approved the project, it would make concessions which would permit the inventive work to be supported. Support would come in a way which subjected the work continuously to the disciplines and checks and balances inherent in the free enterprise system. The concessions to the inventor are worth recounting here:

1. The inventor or owner of the invention would be exempted from the S.E.C. limitation of 35 offerees in private placements. This exemption would dramatically ease the task of raising investment money for the invention.
2. Investors in the inventive project would be assured that the invention would not be reduced to practice for tax purposes until the invention was actually being sold on a full scale commercial basis.
3. The inventive project would be specifically permitted to pay sales commissions of up to 10 percent to facilitate the selling of its equity.
4. The government would invest in the inventive project on a dollar-for-dollar matching basis. The government would get the same percentage of the venture as a private investor, except that the government's share would return to the inventive project after the government received five times its investment in inflation-adjusted dollars.

In addition, the government would assist the inventive group in getting detailed specifications which it might not otherwise be able to get for itself: this would involve "Assistance in determining the actual detailed specifications the innovative component would have to meet to be fully acceptable in the technical sense (getting a realistic set of specifications on the level described in the "selected Topics of Specification" example submission). Every effort should be made to secure the comments of the auto industry, and to secure their cooperation and technical input, although the program should be prepared to proceed without industry cooperation if necessary. Sectors of the industry which take an adversarial stance to the innovation should be carefully recorded for potential use in patent defense.

In any event, the best set of practically obtainable specifications for a complete, practical vehicle demonstration should be set out. The specifications should be tough but reasonable. The auto companies should be given a chance to comment on the proposed specifications before they are settled".

Only after these steps were successfully completed and the specifications were met would the inventor or inventive group be eligible for the large loan guarantess. An invention which has come so far has an excellent chance of offering its target customer very large economic advantages if only it is backed with sufficient power to get it over the barriers built into the industry.

We are talking about government risks here. It is very important to emphasize that our hypothetical inventor will have had to attract several million dollars worth of investor money and satisfy some tough customer-oriented standards before he is in a position to qualify for the loan guarantees. To do this, the inventor will have had to deal with investment bankers who will have carefully considered, independently, the saleability of the invention and the barriers to innovation in the specific target industry. These investment bankers are competent and completely unsentimental people. Their study will have diminished the risk to the government. The inventor and the investors will have worked hard to assure that the invention was attractive to the industrial customers for which it was devised.

There will be cooperative aspects of the relationship between the inventive group and its customers. In the end, the inventive group can only make money by finding

a way to make even more money for its customers. Nonetheless, an auto company is not monolithic. Instead, it is a complexly articulated organization with many separate parts, each with interests which may or may not correspond to the interest of the corporate whole. In the automotive industry "breakthrough innovation" will involve change of existing automotive components. In every case there will be technical individuals and groups in the auto company with a vested interest in the old component design. These are people who value their jobs, and also people who are very aware of the difficulties entailed when *any* change occurs in the production process. These people know Murphy's Law by heart, and have all had bitter experiences with the difficulties involved in production change. If one has been close to a production change, it is impossible not to sympathize with people who never want to change anything again. Most production engineers have had enough bitter experience to have a strong and visceral objection to any production change whatever.

As an inventor, one is ill equipped to please these people. One's organization must work hard to meet their objections as best it can, but nonetheless these people are, because of the nature of their jobs, against innovation. These production people have real power to set out the rules by which an inventor must prove his invention. They stack the cards against innovation as much as they can, even though the technical success of an invention might serve the real economic interest of their company. For an inventor's work to succeed technically and economically requires that the inventive group have access to significant economic power. The purpose of the loan guarantee is to give the innovative group that power.

Basic technical change needs to come to the United States auto industry. It is in the national interest that sufficiently good inventive groups have access to such power as the loan guarantee would give.

What would this power be used for, and what are the risks to the government involved with the loan guarantee?

First, the uses. Money from the loan guarantee, disciplined by the risk money required on a pro-rata basis to get the federal loan guarantee, would be used to overcome the many objections and difficulties which would be raised by the production people. The money would be spent for very extensive verification processes which might be required by the auto companies. The money would be spent doing tooling design and soliciting bids from subcontractors to assure that the invention could in fact be built for an attractive price. The money would be spent to build fully satisfactory full-size vehicles and to buy the plane tickets and do the other things required to make sure that auto dealers were fully aware of the development and to assure that auto dealers supported it. They money would be spent designing the invention to fit a number of particular vehicles sold by several different auto companies (for negotiating reasons, some of these auto companies might be foreign) so as to give the inventive group more negotiating power and more options. The money would assure that the inventive group was capable of whatever patent legal defense expenses were necessary. Most importantly, the availability of the loan guarantee would change the terms of trade under which prices with the auto companies would be negotiated. Auto companies have a traditional unwillingness (which has done the industry great harm) to pay for innovation. In industry, the ability to command a price is a measure of economic power. The presence of the loan guarantee would give the inventive group that power. It is inconceivable that the inventive group would ever be able to negotiate an agreement where it made more money off of its invention than the auto company to whom it had to sell. But without power, the inventive group might make only a pittance.

The availability of the loan guarantee would substantially increase the incentive to do heavy industrial science-based invention, and substantially increase the incentive to invest in invention.

What would the risks be to the government? I feel they would be small enough to be justified. Forfeitures might occur, but I feel that it is most unlikely that any forfeiture would amount to much more than 20 million dollars. The reason is this: for every dollar of loan guarantee some ten cents, perhaps twenty cents would be better, would have to be raised of actual risk money. This risk money would be forfeit unless the invention were able to pay its debt service. If investors, who are able and unsentimental men, thought the prospects of the venture inadequate, the plug would be pulled very quickly. The risks to the government would be carefully watched by interested and competent parties in the private sector. Before $20 million had been expended, one would have an extremely strong idea of what the chances of success in fact were. In this industry, 20 million dollars is not so very much money. The research budget of either Ford research or GM research runs to more than 5 million dollars per working day, to give a basis of comparison.

My bet would be that the innovative group would never have to use much of its loan guarantee if it actually had it as a bargaining chip at the negotiating table. My

bet, also, is that the chances of forfeiture would be rather small. Still, the risks would be significant. But neither government nor industry faces a situation where it is possible not to take risks. What fraction of federal research projects, or industry research projects, find practical application now? I feel that the risks in the loan guarantee program, although real, would be very well justified.

Senator STEVENSON. Thank you.

Let me make sure I understand the proposal. The NBS would need about $500 million initially to cover overhead for managing this program.?

Mr. SHOWALTER. $5 million.

Senator STEVENSON. $5 million.

That would be for the first year?

Mr. SHOWALTER. This would do the whole administrative job. The proposal requires the inventor to do most of the selection work on his inventive proposal. The inventor has to chase down the top level people—members of the National Academy of Sciences, the National Academy of Engineering, buy plane tickets, talk these guys into consulting with him. The inventor has to go through the effort of getting very high level and rigorous approval, make sure his analysis is right before his proposal even shows up at the Government agency. The administrative job facing the NBS in evaluating proposals of that quality should be pretty straightforward, and the management overhead costs shouldn't be expensive.

Senator STEVENSON. Well, what does the NBS do with the $5 million? It makes guarantees of loans available to inventors?

Mr. SHOWALTER. I cannot frankly imagine how the management costs of the program would exceed $1 million, but the Government has ways of spending money. So I increased the estimate by that factor.

Essentially, NBS would be administering a filtering function with very high standards, with most of the filtering done by an outside review process analagous to outside review of NIH or NSF. Once the filtering was done, once the hardware invention was passed and judged by the Bureau of Standards to be capable, if fully disseminated, of saving the economy some respectable sum—I suggest $200 million a year as a reasonable cutoff—then, if a few concessions were made, the inventor or inventive group could support its work with private capital. Some reasonable changes in the patent law, some clarifications of tax law, the expert approval in the NBS process, and any inventor can go to the private market and get all the capital he needs for his engineering and proof-of-principle work. I'm certain of that.

Now, the big question is, once the process is reasonably far along, how do you get complete enough specifications from the industry to make a real, full-scale commercial proof-of-principle an engineering possibility? The inventor could use Government help to get the specs he needs.

It's hard to get specifications out of industry. Given specs, commercial proof-of-principle will obviously have to take $5, $10, $15 million. But you can get that money.

Senator STEVENSON. But you need a guarantee?

Mr. SHOWALTER. You can get money for the commercial full-scale demonstration without a Government guarantee.

Senator STEVENSON. Why would you need a guarantee?

Mr. SHOWALTER. The Government guarantee would be needed later, after you have proved, in terms of extremely well-worked-out specifications, that you have a technology that has actually demonstrated full-scale proof-of-principle. You would need a loan guarantee to put the innovative group in a reasonable negotiating position.

The innovative group will be facing huge and tough companies. The innovative group will need power to have a decent chance in this face-off. The loan guarantee would give that power.

The amount of money needed to have negotiating power—which means real alternatives—in this industry is too large to get from private sources. One can raise $10 or $15 million of risk capital. Even when risk is much reduced, one cannot raise a hundred.

If the innovative group had the loan guarantee, my guess would be that an accommodation with industry would be quickly reached. The loan guarantee probably wouldn't have to be used. But it would be vital that the innovative group had it as power in reserve. This is a situation where the innovative group, even with superlatively good hardware, needs a leg up from the Government.

The presence of the loan guarantee program would greatly increase the incentive to invent and invest in invention, and would greatly increase the chance of good ideas coming to fruition as practical hardware. With the safeguards I suggest—very tough standards to qualify, pro-rata risk capital matching—I feel the risk to the Government would not be excessive, and the benefit to the public interest would more than justify the risk.

Senator STEVENSON. Well, at the outset, what assurances are there that this program would produce the kind of inventions that you anticipate that the industry will accept?

Mr. SHOWALTER. There can be no assureances. May I treat the issue of acceptance first? If the hardware is actually fully developed, and well backed, the industry would have to use it. It couldn't help itself. You could get in if you had hardware and sufficient economic leverage. From a practical point of view, I have no doubt of that. I have had some practical experience.

Essentially, the difficulty is what constitutes proven hardware. Proof-of-principle, in this industry, involves a great deal of expense. Also, once you have proven your hardware, you still have to be in an economic position to negotiate a price: It's a matter of greatest possible importance to the investment banker with whom you must deal.

If you knew that if you could produce a system that would give very substantial technical improvement; if I knew that, given first rate technical performance, you could come up with the capital to sit at a negotiating table with the auto industry on the basis of rough equality for purposes of negotiation; and if your investment bankers knew that; then you could get in the private sector all the money that was needed to support heavy industrial invention. The opportunities for heavy industrial invention would have drastically increased.

May I say, by way of example, that my shop spends half a million dollars a year, and we are having to escalate spending rather rapidly now. This should give some sense of the support you need to do science-based inventive work in this industry.

I think it's improper for this funding to be a matter of Federal dole. But Government programs could be put together at reasonable cost to facilitate entry of innovative groups into an industry which at the moment is very well defended.

Now, it may give a false impression to say that the auto industry is against innovation. That's not entirely the way it is. The problem is much more a situation where they are so risk-adverse, their needs for data are so large, the bureaucracies are so many-headed, that you need individuals and groups disciplined, funded, and determined to go in and make it work. The capitalistic system, given a good incentive and given some reasonable hope that, with solid hardware, you can get leverage, provides the very mechanism for doing that.

My judgment is that if what I am asking for here were done by the Government, my ability to raise capital would be quadrupled, roughly. So, it is a self-serving trip I take. It is also my judgment that the sort of people who are frequently close friends of mine, who tell me I am crazy to be an inventor—first-rate minds, many top-rated academics—people who wouldn't be caught dead working in automotive engineering now would go into the business if the program I suggest were instituted. These first-rate people are aware of their opportunities. Given the program, many first rate people would enter the field in search of money and glory. Presently these same people think of automotive invention as an excellent way to achieve poverty and disgrace. The program suggested would change that.

At the moment, you can't find competent people, in the sense that the medical research people are competent, working in automotive or energy related invention. You can't, because nobody thinks the opportunities are there for a first-rate person.The program I suggest would offer the opportunities. There can be no assurances, but I feel many people of high ability would enter the field, and they would be able to achieve dramatic results. I feel that the entrepreneurial private enterprise system would deliver very well.

It's fair to point out that, if the high-level inventions were not forthcoming, the program I suggest would cost very little money.

Senator STEVENSON. Why is everybody coming back to automobiles, the one most retarded industry? Mr. Ketcham makes a pretty good point, I thought. He indicated that automobiles shouldn't be the highest economic priority. It's more than we can afford. Yet, I think that he would recognize that transportation of goods and people, regardless of what happens to the automobile, is critical, more so in this shrunken, crowded, interdependent world, than ever before. And yet, the transportation system, the space systems, the aircraft systems, and so on, I don't know, are perhaps as retarded or more so than the automobile industry.

Would you feel differently about a national commitment perhaps along the lines that you suggested to research and develop all modes of transportation, including those which supply the Government market?

Mr. KETCHAM. Mr. Chairman, I would very strongly support that. We need to understand why the Nation's transportation system is continuing to decline. For 30 years we have focused a great deal of

attention on passenger cars and trucks. As a result this Nation is now facing a very serious infrastructure decay problem that is going to require hundreds of billions of dollars of investment over the next two or three decades if we are to maintain the level of mobility we have enjoyed in past years.

I cannot over-emphasize the need to also look at the institutions that comprise the transportation industry and to better understand them. Again: Yes, I would support a broad-based research program in the area of technology and systems development provided it also studied institutional forces and constraints.

I think you have to understand that the aerospace industry, which has been the subject of some attention today, attempted to move into the transportation field but was unable to produce a sound subway car for New York City. We can easily get someone to the Moon, but it's very difficult to get somebody across town in Manhattan traffic.

Again, it's an institutional problem. I don't have the answers, but we sure need to look.

Senator SCHMITT. A motivational problem?

Mr. KETCHAM. In part, yes.

Senator SCHMITT. It's hard to get a lot of people excited about getting people across town in New York. It's easy to get people excited about going to the Moon. Really, it doesn't mean you can't do it. You just have to have a different structure.

Mr. KETCHAM. Cars in Manhattan, where I live, are incompatible, with the city's environment and the cost of too many cars on the Island of Manhattan, is extraordinary and something we haven't dealt with very effectively. In fact, we recently completed a report for EPA on the cost of congestion in Manhattan. It totals billions of dollars a year in lost resources to the city.

Senator SCHMITT. If the chairman will yield.

There is a constituency for the automobile, which includes most Americans. Your organization, I think, serves a very useful purpose in drawing our attention and the attention of Americans to the consequences of the use of the automobile.

Nevertheless, it is still a basic cultural foundation of this country to have personal individual transport, and we can't blame our institutions—public or private—for not having diverted this cultural end. Nevertheless, it's been there ever since the country came into existence. The first settlers arrived, and they all had individual transport—their feet, their horse, their carriages. It is a cultural tradition and not something that's going to change overnight. It would practically take a revolution to change this tradition.

Mr. KETCHAM. Nobody is suggesting, Senator, that it would change overnight, but we certainly should understand what the conditions are today, what the future holds for us, and whether or not we can really afford to be dependent on automobiles.

Both Mr. Wilder and I have designed racing cars and we're still very much involved in racing. We have both had a long-term love affair with the car. But we have come to realize that the automobile is not the meaning of life, that we need to strike a balance.

Senator SCHMITT. I don't think anybody will argue with you, but I think you will get some argument on how quickly you can do that and what the consequences would be. We are seeing, I think, an

unnecessary recession, but nevertheless a recession imposed on the auto industry now. The consequences to the entire country are going to be profound, if only in terms of the cost to the Federal Government and therefore the taxpayer.

Mr. KETCHAM. Senator, we agree, and we think it will take about 50 years to reverse our over-dependence on automobiles. But it can be done if we want to do it. I think it may be our only effective, long-term program for dealing with the energy crisis.

Senator SCHMITT. What would you think—excuse me, Mr. Chairman—what would you think would be the consequences, and then what should be the response to a fairly rapid decrease in the cost of using your personal automobile? Let's say, a factor of two—half the cost?

Mr. KETCHAM. Lots of people would buy cars and drive more.

Senator SCHMITT. What do you think would be the Government's response? Do you think it ought to be the prevention of its happening? Or should it be encouraged?

Mr. KETCHAM. I have been supporting a $1 gasoline tax for 10 years now. I think we've got to price transportation at the real cost of transportation.

Senator SCHMITT. What is the real cost of a gallon of gasoline?

Mr. KETCHAM. About $3. Let me turn the question around. We did research in New York City and its metropolitan area and found that every time a car drives onto Manhattan Island it costs $10. Ideally, there should be a $10 toll around the Island of Manhattan to internalize the full cost of using a vehicle in the New York metropolitan area. Motorists currently pay $1.50 round trip to get onto the Island.

Senator SCHMITT. You have to discount that with the benefits that accrue.

Mr. KETCHAM. I have a copy of the report. I would be happy to leave it with you to show you the methodology and conclusions of this kind of assessment. It's the kind of analysis that should be done in assessing both the cost and benefits of our transportation system. We have begun doing it for New York City.

Senator SCHMITT. What I am getting at is the basic replacement costs of a gallon of gasoline, which now cost probably twice or half of what we are paying. That's just the basic replacement cost of the product. It's overpriced on the world market. Probably the price would be driven down by appropriate domestic energy policy. Technology could rapidly reduce the environmental costs of driving an automobile.

Mr. KETCHAM. That cost is only a small part of it.

Senator SCHMITT. I understand, but I am saying that there is a potential if we started a research policy. I don't think we will for a while, but that potential could be undertaken. It would suddenly make the cost of driving your car approximately half of what it is today.

Mr. KETCHAM. Perhaps, if the motorist were not forced to pay all the costs and if he would continue to be heavily subsidized. But the indirect costs of auto use are substantial. An analysis that was done for the Organization for Economic Cooperation and Development last year, a report entitled "Cost and Benefits of Motor Vehicles," suggests the magnitude of these costs for the United

States. I applied it to the United States, and, as an example, the lost time due to traffic congestion, according to this conservative analysis, is costing us $51 billion a year.

The Office of Technology Assessments report, "Changes in the Future Use and Characteristics of the Automobile Transportation System" suggests that that cost will increase three-fold by the year 2000 if there is no change in current technology. And that's just for congestion losses. Traffic accidents were estimated to cost between $9 and $21 billion a year; traffic noise, between $7 and $23 billion.

Air pollution, between $14 and $28 billion. And other impacts, which include visual intrusion, that is "sterilization of open space," the pollution of water and land by oil, a total of between $12 and $23 billion, for a total nationwide of between $92 and $156 billion, or upwards of 15 to 20 cents a mile, if you apply it that way, for driving a motor car.

Senator SCHMITT. Well, the unfortunate thing, as you are suggesting, is that the majority of my constituents are ready and willing to pay the cost, and that's the political end of it.

Mr. KETCHAM. Not if they pay the full cost.

Senator SCHMITT. I don't think they see that the point of it is that they won't pay it. They want it to be subsidized. They want the highways to be subsidized. But we do everything we can in New Mexico to advocate 55 miles an hour to save a few lives and save some gas.

Mr. KETCHAM. I don't think the American public has a full understanding of the real cost—the significant costs.

Senator SCHMITT. I am saying, until they do it is very difficult to see the kinds of real costs, as you suggest the real costs are, being borne by that public.

Mr. KETCHAM. A full assessment of the impacts of automobiles on our society could provide answers and information for public debate in that particular area of automotive use. I think it's an area that is not being investigated effectively today. The Chrysler loan guarantee study did not look into indirect costs. It should have but it didn't. I recommend that you consider to these kinds of problems.

Senator STEVENSON. Well, another hearing is about to start, so we will have to adjourn. Thank you very much.

[Whereupon, at 1:45 p.m., the hearing was adjourned.]

AUTOMOTIVE TECHNOLOGY AND FUEL ECONOMY STANDARDS

FRIDAY, MAY 2, 1980

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met at 9:35 a.m., in room 235, Russell Senate Office Building, Hon. Adlai E. Stevenson (chairman of the subcommittee) presiding.

Senator STEVENSON. The subcommittee will come to order.

This morning we continue hearings on automobile fuel-efficient research and technology development.

Senator Schmitt.

OPENING STATEMENT BY SENATOR SCHMITT

Senator SCHMITT. Mr. Chairman, I note that the April 28, 1980, Newsweek cover story is entitled "Detroit Hits the Skids and the Recession Is On." Apparently, Time magazine doesn't quite agree, since their cover story was something else—unusually.

This sobering article, however, describes how the U.S. auto industry is going through the deepest crisis since the Great Depression. Nearly 28 percent of the United Auto Workers membership has been laid off, and announcements of plant closings have become alarmingly frequent, with some additional closings just late yesterday.

In 1972, before the first oil embargo, imported cars were no threat to the U.S. automakers. At least they didn't perceive them as a threat. Today, however, imports account for more than one-fourth of U.S. sales. The Japanese alone have captured a larger share of the U.S. market than either Ford or Chrysler.

The principal reason for Detroit's problems stems from the fact that American consumers have become increasingly sensitive to fuel economy and soaring gasoline prices. Accordingly, fuel-efficient and reliable Japanese and European compacts present an attractive investment compared to larger U.S.-manufactured cars.

I just went through a crisis of decisionmaking on that matter myself, as I traded in my old Ford pickup for an Eagle. Although Detroit automakers have made recent improvements in their fleet fuel economy, continued technological advances are critical if domestic manufacturers are to regain a competitive position in world and domestic markets. This means not only basic research, but rapid and continued technological advances, using the results of current and future research.

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This effort will involve billions of dollars in research and retooling at a time of global inflation, high interest rates, and a sagging market for many Detroit products. Yet, this investment is not only imperative to Detroit's survival, but the survival of the U.S. economy in the short term. it is also a key component to achieving energy conservation objectives.

About 35 percent of all petroleum used in the United States is consumed by automobiles. More efficient use of our cars, highways, and trucks obviously presents a vast potential for decreased petroleum consumption.

Today's hearing will focus on title III of the administration's proposed S. 2015, the Transportation Energy Efficiency Act of 1979. Title III would authorize $800 million of revenue generated by the oil company windfall profit tax to be allocated by the President for basic automotive research. Clearly, however, the language for basic automotive research presented in S. 2015 neither establishes program objectives nor establishes an organizational structure—both necessary elements of a successful research effort.

I understand that the testimony presented this morning will supplement that presented yesterday, and we'll continue to have suggestions of more specifically designed structure for expenditure of these research funds. An automotive technology research program—properly administered and focused, similar to programs in aeronautics, agriculture, and communications—could make a very positive contribution to the national economy and energy conservation outlook.

For reference and possibly emulation, we even have a multidecade model of a successful Government-industry partnership in aeronautics to use in our examination of this issue.

I look forward again, Mr. Chairman, to this morning's discussions. And I once again compliment you on your initiative in this and in other areas. The group here today may not understand that the Commerce Committee has named a bill in your honor. S. 1250 is the Stevenson Innovation Act. I hope that the Senate soon will pass it, not only recognizing your contribution, but because it is a heck of a good idea in the first place.

Senator STEVENSON. Thank you, Senator Schmitt.

As you indicate, the experience of NASA and the aerospace industry in the United States may be of some relevance to this inquiry, and, in addition, one of the legislative proposals before us would lodge a new responsibility for automotive research in NASA. Therefore, our first witness this morning is Dr. Frosch, the Administrator of NASA.

Dr. Frosch.

STATEMENT OF DR. ROBERT A. FROSCH, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. FROSCH. Thank you, Mr. Chairman. It is a pleasure for me to appear before you today to contribute to the discussions on a program of support for automotive technology development.

As you know, 4 years ago, the Energy Research and Development Administration greatly expanded its substantive effort in automotive technology development. Now, under Department of Energy management, NASA is implementing the major part of that effort

that includes development of experimental engines and electric and hybrid vehicle research. Recently, the DOE asked NASA to expand its support to include experimental evaluations of possible future automotive fuels with current and advanced automotive engines, and we have agreed to provide the requested support.

About 1 year ago, the administration announced its intention to extend Federal participation in automotive technology by implementing a cooperative research program, automotive (CARP). CARP, as presently envisioned, is designed to provide a broad basic research activity in the fundamental physical and engineering disciplines related to automotive technology. These disciplines include combustion, thermal and fluid sciences, aerodynamics, acoustics, and vibration, to name but a few. NASA believes CARP, which is to be initiated in the next fiscal year, adds an important dimension to Federal Government efforts in automotive technology. It should bring significant new talent to bear on basic research problems and can provide in the years ahead an important new base of fundamental understandings of the physical sciences that impact automotive technology. We endorse the administration's initiative and we will be examining ways in which we can make a contribution to this program.

With this as background, let me now proceed to address the questions you asked in your letter of invitation to these hearings.

First, is the approach contemplated in H.R. 4678 compatible with NASA's technological, organizational, and managerial structure and experience? I believe the answer is, largely, "Yes," although, of course, we do not have and are not seeking the kind of role contemplated by the bill. As we understand the approach contemplated by the bill, it would involve expansion of current DOE efforts in experimental vehicle components and systems, including propulsion systems, and include renewing the Nation's research and technology base in automotive disciplines. NASA has agreed to support DOE's automotive technology development program because it is compatible with our technological, organizational, and managerial strengths developed in the aeronautics program. As to experience, however, it is necessary to understand that there are some very substantive differences between the aeronautics and automotive industries. These differences arise from two fundamental considerations:

One, there is little heritage of cooperative research and technology between the Federal Government and the automotive industry as there is in aeronautics; and two, the automotive industry is fundamentally concerned with technologies suitable for mass production and marketing. NASA, under DOE sponsorship, has been working intensively with the automotive industry over the past 4 years. I believe this relationship is developing well, but we still have a great deal to learn about the industry, as the industry has to learn about us. The fact that NASA is not a regulatory agency has contributed to developing mutual and productive understandings, but it is fair to say that our experience with the auto industry, at this time, falls far short of the cooperative aura we presently experience with the aeronautics industry.

Second, you asked, what is our assessment of the synergism between aeronautical and automotive technology in propulsion,

structures, systems, and electronics? There is, in NASA's view, substantial synergism. First, it is important to understand how NASA and DOE reach an agreement as to programs we are willing to support. In addition to the requirement that NASA possess the requisite capabilities to implement the project effectively, we believe that the work should also be synergistic with the fundamental technological and managerial strengths of the agency. Our extensive support to DOE in their automotive activities reflects our determination that the effort is synergistic with our aeronautics activities. An example of how NASA applies this criteria can be seen in our recent agreement that I mentioned earlier to support DOE's automotive alternative fuels utilization program. As you know, NASA is increasingly directing attention to which alternative fuels may be appropriate in the future for use with aeronautical gas turbine propulsion systems. I believe our support to DOE in automotive alternative fuels will provide valuable research insights for our ongoing, companion aeronautics efforts.

Before proceeding to the next question, it is appropriate to mention the synergism which exists today between aerospace developments and automotive products. As examples, the automotive industry is routinely using the NASA structural analysis program (NASTRAN) in the design analysis of car components, thus significantly improving the component behavior predictions and substantially reducing the time and cost for design and development. Microelectronics developed for space enabled the industry to adapt electronic fuel carburetor controls for improved fuel economy. Composite materials, pioneered by the DOD and NASA, are now finding their way into automotive components. We are, of course, gratified to see the adaptation of NASA-sponsored technology in this manner, and we anticipate an acceleration of this trend in future automotive products.

Next, you asked, should such a program be restricted to basic research or extended to experimental components and vehicles to verify the feasibility of newly developed technology? I stated earlier that NASA supports the administration's program of cooperative basic research in automotive-related technologies. Basic research, in addition to providing needed improvements in fundamental understandings, would contribute to improved automotive products in the long-term future. However, the aggressive goal-oriented program now supported by DOE is also essential, particularly for those technologies which are unfamiliar to the automotive industry, such as automotive gas turbine and Stirling engines and electric and hybrid vehicle propulsion. Both of these will feed into the efforts of the auto industry, which has the essential responsibility in this area.

Finally, what Federal funding level would be required for optimal results in the decade of the 1990's? We had not prepared a detailed plan that would be required if H.R. 4678 were to be implemented. Therefore, we don't have a basis for estimating the fiscal resources required.

There is, I believe, a growing consensus that a wide range of measures must be taken by the Government and industry to assure adequate and affordable personal transportation for the 1990's. The optimal strategy for meeting this need involves more than advanc-

ing and expanding the base of automotive research and technology. An optimal strategy for the 1990's must also include the matter of fuels for the future, including their characteristics, availability, and price. DOE is the only Federal agency which can address this part of the overall strategic equations for transportation. Other elements of this strategic equation include future Federal regulations impacting the automotive industry, as well as contemplated development plans by the automotive industry. DOT and other agencies are addressing all of these issues in the studies launched by the administration and the Congress. I do not believe that NASA alone can structure an automotive research and technology program that will provide the optimal results you have referred to. The development of a national program would, in NASA's opinion, require a cooperative effort between DOE and the Department of Transportation, with NASA participating in the necessary R.D. & D. aspects of the program.

In concluding my testimony, Mr. Chairman, I would add that our working relationship with the Department of Energy in advancing automotive technology has been and is encouraging. This relationship, where DOE develops the budget in the context of overall energy programs and priorities, defends the program before the administration and the Congress, and handles a host of administrative details, leaves NASA free to pursue what it does well—the management and implementation of technology advancement activities through the industry.

In light of these considerations, Mr. Chairman, NASA opposes enactment of H.R. 4678 in its present form.

This concludes my prepared testimony. I will be pleased to respond to your questions.

Senator STEVENSON. Thank you, Dr. Frosch.

If I follow you, you're saying that NASA does have the technological and management competence and experience to manage a broadly based automotive research and development program, but you are not seeking it.

Dr. FROSCH. Yes; I think that is close to what I was saying. We have a lot of experience in a program in aeronautics, which is similar to what we think is being discussed for the automotive business. We have been doing some work for DOE which is similar to our relationship with the aeronautics industry and is beginning, we think, to provide the basis for a cooperative relationship with the automotive industry.

But the problem that the country faces now, with the automotive situation, seems to us to be considerably broader than the question of engine technology and automobile technology directly. There is a question of fuel prospects and fuel policy, as well as the technology of fuels. That is something which goes well beyond the area of traditional NASA competence. We can deal with the chemical and technological questions of fuel, but we are not very knowledgeable in the broader questions of future automotive fuels.

There are whole questions of national transportation policy that go well beyond our normal areas of knowledge. If we were to have the principal task, I think we would be viewing a large problem through the lens of technological improvement only, and it is not

clear that that is an appropriate way to address the total span of automotive issues.

Senator STEVENSON. Well, I don't have much difficulty accepting your reasoning with respect to the responsibility for fuels. But here, the concern is not only with the efficiency of automobiles—and that involves not only fuels, but lubricants, propulsion systems, materials, and so on, most of which, at least, are not logically, I should think, within the Department of Energy's responsibility—but it also does or should involve the efficiency of other modes of transportation.

And you indicated a synergism at least between the automotive and the aeronautics industry. I question whether we won't, 10 years from now, look back to this time and question our preoccupation with the automobile, just as we are looking back now to a few years ago and questioning why we didn't recognize the importance of automobile efficiency. The other modes of transportation with which it also seems to me we ought to be concerned include means, by rail, of transporting people and goods, and by ship, in a very interdependent, shrunken world, in which all countries are dependent on all others and goods and people are in perpetual motion.

And the day before yesterday, when the Department of Transportation witnesses were here, they recognized as much, at least by implication. They said that the Department of Transportation ought to establish a basic research program for all modes of transportation, including aeronautics where NASA has the responsibility.

Now, I would have thought—and I apologize for this long prelude to what will be a question—but I think you also implied some misgivings about combining basic research with regulatory functions.

Now, if I am right or making any sense up to this point, why wouldn't it make more sense to take basic research away from an agency that has had absolutely no basic research experience or responsibility and is a regulatory agency, recognizing the synergism, as you do, and put a much larger responsibility for research—basic and perhaps beyond that—with respect to all modes of transportation, in the one agency that has had the most experience with respect to basic rsearch—and basic research for transportation, including the automobile, which is NASA?

And if not NASA, some agency modeled on the NASA line, perhaps taking from NASA aeronautics and make a major commitment through such an agency to basic research, as I say, perhaps beyond that, for transportation and all modes, and utilize to the maximum extent technologies developed with respect to one for the other, utilizing also the services of an agency that has had a pretty good record, I think, in transferring and encouraging the utilization of its technological developments in the private sector?

DOT has no such experience. It is regulatory experience. I didn't start thinking this way, but that other day's hearing, and especially the testimony by DOT, got me thinking this way.

How do you react?

Dr. FROSCH. My answer may be almost as long as the question, Mr. Chairman, because I think we need to dissect the situation more precisely. Let me make almost a philosophical comment right

at the start. I am afraid I believe that there is no perfect way in which such a very broad matter, as a total transportation research, can be organized in the Government. That is, any particular way is going to have a set of flaws in it, because some of the things that have got to be put together are not always completely compatible in one organization. It is not clear that the U.S. Government should be organized around technology solely, nor is it clear that it should be organized around transportation as a subject. Maybe it should be organized around commerce, with transportation as a sub-subject. There are lots of ways to do it, and no one is perfect.

But more substantively, I think it is worth examining what kind of activities NASA has been successful in doing, what kind of activities it has not even tried to do, and where it has had problems. It has been successful in the aeronautics business when it has stuck closely to the question of technology of flying machines. It has stayed away from the question of route structures, of policy issues with regard to safety and traffic control, stayed pretty much away from the very large-scale aeronautical transportation policy issues. We are a participant in those discussions, working with the FAA. What we do and what we have done best is work on the detailed technology and the basic science and engineering underlying the machines themselves. So, in that sense, to give NASA a full-scale transportation responsibility or even a full-scale automotive transportation responsibility is not in keeping with our role in aeronautics. There is, in a sense, a responsibility for aeronautics that lies in DOT. The history is that DOT did not grow up with the technological research responsibility. NASA growing out of NACA did that, and it has been convenient for NASA and industry to keep that relationship going. In starting a new situation, beginning with automotive or transportation research in general, the question is whether one should rely on synergism—the fact that rotating machinery has all of the same thermodynamics and the same structural characteristics and involves many of the same engineering disciplines—as the operative principle. Because aeronautical technology had been the responsibility of an independent agency doesn't mean that one agency should, therefore, provide for all of the technology for transportation in that way; or that the overall systems questions that go with policy are more important so that one ought to say, "Well, we have a transportation requirement which involves technology. Now let's look at some organizational principles for the transportation requirement and fit technology into it."

I think we would end up feeling more comfortable in a role where we can really contribute if we continued to stick to the technology and particular engineering, rather than trying to absorb into that role the larger policy issues which are not our particular skill. We do have skill in transferring technology, but that's not the same as looking at the large policy issues.

Senator STEVENSON. I agree, and I was not suggesting that kind of a role for NASA or for an agency modeled along NASA's lines. I have in mind an agency with a major commitment to technology and a commitment that supported policy, with policy being made the agency's main responsibility—in this case, transportation.

Senator SCHMITT. Would you yield, Mr. Chairman, just on that point?

I think we may be creating a very dangerous situation if we allow policy to drive technology. Technology is what is really required now in order to give us new policy options. I'm afraid that if we organize it on one of the alternatives that Dr. Frosch has discussed, where the prinicpal driver is policy, and the Department of Transportation would have principal responsibility, we are not going to develop the technologies that allow us to add new policies along the lines discussed by the chairman and many other people. That is what concerns me.

I think one of the reasons that the aeronautics business has been so successful is that we didn't have new technologies being developed in a cooperative program between NACA, then NASA, and industry. This allowed the industry new policy options that they wouldn't have had otherwise.

Dr. FROSCH. If I may comment, that is why I said there is no perfect, and possibly not even a very completely satisfactory solution. One does not want policy developed in the absence of knowledge of the technology to be a driver, and we do have a certain amount of that going on in the U.S. Government.

On the other hand, one does not particularly want the pursuit of technology to be the complete driver of policy. That is, the two have got to fit together. You can't have a policy which is ignorant of technological fact, but it is certainly possible to pursue technology in a direction which is very interesting for its own sake, but may make no policy sense whatever. We have occasionally seen that in the U.S. Government, too. The two parts have got to fit together.

Senator SCHMITT. But, Doctor, I think experience has shown that where you have allowed a policy agency, generally a regulatory agency, to be responsible for technology, the technology we have gotten has been inadequate.

I would say that is true of the AEC. That is true now of DOE. And it is true of the experience we have had with DOT, the Department of Transportation, through the years, where they have been unable to direct their policy toward good basic technology development.

Where we have had basic technology agencies create new technologies, we have in fact created new policy options that then could be adopted.

As a matter of fact, we became so disillusioned with the AEC, that we destroyed it—and I think properly. But then we forget the lesson, and we created DOE, which has the same basic problem.

Dr. FROSCH. I believe Franklin Roosevelt was accused of being a traitor to his class. I guess I would be a traitor to my class if I didn't agree that of the two alternatives I would prefer to have technologists dictating policy than policy people dictating technology. On the other hand, I'm not sure that the alternatives are quite that stark. What one would like to do is invent a system in which there was a certain amount of reasonable respect and cooperation between a policy formulation process and a technological development process.

I think that it is possible to construct such relationships, but I'm not sure that they follow automatically from any particular organizational principle. I think the regulatory problem is a serious one, and I would agree with the concern about regulatory processes that are divorced from knowledge of technological fact. This approach has certainly got us into trouble. If you couple the technological development very tightly with regulatory responsibility, you get into some fairly obvious conflicts of judgments between the two parts of the process.

It may be we need some bureaucratic inventions here that will enable the two to come together.

Senator SCHMITT. Well, I think we need some bureaucratic modifications, but the thing that bothers me is we keep reinventing the wheel when we have something that works.

Now, I'm not necessarily advocating at this point, in view of all of NASA's other responsibilities, that we further saturate management attention with transportation technology initiatives. It doesn't mean that at some point in the future that might not be the appropriate place to go.

Nevertheless, I think we have learned from the aeronautics experience, modified by the way we treated the agricultural development efforts through the years, and by the way communications came into general use. We probably have a model that could be adapted to this transportation question.

Dr. Frosch, could you provide—and maybe in very brief summary, but certainly for the record—any material that NASA has put together on the legislative and organizational history of the NACA and its subsequent NASA progeny so that we could look at that and how it developed?

I think the whole thing started in 1915, but presumably somebody in NASA, a historian or otherwise, has pulled togehter a general summary of how this all happened, legislatively and organizationally.

Dr. FROSCH. We can certainly provide a summary for the record.[1] I am quite sure the committee doesn't want the total history. The actual formal establishment date of the NACA was 1917, and it was established, for the usual reasons. There was a fear that in the course of World War I and indeed some evidence, that the European countries had taken the jump in the aeronautics business and the United States needed to catch up. President Wilson signed a bill into law and in 1920 the first laboratory was established. The idea was to provide an advisory committee on aeronautics from outsiders, which would advise the government on what it should do in the aeronautical business and essentially guide an internal-to-the-government laboratory organization.

The idea from the beginning was to do research, provide facilities for research, and to couple this capability with the actual development of technology that the industry could then incorporate. This was a fairly early set of objectives that were met.

The NACA was the source of all of the theoretical and experimental basic aeronautics in the early years, things like wing shapes and the demonstrations of wing shapes. NACA provided

[1] The material referred to has been retained in the committee files.

some important technological changes that the industry incorporated.

An early important activity was noting that one could reduce the drag of an aircraft in those days by putting an aerodynamic cowling around what were then exposed engine parts. This improved the airflow and therefore gave a higher flight efficiency. This kind of activity was demonstrated in experimental flights at Langley. Industry then adopted the principle and designed it to its own uses when it was a useful thing to do.

There was a continual flow of testing, technological ideas, and a very early growth of a collegial relationship between the people who worked for NACA and the industry. They sought each other's advice, knew each other's work and respected it. At the beginning of World War II, two other centers were authorized, Ames and Lewis, and those have continued.

When Sputnik occurred, that was, I suppose, a second foundation for the instituion, for much the same reason as the first foundation. After considerable political tussling over exactly where and how, and who should have the responsibility, the Congress decided to use NACA as a body upon which to expand and graft NASA. So NACA was incorporated into the larger responsibility, as you know, in an organizational approach based upon the NACA experience, but not exactly on the structure and methods. The working relationships and arrangements of the old NACA have in many ways continued into the current era. The bulk of the research and development and technology is done in much the same way as it was developed with the aeronautical industry.

NASA maintains the major research facilities for wind tunnels and simulators that are larger, more complicated and more expensive than would be convenient for the industry to maintain for long-range research purposes. We specialize in the long-range and more basic research, but try to keep a tight coupling with what it is that the industry sees as needed in the coming future. Our work is concentrated on long-range technological needs that the industry cannot pay attention to or fund in its day-to-day business.

The real policy question now is: "How close in the line of things, from basic research to actual industrial work on aircraft, should NASA operate? Should we stick only to basic research? How should we deal with the technological coupling?"

We have wandered back and forth in that interface, never getting so close to the industrial responsibilities that we were in anything like a prototype or product demonstration business, but frequently working on specific industrial problems which seem to crop up in helping with industry adapting our technology advances. I think the personal relationships with the industry are very good, in the collegial sense that I mentioned earlier. Industrial people in aeronautics call upon individuals and NASA for help, advice, and conversation when they have problems. Indeed, it works the other way, when we have problems in space business and in aeronautics. We will call upon industrial people to help us solve them. It has been a very good working relationship, but one in which there has been almost no component of policy determination for the aeronautical industry. The industry has chosen completely what it wants to adopt and how it wants to build its aircraft. We have tried to help

provide the best technological advancements from which those selections can be made.

Senator SCHMITT. The technology leads and the development policy is left behind, isn't that correct?

Dr. FROSCH. Well, it certainly provides the boundary conditions for policy.

Senator SCHMITT. But if you look back in time at the changes in policy that have occurred in both the FAA and the CAB, in partnership with the Congress, to a great extent they have been driven by the technological capability of the industry.

Dr. FROSCH. I think that's right. I want to emphasize again the personal relationships that have grown up, because I think the fostering of those arrangements are more important than the mechanics of the organizational system. As a new boy in this business, I began questioning what really are our relationships with the aeronautical industry by asking around and talking to people. It is very important that the relationships enable individual people outside NASA and individual people inside NASA to know each other and respect each others work. That is the important thing that has got to be built up.

Senator SCHMITT. Now, what kind of relationship did the NACA and then subsequently the OAST component of NASA have with the academic community? Is that a third partner?

Dr. FROSCH. The academic community is essentially a third partner. I think over the past decade or so the aeronautical relationship with the universities probably decayed slightly in that period when the space relationships were building up. There is some feeling, both within NASA and within the universities, that perhaps the aeronautics component of the relationship has gotten a bit too weak. Partly because of money, where there hasn't been enough money available to keep some of the university laboratories and establishments where they should be with regard to facilities. That is something that I think we are paying more attention to now. Universities have clearly been a part of the aeronautics community, not only in the sense of working directly together, but also in the sense of some direct flow of people from academia, as well as from industry, into NASA and out of NASA. One can, in fact, say that there is a U.S. aeronautical engineering fraternity, if you like, that is a group of people who work together on these problems and know each other. I know that it is not fashionable to approve of invisible colleges, as they are called; but they are, in fact, the stuff out of which successful change is created.

Senator SCHMITT. Now, has this relationship ever dealt with manufacturing technology, or has NASA and NACA's contribution always been within the technology itself and not as concerned with how you make it into something useful?

Dr. FROSCH. I will answer based on my impressions and knowledge, but I will provide more detail for the record.

Senator SCHMITT. I hope you will amplify all of this for the record, particularly the contributions that have been made.

[The following information was subsequently received for the record:]

Although NASA does not conduct the type of manufacturing technology program that is directed toward the development of specific manufacturing technologies to

reduce unit costs inherent in many of out R&T programs, it is manufacturing a technology component which is inseparable from the generic technology issues.

An example is the Composite Primary Aircraft Structures (CPAS) element of the Aircraft Energy Efficiency (ACEE) program which has as its goal the development of structures which could reduce aircraft weight by 25 percent leading to fuel usage reduction of 10 to 15 percent. The basic goals of the that program are to learn how to design with materials that are substantially different from our previous experience with aluminum, and to demonstrate structural safety and durability in addition to functionality. But inherent in the process of designing a composite is the deliberate precise arrangement of the oriented layers and the manufacturing techniques for achieving that arrangement with consistent structural reliability. Certainly the economics of that process bear heavily on the ultimate utility of the technology. In such cases, manufacturing technology is inextricably part of the whole program. The conduct of this program has allowed the aircraft manufacturers to commit to extensive use of secondary composite structures on new aircraft such as the Boeing 767 and 757. This early commitment was made possible in large part by the manufacturing experience in the ACEE program.

Another example is the Laminar Flow Control (LFC) element of our ACEE program which has as its goal the demonstration of substantially reduced drag which could result in 20 to 40 percent fuel use reduction. Although it is basically a fluid flow technology program, its feasibility will be determined by our ability to construct wings which will suck air from the boundary layer and also maintain structural integrity and configurational cleanliness. As a consequence, much of our effort is focused on technology to fabricate such wing structures.

Dr. FROSCH. Basically, NASA has stayed out of manufacturing technology except when a brandnew technology was coming into existence, where it has provided and tested fabrication techniques that are essential to transferring materials knowledge in the laboratory to real applications. The composite materials business is a good example where the basic technology has been tested and established in NASA. We have done contractual work with the airframe manufacturers so that they could test their materials in actual aircraft. As they begin to use the technology, they have done their own manufacturing technology work, occasionally coming back to us when they ran into problems that looked as if they were fairly fundamental in applying composites to structures. We have worked closely with them.

But as it goes out into the industry, we release our grasp of it. My description of this is that in order to do a proper technology transfer process, you have to have a long splice, that is, you cannot simply take it out of the development laboratory and hand it to a manufacturer and say, "There it is; you're on your own."

There has to be some consultation and ability for both parties to go back and forth at their volition—that is, the developers shouldn't be forcing advice on the manufacturer, but the manufacturer should feel perfectly free to ask for help and advice when required. Again, it becomes a matter of personal relationships. The people who are developing things in the factories must know and trust the people who have done the basic development work. The trust must go the other way as well.

Senator SCHMITT. As I recall, a good example of that basic applied research that NASA was doing or has done, might be in turbine blades. How can you rapidly build turbine blades that are also functionally as good or better than what one would do under classical tooling techniques?

Dr. FROSCH. There has been a lot of turbine blade research. Attempts have been made to shift from blade fabrication machining to casting techniques that produce a blade almost in finished character, and with the right fabrication processes to minimize

what we have learned from the industry are the expensive manufacturing processes. We do not to devise the manufacturing flow, nor invent techniques that can then be built into a manufacturing line.

Senator SCHMITT. What percent of the effort at Lewis and other labs, or labs associated with NASA, is now involved with automotive or transportation research?

Dr. FROSCH. I will provide more detail for the record, but the total man-years at Lewis in the automotive business now is about 100 people, supporting research of about $50 million a year.

[The following information was subsequently received for the record:]

We have slightly over 100 civil service employees working on automotive research at LeRC. We estimate that JPL employees will spend about 50 direct work years on automotive research in fiscal year 1980.

The total number of people directly involved in all research at LeRC about 2,200.

Senator SCHMITT. That's 100 people out of how many?

Dr. FROSCH. Out of about 2,200 directly involved in all research at Lewis.

Lewis is mostly engaged in doing some in-house laboratory and test work including a good deal of contract work with industry.

Senator SCHMITT. Now if one was to add to that people working in aeronautical activities that are closely related to general transportation questions, what might that number be?

Dr. FROSCH. Lewis is a laboratory that is professionally engaged in rotating machinery for aircraft and all the things that go into that including propellers and turbines. This is the reason why it is sensible for us to engage in the automotive machinery business. There are people there who have worked with similar problems. So, in a sense, Lewis has that kind of talent, but I will provide a more precise answer for the record.

[The following information was subsequently received for the record:]

The total number of people working in aeronautical research and technology at LeRC is about 1,100. The total for all of NASA is about 2,700.

Senator SCHMITT. That will help us in understanding the ongoing effort. JPL is a different kind of laboratory, both contractually and conceptually. What level of effort would you say is now there in automotive research?

Dr. FROSCH. About 55 professional engineers and technicians are supporting automotive research at JPL, conducting in-house research and managing contracted efforts totaling approximately $9 million.

Senator SCHMITT. In other NASA laboratories, is there any?

Dr. FROSCH. None in automotive research.

Senator SCHMITT. Could you supply for the record some specifics in automotive research that have now benefited or soon will benefit the automotive industry?

Dr. FROSCH. I think we can do that.

[The following information was subsequently received for the record:]

The automotive research NASA is managing for DOE, particularly the advanced automotive gas turbine and stirling engine developments, could probably not benefit

industry before the late 1980's or early 1990's, None of our DOE-sponsored research, to NASA's knowledge, has benefited current automotive products.

It is not possible for NASA to predict how soon our automotive research will benefit the industry. The decision to implement a new technology and produce a new product-line is entirely an industry decision, as it should be.

Perhaps electric vehicle research may see the earliest application. There is already a limited market for electric vehicles. The pace of electric vehicle and propulsion research performed by NASA should provide the technology to support industry's commercialization as early as the mid-1980's. However, large scale production of electric vehicles probably depends on battery advances not yet in hand.

Another relatively near-term benefit may arise from a NASA-managed effort at GM's Detroit Diesel Allison to explore the use of ceramic turbine parts in the 300 HP GT-404 bus and truck engine. This engine is the one used in DOE's inter-city and transit turbine powered bus demonstration program now in progress. It is possible that the ceramic advances developed for this engine could lead to a bus and truck engine competitive with large diesels in the next several years.

Senator SCHMITT. Really, you've been at this in a significant way since 1975, I guess, early 1975. So that is 5 years. There ought to be some good transfer of technologies.

Dr. FROSCH. There have been some products that have flowed in. I think more of these which have flowed into the automotive industry have come out of the general NASA technology utilization and transfer program; however, I will supply that for the record.

[The following information was subsequently received for the record:]

Our automotive research for DOE is emphasizing work with long-range potential, consequently very little of the results of our efforts will be incorporated in automotive products in the very near-term. Technology that has flowed from NASA to the automotive industry through our technology utilization and transfer program has come from our aeronautics and space activities. I cited some examples of this in previous testimony.

Senator SCHMITT. What has been the history of the relationship NASA has had with the automobile industry itself, the research and technology of the automobile industry? Has that begun to develop as did the aeronautics relationship?

Dr. FROSCH. The relationship has begun to develop. It is nowhere near the kind of collegial relationship I described in aeronautics. I think such a thing will take quite a long time.

Senator SCHMITT. Why is that?

Dr. FROSCH. The situation with the automotive industry is different from the aeronautics situation. The early days of aeronautics were early days for NACA and the aeronautics industry, in a sense, grew up together and there was no problem of establishing a new relationship.

The automotive situation is rather different. We have a fully developed, mature, successful industry which is being told it isn't so good after all and I think there is a natural adverse reaction to being told that. The U.S. Government comes around and says, in the words of the joke which is prevalent, "We're from the U.S. Government and we're here to help you." The industry has a natural reaction to that. They have no history of working with a Government agency that is trying to keep its distance from them and yet be of assistance.

We don't have an awful lot of experience with an industry with a very large-scale identical item production, therefore, both of us are feeling our way into a relationship that makes some sense. The other thing to keep in mind is that the principal problems we are working on, such as gas turbine engines for automotive use, Stir-

ling engines, electric cars, and so on. We see it as something that we would not want them to try to put out on the road right away, either. There is a lot of work to be done. What we are working on is nowhere close to anybody's idea of what would go into production. Our efforts are probably not central to what the industry is worrying about today.

Senator SCHMITT. It makes some sense from the historical point of view because in those areas, you all are freshmen again. Is that correct?

Dr. FROSCH. Yes, we are stepping out ahead. We have got some time to learn whether we could, in fact, work together.

Senator STEVENSON. Is basic research enough, or should this automotive research enterprise include technology development, equipment for the testing and demonstration of technologies.

Dr. FROSCH. When this question was first under discussion, I expressed to Frank Press my feeling that basic research is probably not enough. If we really want to have some effect in assisting change in the industry, some technology work is very important. My own feeling is that the basic research is not likely to influence anything in a real automobile for quite a while unless it can be coupled through technological development to the industry. I believe some technology program of the kind we are doing with DOE is an important component of this, although it's not clear what the scale should be yet.

Senator STEVENSON. Hasn't technology development been vital to NASA's research over the years and that of its predecessor?

Dr. FROSCH. Technology development has been essential to keeping the aeronautical industry ahead of the competition. We've been successful in doing that.

Senator STEVENSON. What has the attitude of the aeronautical industry been towards that forum?

Dr. FROSCH. The aeronautical industry takes the attitude that they don't want us in their day-to-day manufacturing and design business, and we stay out of that. They do want us to be doing the research that are some years ahead of what they can pay attention to. We are a kind of technological leader far enough out so that we are doing the things that they would rather not put too much effort into because they've got a lot of day-to-day business matter to handle. They watch what we're doing and we try to keep in close touch with them so that what we're doing is irrelevant to what they think is likely to happen. Then as new technology becomes available they will choose whether to adopt it and sometimes do this very rapidly. I have even had occasion to worry whether, in fact, it was being adopted into design before we were through convincing ourselves it was a good idea. But that simply meant that they could perceive where it fits better than NASA and they do their own test work.

Senator STEVENSON. Why is the aeronautical industry sympathetic to the technology development by NASA and the automotive industry unsympathetic to such technology development by any Government agency?

Is this for the reasons you were getting to?

Dr. FROSCH. I think the aeronautical industry grew up with it. They think that's the way it's done because they never did it any other way.

Senator SCHMITT. The fact is, Mr. Chairman, as I've gone around in my previous NASA career, to the aeronautics industry, most were complaining that they have lost because of the space program.

Senator STEVENSON. That they weren't getting enough and they end up, the aeronautical industry, as one of the Nation's most competitive and the automotive industry ends up as one of the Nation's least competitive industries.

Dr. FROSCH. There may be other factors involved as well.

Senator STEVENSON. There's no doubt about that. But it may also say something about the productivity of this industry across a broader front than just the technology development aspects.

Thank you.

Now, to save time, I'm going to invite all of the industry representatives to come forward. We will go through all of their statements and then come back to them with some questions for all of them, Senator Schmitt permitting.

They are Joseph Bidwell, executive director of General Motors Research Laboratories; W. Dale Compton, vice president for research of Ford; Chris M. Kennedy, director of Federal Government affairs for Chrysler; and Marvin W. Stucky, vice president for governmental affairs and corporate planning for American Motors.

Gentlemen, if you can summarize your full statements, we will be happy to enter them in our record.

Mr. Bidwell?

STATEMENT OF JOSEPH B. BIDWELL, EXECUTIVE DIRECTOR, GENERAL MOTORS RESEARCH LABORATORIES

Mr. BIDWELL. Mr. Chairman, I am Joseph Bidwell, executive director of the General Motors Research Laboratories, and I appreciate this opportunity to provide the committee with our views on legislation to establish a Federal program of support for basic research underlying automotive technology development.

I believe our statement to the subcommittee adequately responds to those questions you raised in your invitation letter. Currently, the domestic auto industry is deeply involved with the administration in the development and refinement of an administrative framework for conducting a 5-year cooperative industry-Government basic automotive research program, which would appear to fulfill the intent of title III of S. 2015.

For the better part of a year, we have been negotiating principally with the Office of Science and Technology on the principles, research procedures, fields of study, and funding levels of this research program, which could yield significant new information of a fundamental nature.

It is anticipated that the knowledge derived from this program would provide an expanded scientific base for the future development of safer, more fuel efficient, and environmentally acceptable motor vehicles. While this basic research effort is aimed primarily to advanced automotive technology, the results are likely to have application in many non-automotive areas as well.

Our statement briefly addresses what has transpired to date in these negotiations and where we see this program heading.

In summary, this cooperative research program would increase total basic research in disciplines important to the automotive industry by supplementing the ongoing research efforts of the participants, both Government and industry.

In view of our progress toward the development of this cooperative research effort, we question the need for legislation to establish an alternative research program. However, for any similar Government-funded programs, we suggest you give consideration to the following thoughts:

First, Government support for automotive technology is both most appropriate and most effective if directed to basic research that will generate new knowledge applicable to the design, manufacture, and use of automotive vehicles.

It is most appropriate because it is nonproprietary in nature and not directed toward the design of a consumer end-product which, in our free enterprise system, should be the responsibility of the manufacturer.

Second, basic research is the most effective means to utilize public funds since the results are leveraged by broad applicability to many industries rather than one. Although there is no simple, easily quantified connection between basic research and the introduction of new products into the market place, new knowledge is clearly a critical step in the process.

On the other hand, it is difficult to justify public funding of development programs aimed at consumer products which may benefit only one company or industry.

Therefore, we strongly recommend that the Government not support product development programs, but leave this aspect of innovation to private industry.

The principal criterion for determining where a research program should be carried out must be the competence of the research staff. The choice should be based on the quality of the staff and the suitability of the facilities rather than whether it is a Government industry or university laboratory.

However, it is essential that industry be involved in program planning since they are in the best position to assess the potential value of a basic research program and are, indeed, the customers for the result.

Moreover, it is essential, in our opinion, that whatever Government agency directs the Government research effort, management and staffing for such research should be separate and independent of any regulatory functions involving the auto industry in order to maintain essential objectivity.

Regarding Representative Harkin's bill, H.R. 4678, the National Automotive Research Act of 1979, we believe this bill goes well beyond the discovery of new knowledge and would have the Government funding projects competing with industrial development.

Incidentally, I spent 2 days this week at NASA Lewis with the group there, and I would point out that members of our research laboratories have been in communication with them for many years. The expertise of NASA personnel in many disciplines is widely recognized and we suggest that they be applied to appropri-

ate basic research areas as defined in the cooperative automotive research program.

Before concluding my remarks, I would like to take this opportunity to correct a false impression of research in the automotive industry.

In General Motors, at least, it is alive and healthy. The GM Research Laboratory is this year celebrating its 60th anniversary. This organization of some 1,600 employees has as its primary mission the development of new knowledge in those fields of science and engineering which may have potential application to General Motors' products and operations.

In order to acquaint you with the scope of activities at our research laboratories, I have attached a copy of a publication, "Seminars, Publications, Presentations, Symposia," for last year. This booklet lists these functions for the 1-year period from September 1, 1978, to August 31, 1979. I think you will find a wide range of subjects covered of particular interest in connection with your deliberations.

In summary, we believe the Government can contribute to the discovery of new knowledge through a program that emphasizes basic research. The cooperative automotive research program now in the final stages of organization would accomplish this while leaving the industry free to undertake the development of hardware and vehicles that best meet the transportation needs of the public.

That concludes my prepared remarks, Mr. Chairman. I will try to answer your questions.

[The statement follows:]

STATEMENT OF JOSEPH B. BIDWELL, EXECUTIVE DIRECTOR, GENERAL MOTORS RESEARCH LABORATORIES

Mr. Chairman, I am Joseph B. Bidwell, executive director at the General Motors Research Laboratories. Thank you for this opportunity to provide the Subcommittee with our views on legislation to establish a federal program of support for basic research underlying automotive technology development. I believe within our statement we have adequately responded to those questions you raised within your invitation letter.

Currently, the domestic auto industry is deeply involved with the Administration in the development and refinement of an administrative framework for conducting a five-year cooperative industry/government basic automotive research program which would appear to fulfill the intent of this legislation. In view of the fact that we are well along in development of an agreement for this program, we would like to review briefly what has transpired to date and where we see this program heading, at least in the near term.

In May of last year president Carter met with leaders of the American automotive industry at which time it was agreed, in principle, to develop a joint industry/government program of basic automotive research. This program was described by Philip Smith, associate director, Office of Science and Technology Policy, in his testimony to the House Subcommittee on Transportation, Aviation and Communications on May 2, 1979. While we are nearing formalization of this program, final agreement is subject to resolution of several technical issues of concern.

For the better part of a year we have been negotiating, principally with the Office of Science and Technology Policy on the principles, research procedures, fields of study and funding levels of a research program which could yield significant new information of a fundamental nature. It is anticipated that the knowledge derived from this program would provide an expanded scientific base for the future development of safer, more fuel efficient and environmentally acceptable motor vehicles. While this basic research effort is intended to contribute primarily to advanced automotive technology, the results are likely to have a broader application in a number of nonautomotive areas as well.

PRINCIPLES

Several fundamental principles have been reached in the administrative framework. The most significant is that the research to be conducted will focus solely on basic research, but in areas where new knowledge is likely to be applicable in future automotive systems. Basic research can be defined as an effort to discover new knowledge rather than the application of known principles to the solution of specific problems or development of products.

In addition, it is anticipated that this program would be carried out by a range of universities and research organizations as well as industrial and federal laboratories. It is believed this widespread scientific involvement from many backgrounds will produce a synergistic effect. Personnel exchanges among the participants will be encouraged to further exploit the potential for cross-fertilization.

New knowledge and advancements from the various research programs will be widely disseminated and results that are achieved will be made publicly available to all interested parties—not limited solely to program participants.

In essence, this cooperative program is intended to supplement the ongoing research efforts of the participants and will be relevant to the participants' existing research programs.

RESEARCH PROCEDURES

The nature of the relationship among the participants would be that of a cooperative voluntary confederation. Each participant will have the right to select from a predetermined range of research projects those areas on which to concentrate, and each will retain final authority for implementation of its research program. This management philosophy provides for effective and responsive direction essential to a successful research program.

FIELDS OF STUDY

Tentative agreement has been reached as to the areas of research which are viewed as supportive of the automotive industry. The fields of study, agreed to by industry and the Office of Science and Technology Policy, as outlined in the administrative framework for the cooperative basic research programs are: Combustion and Fluid Sciences, Structural Mechanics, Electrochemistry, Aerodynamics, Material Science and Processing, Control Systems, Tribology, Acoustics and Vibration, Surface Science and Catalysts, Environmental Science, Biomedical and Behavioral Science.

Each of these is an important area where new knowledge obtained through an expanded research effort would benefit not only the auto industry, but society as a whole.

FUNDING

Funding of this basic research program will be accomplished by each of the participants, both government and industry, directly supporting those study fields which they have chosen. It is proposed that each of the industrial participants will fund research programs to a dollar amount equivalent to their percentage of domestic vehicle market penetration, multiplied by the government program investment (up to a defined maximum level). In order to promote new monies for basic research, these expenditures will be in addition to the amounts spent on basic research in the same areas during the years 1977, 1978, and 1979 for both industrial and government participants.

The proposed expenditure by participating federal entities is $17 million in 1981, $34 million in 1982, and $50 million in the years 1983 through 1985. Corresponding expenditures by industrial participants would be based on their market penetration as noted earlier.

Since there is no straightforward procedure to forecast the future benefits of a basic research program, it is not possible to determine analytically an optimum level of funding for a basic research program of this sort. Rather, it is a matter of judgment reflective of a careful review of the specific research proposed to assess potential values and costs. Up to this time most of the automotive related basic research has been done with industry support, but additional funding by the government will clearly accelerate some of the research in progress as well as permit attention to additional areas.

In light of the current economic climate, it would appear that initial funding for this activity will be somewhat less than proposed. This will not affect the quality of research, but rather extend the timing of the research endeavor.

As we are well along in our discussions for the development of this cooperative research effort, we seriously question the need for legislation that would appear to establish another competing research program.

However, if legislation is to be enacted, we suggest you give consideration to the following thoughts:

First, government support for automotive technology is both most appropriate and most effective if directed to basic research that will generate new knowledge applicable to the design and manufacture and use of automotive vehicles. It is most appropriate because it is nonproprietary in nature and of broad general value to society not only in automotive technology, but in many other technologies as well. While individual industrial companies engage in basic research, many are unable to realize direct benefits and are thus motivated to perform less basic research than may be viewed as desirable for our society as a whole.

Second, basic research is the most effective means to utilize public funds since the results are broadly applicable to products produced by many manufacturers rather than being directed toward narrow special applications of special interest. Although there is no simple, easily quantified connection between basic research and the introduction of new products into the marketplace, new knowledge is clearly a critical step in the process.

On the other hand, manufacturers are strongly motivated by the competitive forces of the free marketplace to utilize the best technology available to produce products which are more attractive and useful to the consumer. Industry will use any new knowledge available to produce a product which is more efficient, less expensive, and more reliable in order to better satisfy the customer. Government support of development programs aimed at consumer products are redundant and have not demonstrated that they can be effective. Therefore, we strongly recommend that the government not support development and demonstration programs, but leave this aspect of innovation to private industry.

Regarding research facilities, the principal criterion for determining where a program should be carried out must be the competence of the research staff. The choice should not be based on whether the organization is educational, government laboratory, non-profit institution, or industry laboratory, but rather the choice should be based on the quality of the staff and the suitability of the facilities to carry out the intended research. In the program planning, however, it is essential that industry be involved since they are in the best position to assess the potential value of a basic research program.

Moreover, it is essential in our opinion, that whatever government agency directs the research effort, staffing for such research should be separate and independent of any other primary activities, especially those activities related to regulatory matters involving the auto industry. Objectivity should be emphasized at all times. This separation from regulatory functions will reduce the possibility of research being conducted to support predetermined conclusions rather than expansion of existing knowledge.

As you are aware, H.R. 4678—"The National Automotive Research Act of 1979"—proposes to establish within the National Aeronautics and Space Administration a centralized automotive research and development program. We believe this bill goes well beyond the discovery of new knowledge and would have the government working on a parallel path with industry by authorizing the government to "devise new component and system concepts, and develop new experimental components, subsystems and vehicles when necessary to verify such concepts."

In our view, the bill would encourage the government to compete with industry in the area of product development, whereas we believe technology development—the application of the results of basic research—should be left in the hands of industry.

Before concluding my remarks, I'd like to take this opportunity to tell the Committee a little about the General Motors Research Laboratories and their particular activities and areas of responsibility. The GM Research Labs is this year celebrating its 60th anniversary. This organization of some 1,600 employes has as its sole mission developing new knowledge in those fields of science and engineering which may have potential application to General Motors products and operations. Although the major portion of the projects carried out here are categorized as applied research, about 12% of the effort is devoted to basic research. Only a small fraction of the work at the Research Laboratories is related to near-term product programs. The responsibility for these activities rests with our operating divisions and other corporate staffs.

In order to acquaint you with the scope of activities at General Motors Research, I've attached a copy of "Seminars, Publications, Presentations, Symposia." This booklet lists these functions for the one-year period September 1, 1978 to August 31,

1979. I believe you will find the wide range of subjects of interest in connection with your deliberations. I would call to your attention that much of our work is nonproprietary and is made available to the scientific and technical community through publications such as these.

One of the principal responsibilities of research management is the allocation of resources among competing programs. The distribution of effort outlined above is, in the judgment of our Research Laboratories management, appropriate to satisfying the long-term needs of General Motors. Since basic research is an investment with a very indefinite payout, the fraction of effort devoted to basic research is primarily a matter of judgment and therefore subject to differing opinions. Since the optimum is poorly defined, and since additional basic research may contribute ultimately to additional innovation, it is probably desirable to err on the side of more basic research than less.

In summary, we believe that government can contribute to the discovery of new knowledge through a program that emphasizes basic research. The Cooperative Automotive Research Program, now in the final informal stages of organization, would accomplish this while leaving the industry free to undertake the development of hardware and vehicles that best meet the transportation needs of the public.

Mr. Chairman, that concludes my prepared remarks. Thank you for your attention. I will now respond to any questions you may have.

Senator STEVENSON. Thank you, sir. Mr. Stucky?

STATEMENT OF MARVIN W. STUCKY, VICE PRESIDENT, GOVERNMENTAL AFFAIRS AND CORPORATE PLANNING, AMERICAN MOTORS CORP.

Mr. STUCKY. Thank you, Mr. Chairman. My name is Marvin Stucky, vice president, governmental affairs and corporate planning, American Motors.

I appreciate your invitation to appear today and the opportunity to present our company's views. It is timely that this committee should begin the process necessary to establish a Federal program of support for the basic research projects that could contribute to improved automobile technology.

Along with other industry representatives, we also have been working with the Office of Science and Technology Policy and the Department of Transportation to develop a framework for the proposed industry-Government cooperative automotive research program.

In order to put our views into perspective, a few words about American Motors and our position in the automobile industry are appropriate.

Our sales are currently at an annual rate of over $3 billion. We employ 26,000 people, principally in Michigan, Wisconsin, Ohio, Indiana, and Ontario, and have 2,200 dealers who employ an additional 46,000 people.

Our company is owned by more than 150,000 individual stockholders. By most standards, American Motors is a large company, as indeed it is, ranking about 100th on the recent Fortune 500 lists.

We find ourselves, however, in a highly competitive, capital-intensive industry populated by giants, both foreign and domestic. Our share of the car market is small, and our resources limited, as compared with our competitors.

The automobile industry is not one large monolith, as often portrayed, but instead, is made up of a number of companies of widely varying size, objectives, and capabilities, both financial and techical.

The resources available to smaller manufacturers are insufficient to fund the massive automobile changeovers required to meet cus-

tomer demands and existing Government mandates. Even the larger manufacturers will find it difficult to fund the expenditures required, especially with sales and earnings of our industry so severely depressed.

New initiatives are needed in both the public and private sectors to accelerate the rate of capital formation necessary for funding such a large turnaround in such a short time.

It is in this context, especially, that American Motors is interested in exploring the possiblity of some forms of cooperative effort between Government and industry which may accelerate the advancement of automotive technology.

Any jump in technology will likely require a massive commitment to research and development. Individual firms cannot marshal the necessary resources to carry out such a program. Cost effective means must be sought that maintain the appropriate roles of the Government and private sectors in the effort.

A joint voluntary program of basic research which includes industry and Government would be the most productive and cost effective way to quickly develop new automotive technologies.

Federal funding of a portion of the program will accelerate the process and shorten the time period in which results could be expected. The sooner the results are available, the sooner they can contribute to the national goals of energy conservation, increased exports, safety, and environmental protection.

In our opinion, any industry/Government automotive research program should be limited to basic research intended to contribute to improved automotive technology in the future. It should focus on basic research that ordinarily could not be undertaken by a single automotive manufacturer, and would include high risk/high cost projects which have potential for high pay-off.

Applied research, or how this new-found knowledge should be used in near-term products, should be left to the private sector. H.R. 4678, which would extend the automotive basic research program to "experimental components, subsystems and vehicles," is unnecessary and unwise. Both industry and government agree that the results of all research should be widely disseminated in the scientific community and accessible to all participating manufacturers. The task of applying breakthroughs from such joint basic research efforts should be left to the individual firms where normal competitive incentives will assure that consumers continue to be given a choice in the marketplace.

The program should involve a wide range of univesities, research institutes, and industrial and Federal laboratories in performing the basic research. We should encourage a continuous and ongoing flow of scientific and engineering knowledge between industrial, university, and Government communities. Appropriate research facilities, including those of the automotive manufacturers themselves, should be utilized.

The joint research effort we envision would involve a cooperative Government/industry agreement on funding, project selection and program management. The manufacturers would participate through direct grants to universities as well as increased efforts in their own research laboratories.

A review of existing antitrust statutes and concurrence by the Justice Department and the Federal Trade Commission would be a prerequisite for undertaking a cooperative program which includes automotive manufacturers. Our antitrust laws were formulated many years ago when economic conditions were very different. Perhaps they should be reviewed in the interest of keeping the United States competitive in the worldwide economic arena in which we now find ourselves.

With the current abundance of Federal departments and agencies, it is unnecessary to create a new bureaucracy to manage this single program. Under no circumstances, however, should any automotive regulatory agency be allowed to participate, either directly or indirectly.

S. 2015 includes provisions for Federal funds of up to $800 million over a 10-year period and a similar amount from a private sector. Care wil have to be taken in order to assure that total research capacity available can utilize these funds efficiently within this timeframe and at the same time produce the desired results.

In closing, I would emphasize that American Motors is a company seeking new ideas for its own welfare, for the benefit of our industry and the American public. American Motors would cooperate fully in any such undertaking, and we look forward to participating in further discussions of the subject. Thank you.

Senator STEVENSON. Thank you, Mr. Stucky.

Dr. Compton?

STATEMENT OF W. DALE COMPTON, VICE PRESIDENT FOR RESEARCH, FORD MOTOR CO.

Mr. COMPTON. Mr. Chairman, I'm pleased to have the opportunity to express to the subcommittee some of our views on the Federal Government in the support of basic research that can underlie automotive technology. In addressing this issue, we make the assumption that the Federal Government has the objective of assisting the industry in developing a strong technical base so that we can continue to compete effectively and profitably in the world marketplace with a product that meets the needs of the consumers.

We further assume that the Federal Government recognizes that it has no direct role in developing the product that the domestic vehicle manufacturers will market or even in participating in that development. Within this context, we welcome the participation of the Federal Government in the support of basic research.

As this statement will make clear, we believe that considerable progress has been made in establishing a framework under which members of this industry and government can join in the support of basic research. We have actively participated in such efforts and we look forward to the implementation of the program that has been developed.

Before proceeding with a discussion of this cooperative research program, I would like to spend a few minutes discussing the role that basic research can be expected to play in the development of the technology that will be needed in the decades ahead.

While the principal concern in these hearings is with basic research, it is important to recognize that basic research is only one

element of the long chain that starts with the understanding of a physical principle and ends with the incorporation of some elements of that understanding in a product that appears in the hands of the consumer. Many steps are required after the completion of the basic studies.

The pattern of events is often oversimplified by suggesting that the basic research is followed first by applied research that establishes technological feasibility, then an early development phase that generates prototypes of the product, and then a final development phase that leads to production.

During this final development phase it must be established that the product meets the necessary objectives for safety, performance, reliability and cost. The time required to accomplish each of these steps varies with the product and the industry. Even the sequence, as just described, varies with the circumstances. But the general trend is as stated. Perhaps it would be helpful if I illustrated this for a couple of our own developments.

I urge you to read these examples, because they give the examples of the research process and the development process and the timing in getting to the marketplace. Now, the two examples that I just referred to dealt with the Proco engine and the catalyst system that is used to reduce emissions from the vehicle. In both examples, a period of 25 or so years elapsed between the time that the early basic work was done and the appearance of the idea in the product.

It is perhaps worth mentioning that a number of independent studies involving a whole host of innovations in a number of different industries suggest that this is a normal time interval. The average time between the conception of a new idea and its successful innovation as a usable product is about 20 years.

I have gone through these examples in order to illustrate several key aspects about basic research. First, it is common for 20 or more years to elapse between the carrying out of a basic research program and the inclusion of the results of that work into a fully developed device or system.

Second, the many critical basic ideas that contribute to the final successful development of a device often come from a wide variety of sources, including work carried out by researchers in universities, industry, and Government laboratories, and often in a number of different countries.

Third, when a basic research project is initiated, it is seldom possible to identify the specific applications that will depend upon it.

And fourth, it is often found during the development phases that further directed basic research is needed if the development is to go forward and be successful.

These observations, then, lead us to conclude that future automotive technology will undoubtedly benefit from the support of basic research and that the best way to undertake such research is to encourage the best research minds in this country to become interested in the problems. But we must emphasize that history teaches us that the principal impact of basic research may be many years in the future and so we must not be impatient in demanding

immediate results whose short-term impact upon the product can be clearly demonstrated.

We must not expect that an investment in basic research in the next few years will solve the current problems that the industry faces. An investment in basic research is an investment in the future. To view it otherwise would be inaccurate and unfortunate.

Finally, it should be noted that the directions taken by the basic researcher can be influenced by an awareness of the questions that face the development engineer. This does not mean that the research is any less basic, only that it is carried out within the intellectual framework of real world questions.

Thus, it is concluded that an association among the basic research scientists within the universities, the industrial laboratories and the Government laboratories will be of great value in stimulating the research activities. Through such an association, the industrial group will be able to interpret the problems whose solutions would serve to enhance the application of the technology.

All of the above considerations have played a major part in the deliberations that have led to the construction of the cooperative automotive research program. Ford has been an active participant in these deliberations and we support the contents of the present draft of the administrative framework.

Three issues remain to be resolved before we can ratify the document and proceed with the program:

The first is a legal issue. Drafts of letters from the Department of Justice and the Federal Trade Commission have been received. If the proposed supplement to the January 25, 1980, Department of Justice letter becomes a part of the framework, Ford has concluded that they have no legal objections to Ford participation.

The second issue has to do with the management of the Federal portion of the program—the lead agency issue. We recognize the desire on the part of the Federal Government to have the Department of Transportation play a prominent role in this program. We commend Secretary Goldschmidt's action in requesting that the Office of Science and Technology Policy of the Executive Office of the President undertake a study of the institutional and administrative arrangements that DOT should implement if it is to effectively participate in CARP. This report was completed in February 1980 and was forwarded to Secretary Goldschmidt soon thereafter.

Ford views the implementation of the recommendations of this report as a prerequisite of our participation in CARP. Further, it is Ford's view that the recommendations put forth in the OSTP advisory panel report of February 1980 must serve as a guideline for future administrations and that our continuing willingness to participate in this voluntary program will be dependent upon the adherence of future administrations to these recommendations.

Finally, there is the issue of the monetary commitment that we can make to the CARP during the first year or two of the program. As this subcommittee is well aware, the automotive industry is faced with unprecedented financial burdens. We believe that it is essential that we minimize the financial commitment that participation in this program will demand of the industry in the near term.

I might observe that one of the reasons we are a bit sensitive about the request that we should increase our funding of basic research is the apparent lack of priority that the Federal Government has given to this area in its own programs. In 1977 the Federal Government spent $2.9 billion on basic research. This rose to $3.7 billion in 1978 and to $4.1 billion in 1979. Based on an analysis recently completed by the Federal cooperative automotive research program planning staff, the total spent on basic research in support of automotive technology was $28.3 million in fiscal year 1977, $32.9 million in fiscal year 1978, and $34.7 million in fiscal year 1979.

We find it astonishing that the Federal support of basic research for an industry that contributes such a large fraction of the GNP should be less than 1 percent of the total Federal expenditures for basic research. We urge the Federal Government to go forward with its program of increasing its expenditures for basic research, whether or not the industry can participate financially during the first year or two.

This is an issue that is well recognized by the Federal participants. I hope that we can successfully negotiate a level of industrial participation that will be acceptable to all of the parties.

With the resolution of the above three issues, Ford will formally join the cooperative automotive research program. We look forward to a fruitful interaction with university, industry, and Government researchers who are involved in pursuing basic research studies of importance to automotive technology.

Now, you asked that we comment specifically on five questions. Our responses are contained in the text. I will conclude by commenting only on question 2 at this time, and ask that you refer to the text for the other responses.

Question 2 asked: "Should such a federally funded program be restricted to basic research or extended to experimental components and vehicles to verify the feasibility of newly developed technology?"

Ford strongly opposes the direct involvement of the Government in the development process, as would be provided by H.R. 4678. We have stated repeatedly that the Government should restrict its participation to the support of basic research. We recognize, of course, that a basic research program will require experimental engines or experimental vehicle sub-systems in order to confirm technological feasibility. The DOE/NASA automotive gas turbine project is an example of a joint Government/industry program that is directed at establishing technological feasibility and relies heavily on experimental systems.

But the manufacturer is the only entity that can make the many essential tradeoffs between performance and cost, that can establish manufacturability and that can properly assess market pressures. To even imply that a portion of the development function could be transferred to the Government would undermine the responsibility of the manufacturer to the consumer. It is this responsibility that provides the customer with the leverage in the free marketplace that is essential for our system. The Government should not and, in fact, must not insert itself between the consumer and the manufacturer in the development process.

With that, Mr. Chairman, I will conclude my remarks and would be happy to respond to any comments you may have.

[The statement follows:]

STATEMENT OF DR. W. DALE COMPTON, VICE PRESIDENT-RESEARCH, FORD MOTOR CO.

Mr. Chairman, I am pleased to have the opportunity to express to this subcommittee some of our views on the role of the Federal government in the support of basic research that can underlie automotive technology. In addressing this issue, we make the assumption that the Federal government has the objective of assisting the industry in developing a strong technical base so that we can continue to compete effectively and profitably in the world marketplace with a product that meets the needs of the consumer. We further assume that the Federal government recognizes that it has no direct role in developing the product that the domestic vehicle manufacturers will market or even in participating in that development. Within this context, we welcome the participation of the Federal government in the support of basic research. As this statement will make clear, we believe that considerable progress has been made in establishing a framework under which members of this industry and government can join in the support of basic research. We have actively participated in such efforts and we look forward to the implementation of the program that has been developed.

Before proceeding with a discussion of this cooperative research program, I would like to spend a few minutes discussing the role that basic research can be expected to play in the development of the technology that will be needed in the decades ahead.

While the principal concern in these hearings is with basic research, it is important to recognize that basic research is only one element of the long chain that starts with the understanding of a physical principle and ends with the incorporation of some elements of that understanding in a product that appears in the hands of the consumer. Many steps are required after the completion of the basic studies. The pattern of events is often oversimplified by suggesting that the basic research is followed first by applied research that establishes technological feasibility, then an early development phase that generates prototypes of the product, and then a final development phase that leads to production. During this final development phase it must be established that the product meets the necessary objectives for safety, performance, reliability and cost. The time required to accomplish each of these steps varies with the product and the industry. Even the sequence, as just described, varies with the circumstances. But the general trend is as stated. Perhaps it would be helpful if I illustrated this for a couple of our own developments.

First, I will briefly review the history of the development of our stratified charge engine, the PROCO (Programmed Combustion). Then, I will discuss the steps that led up to the development of the most recent catalyst technology that is being used by the industry.

First, the PROCO. H. Ricardo, in 1922, first published the results of an investigation of the combustion of a stratified air-fuel mixture in which the fuel was directly injected into a divided combustion chamber. Subsequent literature abounds with papers that explore the basic phenomena and the possible implications upon the operation of an internal combustion engine. Without attempting to identify all of the key publications, it should be recognized that the works of J. Witzky at Southwest Research Institute and those of many workers at Texaco were important in understanding stratified charge combustion in an open combustion chamber.

Ford initiated its basic research in the late 1950's. This basic work and the associated applied work resulted in a demonstration engine being built in the early 1960's. But by the mid-1960's, it became clear that complying with the constraints of the newly established emission regulations required a more fundamental understanding of the combustion process. So it was again necessary to return to the basic research. Key publications by Ford researchers, I. Bishop and A. Simko, followed from these efforts. By the early 1970's this basic understanding had evolved to such a point that further applied research was able to provide a group of demonstration engines. By the mid-1970's it became clear that a development program was warranted. This was begun in late 1977. We are currently proceeding with this development and expect full production in the mid-1980's. It should be emphasized that the Ford stratified charge engine differs in significant ways from the eingine as proposed by the Texaco or the Southwest Research groups.

Please note that production is expected to commence some 25-30 years after basic work was first initiated at Ford and some 60 years since the first basic research was done.

My second example will consider the three-way catalyst system that will be used by many vehicle manufacturers in their efforts to achieve the 1981 vehicle emission standards for hydrocarbons, carbon monoxide and the oxides of nitrogen. Catalysis is a very old science but its practical utilization for treatment of vehicles exhausts dates only back to the early 1970's. The first studies on the rapid reduction of nitric oxide by a catalyst were published in England in the late 1880's. Exploratory studies of the applicability of these ideas to the treatment of automotive exhausts took place in the late 1950's and early 1960's, with a portion of this early work being done by Ford scientists, J. Kummer and M. Shelef. In the late 1960's other Ford researchers, H. Lassen and E. Weaver, discoverd the first evidence of three-way catalyst action—the simultaneous oxidation of hydrocarbons and carbon monoxide and the reduction of the oxides of nitrogen on a single catalyst. In 1973 a key discovery that rhodium would contribute significantly to the reactions was made by G. Meguerian and co-workers at Amoco. With this discovery, Ford researchers, Gandhi, Piken, Shelef and DeLosh, then carried out detailed experiments on the characteristics of specific formulations. During this time, the catalyst manufacturers were completing the development of the first practical three-way catalyst. Volvo introduced this system into production in 1976 and Ford in 1977.

But the catalyst is only one element of this system. It is necessary to control the air-fuel ratio accurately at a value close to the stoichiometric ratio of the air and fuel—the mixture ratio for which combustion would result in complete burning of the fuel with no excess of oxygen remaining. It has been found that the most efficient catalyst operation occurs only if a sensor is placed in the exhaust that measures the oxygen content of the exhaust and provides a signal that can be used to control the fuel flow to the engine.

A number of physical phenomena are known that could serve as the basis for such a device. The first commercial implementation is in the form of an electrochemical cell with zirconium oxide as the key element. An attractive alternative appears to be a device based upon the dependence of the resistance of titanium dioxide upon oxygen concentration. The pioneering work on the conductivity of these materials dates from the late 1930's with the most definitive early work being published in the late 1940's and early 1950's by two Dutch scientists named F. Kröger and H. Vink. Many basic research studies followed these early studies. In 1971 Ford began work aimed at applying these basic results to a device. In 1974 a development effort was initiated which continues today. Limited production is expected to begin soon.

As with PROCO, a period of 25 or so years elapsed between the time that the early basic work was done and the appearance of the idea in the product. It is perhaps worth mentioning that a number of studies involving a whole host of innovations in a number of different industries suggest that this is a normal time interval. The average time between the conception of a new idea and its successful innovation as a usable product is about 20 years.

I have gone through these examples in order to illustrate several key aspects about basic research. First, it is common for twenty or more years to elapse between the carrying out of a basic research program and the inclusion of the results of that work into a fully developed device or system. Second, the many critical basic ideas that contribute to the final successful development of a device often come from a wide variety of sources, including work carried out by researchers in universities, industry and government laboratories, and often in a number of different countries. Third, when a basic research project is initiated, it is seldom possible to identify the specific applications that will depend upon it. And fourth, it is often found during the development phases that further directed basic research is needed if the development is to go forward and be successful.

These observations, then lead us to conclude that future automotive technology will undoubtedly benefit from the support of basic research and that the best way to undertake such research is to encourage the best research minds in this country to become interested in the problems. But we must emphasize that history teaches us that the principal impact of basic research may be many years in the future and so we must not be impatient in demanding immediate results whose short-term impact upon the product can be clearly demonstrated. We must not expect that an investment in basic research in the next few years will solve the current problems that the industry faces.

An investment in basic research is an investment in the future. To view it otherwise would be inaccurate and unfortunate.

Finally, it should be noted that the directions taken by the basic researcher can be influenced by an awareness of the questions that face the development engineer. This does not mean that the research is any less basic, only that it is carried out within the intellectual framework of real world questions. Thus, it is concluded that

an association among the basic research scientists within the universities, the industrial laboratories and the government laboratories will be of great value in stimulating the research activities. Through such an association, the industrial group will be able to interpret the problems whose solutions would serve to enhance the application of the technology.

All of the above considerations have played a major part in the deliberations that have led to the construction of the Cooperative Automotive Research Program. Ford has been an active participant in these deliberations and we support the contents of the present draft of the Administrative Framework.

Three issues remain to be resolved before we can ratify the document and proceed with the program. The first is a legal issue. Drafts of letters from the Department of Justice and the Federal Trade Commission have been received. If the proposed supplement to the January 25, 1980, Department of Justice letter becomes a part of the Framework, Ford has concluded that they have no legal objections to Ford participation. The second issue has to do with the management of the Federal portion of the program—the lead agency issue. We recognize the desire on the part of the Federal government to have the Department of Transportation play a prominent role in this program. We commend secretary Goldschmidt's action in requesting that the Office of Science and Technology Policy of the Executive Office of the President undertake a study of the institutions and administrative arrangements that DOT should implement if it is to effectively participate in CARP. This report was completed in February, 1980, and was forwarded to Secretary Goldschmidt soon thereafter. Ford views the implementation of the recommendations of this report as a pre-requisite of our participation in CARP. Further, it is Ford's view that the recommendations put forth in the OSTP Advisory Panel Report of February, 1980, must serve as a guideline for future administrations and that our continuing willingness to participate in this voluntary program will be dependent upon the adherence of future administrations to these recommendations.

Finally, there is the issue of the monetary commitment that we can make to the CARP during the first year or two of the program. As this Subcommittee is well aware, the automotive industry is faced with unprecedented financial burdens. We believe that it is essential that we minimize the financial commitment that participation in this program will demand of the industry in the near term.

I might observe that one of the reasons we are a bit sensitive about the request that we should increase our funding of basic research is the apparent lack of priority that the Federal government has given to this area in its own programs. In 1977 the Federal government spent $2.9 billion on basic research. This rose to $3.7 billion in 1978 and to $4.1 billion in 1979. Based on an analysis recently completed by the Federal Cooperative Automotive Research Program Planning Staff, the total spent on basic research in support of automotive technology was $28.3 M in fiscal year 1977, $32.9 M in fiscal year 1978, and $34.7 M in fiscal year 1979. We find it astonishing that the Federal support of basic research for an industry that contributes such a large fraction of the GNP should be less than one percent of the total Federal expenditures for basic research. We urge the Federal government to go forward with its program of increasing its expenditures for basic research, whether or not the industry can participate financially during the first year or two.

This is an issue that is well recognized by the Federal participants. I hope that we can successfully negotiate a level of industrial participation that will be acceptable to all of the parties.

With the resolution of the above three issues, Ford will formally join the Cooperative Automotive Research Program. We look forward to a fruitful interaction with university, industry and government researchers who are involved in pursuing basic research studies of importance to automotive technology.

Although I have touched on several aspects of the questions that you addressed to us, I will now try to answer them in a more specific form.

1. "Is a federally-funded basic research program necessary for development and application of automotive technology in order to promote energy conservation, exports, safety and environmental protection?"

Ford believes that the long term health of the automotive industry will be enhanced by an increased investment in the long range research that relates to automotive technology. For this reason we have actively supported the development of the Cooperative Automotive Research Program as proposed in Title III of S. 2015. Under the conditions that I have previously mentioned, Ford will agree to participate.

2. "Should such a program be restricted to basic research or extended to experimental components and vehicles to verify the feasibility of newly developed technology?"

Ford strongly opposes the direct involvement of the government in the development process as would be provided by H.R. 4678. We have stated repeatedly that the government should restrict its participation to the support of basic research. We recognize, of course, that a basic research program will require experimental engines or experimental vehicle sub-systems in order to confirm technological feasibility. The DOE/NASA automotive gas turbine program is an example of a joint government/industry program that is directed at establishing technological feasibility and relies heavily on experimental systems.

But the manufacturer is the only entity that can make the many essential trade offs between performance and cost, that can establish manufacturability and that can properly assess market pressures. To even imply that a portion of the development function could be transferred to the government would undermine the responsibility of the manufacturer to the consumer. It is this responsibility that provides the consumer with the leverage in the free marketplace that is essential for our system. The government should not and, in fact, must not insert itself between the consumer and the manufacturer in the development process.

3. "Should such a program be funded and carried out through government facilities and educational and other nonprofit institutions without direct involvement of the auto industry. Alternatively, should it involve a cooperative government/industry relationship for funding, project selection, and program management?"

We strongly believe that the industry should be an active participant in any such program. We also recognize the need for the participation by educational and nonprofit institutions and that unique government facilities should be made avaible to the program. The administrative Framework for the CARP establishes a cooperative government/industry relationship that provides autonomy for the various participants, allows flexibility in the choice of programs by each participant, but establishes a mechanism for insuring good communication among the participants. The existence of good communication enhances the probability that the results of the program will be available in a timely fashion and interested persons will have the opportunity to take advantage of them at an early date.

4. "Should such a program (a) be structured and administered within a Federal department or agency, (b) be structured as a multi-agency activity, or (c) be carried out in some newly established institutional framework?"

We believe that the proposed organizational structure for the CARP is proper. This structure encourages several Federal agencies to participate and allows each to pursue those research areas that are most appropriate in terms of their technical expertise, the mission of the agency, and any particular relationships that exist with outside research groups. The lead agency will serve as a coordinator and not as a manager of the Federal program. We believe this is appropriate. We believe it would be quite inappropriate to attempt to carry out this research in one of the generic centers for industrial technology as contained in S. 1250. The diversity of research areas, the complexity of the overall research needs and the need to involve academic researchers from a wide variety of universities make this arrangement untenable.

5. "What Federal funding level would be required for optimal results in the decade of the nineties?"

There is no way to answer the question of the optimal level of federal funding for basic research. In view of the importance of this industry to the nation's economic well-being, it is clearly suboptimal now. When viewed in the context of the national expenditure for basic research, it would seem that the automotive area deserves significantly more than currently exists. But care must be taken in an expansion of this funding. It should be done slowly with a recognition that it takes time to attract good people to this field. Furthermore, some new facilities will be needed in the universities and it will take time to put these in place. There must also be the recognition that stability of funding is of paramount importance. The basic research community cannot operate effectively in a highly fluctuating budget situation. With these conditions in mind, it is our conclusion that, over the next several years, the Federal funding for this area of basic research could profitably increase by factors of five to ten over current levels. Such a funding level would place a more proper emphasis upon the automotive needs for research.

We appreciate this opportunity to present our views to you on these important issues. Thank you.

Senator STEVENSON. Thank you, sir. And Mr. Kennedy?

STATEMENT OF CHRIS M. KENNEDY, DIRECTOR, FEDERAL GOVERNMENT AFFAIRS, CHRYSLER CORP.

Mr. KENNEDY. Thank you, Mr. Chairman.

Chrysler supports the program for a cooperative research program in automotive technology. By 1985, we expect to exceed the 27.5-mile-per-gallon standard for passenger cars, and that will nearly double the fuel economy of our fleet in 11 years. But in that process,we will just about exhaust the readily available technology for improving fuel economy.

We have made most of the improvements in fuel economy so far by reducing the weight of our cars. For every 100 pounds we take out, we get an improvement of about three-quarters of a mile per gallon. The most economical way to reduce weight is to reduce size. As our cars get smaller, Chrysler will convert its entire fleet to front-wheel drive to provide the maximum of interior space. Front-wheel drive is the most efficient way to improve fuel economy without sacrificing interior space.

But this approach to improving fuel economy won't work forever. There is a limit to how small we can make a car and still meet the demands of American families.

But at the same time, the public is going to want improved fuel economy in the 1980's and 1990's. People are talking about a 30-, 40-, or even 50-mile-per-gallon fleet. Producing that kind of fleet, with the room and comfort our customers want, will be a tough job.

We will need to make some major changes in engines, the shape of our cars, and the materials we put into them. And we're going to have to rely more and more on the basic sciences to help us make those changes. That means a lot of costly, time-consuming research that will affect every area of automotive technology.

Let me cover just a few of the areas where we need more research.

First, engines. The industry has experimented with a variety of powerplants. Chrysler has pioneered in turbine research, and we currently hold a contract with the Department of Energy for work on a seventh generation turbine. We've produced an experimental electric car in cooperation with General Electric. Other manufacturers have looked at the Stirling, the Wankel, and a number of other experimental powerplants.

With more research, some of these engines may well replace the piston engine in the future. However, so far, no engine is as clean, as economical, and as reliable as the piston engine. We expect it to be the workhorse of the industry for years to come.

But good as this engine is, we can still increase its efficiency. To do that, we need to look at basic combustion processes, thermodynamics, and heat transfer. We'll also have to find new lubricants to reduce internal friction. And for the long run, we'll have to go much farther than that and design engines that can operate on radically new fuels like hydrogen.

Second, transmissions. We are already looking at electronically controlled four-speed transmissions. But that doesn't go far enough. We need to find a way to keep the engine and transmission system operating at maximum efficiency under every level of driving conditions.

Third, aerodynamics. Cars of the future used to be designed from the ground up for aerodynamic efficiency. If we can reduce wind drag in a car by 10 percent, we can improve fuel economy by 2 or 3 percent. To get this kind of efficiency, we're already spending more time in wind tunnels with new models. And we're using computer simulations to achieve the sleekest possible design. We've made a lot of progress, but there is a lot more to be done. We need more research in external shape, internal airflow, and the aerodynamic interference caused by a fixed roadway.

Fourth, materials technology. Once we reach the practical limits of downsizing, we'll have to depend on lighter materials to reduce weights still further. Within a few years, cars will be about as small as we can practically make them, and we will be turning more and more to lighter materials like aluminum, ultra-high-strength steel, superplastic zinc, magnesium, and plastics.

We need to go farther. We need materials which are lighter still and we need to find ways to produce them in quantity and at reasonable cost. These are just some of the areas in automotive technology that will need major research efforts over the next few years. There are many others.

Right now, the industry has committed virtually all of its resources to applying known technology to our products as quickly as we can. Between 1978 and 1985, the industry will invest nearly $80 billion in new plants, tools, equipment, technology, and new products.

The staggering cost of these changes and the tremendous technical and financial resources they require leave very little for the kind of basic research necessary to any breakthrough in technology. For that reason, we support the suggestion that Government and industry share some of the burden of these expensive programs that are so important to meeting our national energy goals.

Of all the suggestions for Government-sponsored research, we support the cooperative automotive research program proposed by President Carter last year. There are two reasons why we think it's the best approach:

First, it concentrates on basic research where the work really needs to be done. It sets up research programs in 12 critical areas and insures that the results will be available to everyone. For the first time, the U.S. automobile industry will have available the tremendous resources of the university and Government research communities to concentrate on the kind of problems I've been discussing.

Second, it's a realistic program, that already has the support of Government and the industry. All of the major manufacturers have worked with the administration to hammer out the details. We have a timetable, an administrative framework, and a level of funding that everyone can agree to. It makes no sense to start over now.

It will require time, patience, and the good will and best efforts of thousands of scientists and engineers from the American research community.

We pledge to do our part in that effort.

That concludes my remarks.

[The statement follows:]

STATEMENT OF C. M. KENNEDY, DIRECTOR, FEDERAL GOVERNMENT AFFAIRS, CHRYSLER CORP.

Chrysler Corporation supports the proposal for a cooperative research program in automotive technology.

We have already improved the fuel economy of our fleet by 40 percent since 1974. By 1985, we expect to exceed the 27.5 mile-per-gallon standard for passenger cars, and that will nearly double the fuel economy of our fleet in eleven years. But in the process, we will just about exhaust the readily available technology for improving fuel economy.

We have made most of the improvements in fuel economy so far by reducing the weight of our cars. For every 100 pounds we take out, we get an improvement of about three-quarters of a mile per gallon. The most economical way to reduce weight is to reduce size. As our cars get smaller, Chrysler will convert its entire fleet to front-wheel drive to provide the maximum of interior space. Front-wheel drive is the most efficient way to improve fuel economy without sacrificing interior space.

But this approach to improving fuel economy won't work forever. There is a limit to how small we can make a car and still meet the demands of American families.

But at the same time, the public is going to want improved fuel economy in the 1980s and 1990s. People are talking about a 30, 40, or even 50 mile-per-gallon fleet. Producing that kind of fleet, with the room and comfort our customers want, will be a tough job.

We will need to make some major changes in engines, the shape of our cars, and the materials we put into them. And we're going to have to rely more and more on the basic sciences to help us make those changes. That means a lot of costly, time-consuming research that will affect every area of automotive technology.

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However, so far, no engine is as clean, as economical, and as reliable as the piston engine. We expect it to be the workhorse of the industry for years to come.

But good as this engine is, we can still increase its efficiency. To do that, we need to look at basic combustion processes, thermodynamics and heat transfer. We'll also have to find new lubricants to reduce internal friction.

And for the long run, we'll have to go much farther than that, and design engines that can operate on radically new fuels—like hydrogen.

Second, transmissions. We are already looking at electronically-controlled 4-speed transmissions. But that doesn't go far enough. We need to find a way to keep the engine and transmission system operating at maximum efficiency under every level of driving conditions.

Third, aerodynamics. Cars of the future used to be designed from the ground up for aerodynamic efficiency. If we can reduce wind drag in a car by 10 percent, we can improve fuel economy by 2 or 3 percent. To get this kind of efficiency, we're already spending more time in wind tunnels with new models. And we're using computer simulations to achieve the sleekest possible design. We've made a lot of progress, but there is a lot more to be done. We need more research in external shape, internal airflow, and the aerodynamic interference caused by a fixed roadway.

Fourth, materials technology. Once we reach the practical limits of downsizing, we'll have to depend on lighter materials to reduce weight still further. With a few years, cars will be about as small as we can practically make them, and we will be turning more and more to lighter materials like aluminum, ultra high-strength steel, superplastic zinc, magnesium, and plastics.

At Chrysler, we have experimented with one of our production cars—a Chrysler LeBaron—by replacing 20 conventional parts with components made of new light weight materials. We used materials with polymerics which are tough, durable, and won't corrode. The new materials included graphite fiber composites, and fiberglass reinforced thermosets and thermoplastics. But even with all these changes we were only able to take 140 pounds off the car.

We need to go farther. We need materials which are lighter still and we need to find ways to produce them in quantity and at reasonable cost.

These are just some of the areas of automotive technology that will need major research efforts over the next few years. There are many others.

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Right now, the industry has committed virtually all of its resources to applying known technology to our products as quickly as we can. Between 1978 and 1985, the industry will invest nearly $80 billion in new plants, tools, equipment, technology, and new products.

The staggering cost of these changes and the tremendous technical and financial resources they require leave very little for the kind of basic research necessary to any breakthrough in technology. For that reason, we support the suggestion that government and industry share some of the burden of these expensive programs that are so important to meeting our national energy goals.

Of all the suggestions for government-sponsored research, we support the Cooperative Automotive Research Program proposed by President Carter last year. There are two reasons why we think it's the best approach.

First, it concentrates on basic research where the work really needs to be done. It sets up research programs in twelve critical areas and ensures that the results will be available to everyone. For the first time, the U.S. automobile industry will have available the tremendous resources of the university and government research communites to concentrate on the kind of problems I've been discussing.

Second, it's a realistic program, that already has the support of government and the industry. All of the major manufacturers have worked with the Administration to hammer out the details. We have a timetable, an administrative framework, and a level of funding that everyone can agree to. It makes no sense to start over now.

It will require time, patience, and the good will and best efforts of thousands of scientists and engineers from the American research community.

We pledge to do our part in that effort.

Senator STEVENSON. Thank you, sir.

You have all supported basic research and none of you supported technology development. But I am confused as to the meaning of some of your expressions.

Mr. Bidwell—I beg your pardon. No; I am going to start with Mr. Bidwell. I will come back to Mr. Compton.

You indicated that the Government should stay out of product development. I don't know of anybody who has suggested that it get into product development.

Mr. BIDWELL. Well, Mr. Chairman, I think I would observe that they tend to be going in that direction more and more. And one of my concerns about that is the tendency to duplicate effort that is already ongoing in industry.

Let me mention, there are a number of comments that the industry may not look far enough ahead in some of the earlier discussions and so on. Let me go back to the gas turbine engine as an example. General Motors Research Laboratories set up a department to work on automotive gas turbine engines in 1949. In 1952 we installed our first gas turbine engine in an automobile. By 1956 we had built a regenerative gas turbine. That is exactly the configuration which is currently still being worked on. That is a compressor, a compressor turbine, a free turbine, a regenerator, rotary regenerator. We had installed that engine in a truck, a bus, a passenger car, and in some military vehicles.

Now, that has been something over 30 years ago. I think that is looking fairly far ahead. We have continued the development programs on the gas turbine through all of those years. I think a lot of work that has gone on—in fact, I might mention even the blade materials for some of the early aircraft gas turbines were materials that were developed in our research laboratory.

Senator STEVENSON. I think you are digressing. Are you suggesting that the Government should not, through CARP, involve itself in gas turbine technology?

Mr. BIDWELL. Certainly it should. But the point I think I would like to make is that it seems more logical to me, at least—here is

an engine that people have been working on for 30 years, but still isn't a commercial product. It seems to me the thing the Government might do is take a careful look at that situation and ask the question, why isn't it a commercial product, and try to identify, is it a technological problem, is it an institutional problem. If it's a technological one, let's work at that problem.

And for example, I think the program that NASA-Lewis has looking at ceramic components, for example, which are applicable to a wide range of engines, makes a lot of sense. That is a critical problem that needs a technical solution.

It doesn't make much sense to start over from scratch and build a whole new engine to evaluate material, and I don't think it's necessary.

Senator STEVENSON. What I am trying to do is to figure out where this line is that you all draw between product development and basic research?

Now, let me follow up. Dr. Compton said—and these are answers to the written questions we submitted—that Ford, and I quote, "Ford strongly opposes the direct involvement of the Government in the development process, as would be provided by H.R. 4678."

And with differing words, the industry witnesses all seemed to agree up to this point.

Then he goes on to say, "We have stated repeatedly that the Government should restrict its participation to the support of basic research."

Everybody agrees.

"We recognize, of course, that a basic research program will require experimental engines or experimental vehicle subsystems in order to confirm technological feasibility," which is, I think, exactly what we are all referring to when we speak of technology development. And that is exactly what Dr. Frosch was referring to.

Mr. BIDWELL. Perhaps a definition might be helpful. And I have to admit the line between basic research and applied research is a pretty fuzzy one. But the objective of basic research is generally knowledge, not a new product. The intention is to find—get some information that will help you in designing new products. And I agree you need to do some experiments. And as I pointed out in the case of turbine blade materials, you certainly have to run those in an engine. But you don't have to start out and design an engine or a whole vehicle with that kind of an engine. That is not necessary.

Senator STEVENSON. Then I don't think there is anything except a semantic difference between us.

I haven't read, word for word, Congressman Harkin's bill. I have talked to him about it. It is our impression that, in his proposal and the other ideas that have been advanced, the Government simply supports basic research, but to include hardware that demonstrates the technology.

Dr. Frosch cited the cowling example. It is that sort of thing, I believe, that we have had in mind.

Would you disapprove the Government support research that goes that far?

Dr. Compton, isn't this what you are suggesting that the Government should do?

Mr. COMPTON. Clearly, one needs experimental test beds. I might respond just a little more generally to your question. The kind of wording that makes us nervous in H.R. 4678 are phrases such as—and I'm quoting here—"be directed to automotive research and technology development activities."

We have seen on a number of occasions Government bodies representing what they declared to be a manufacturable car and declaring that it was simply the recalcitrant industry that refused to accept and believe that.

Now I believe that everyone was convinced that it was not a manufacturable vehicle. It was not something that could appear in the hands of the public for many years.

You have to realize that the point at which the support and development of a technology stops, and when it is transferred to the industry, is extremely critical. We just are very concerned about being put in a position of always arguing about what is manufacturable and what is not. In fact, that job is ours.

Senator STEVENSON. Well, I don't think there would be any disagreement. NASA doesn't manufacture airplanes.

Mr. BIDWELL. Well, I think an example of what Dale has commented on is the research safety vehicle series that we keep hearing from NHTSA.

Senator STEVENSON. The what?

Mr. BIDWELL. The research safety vehicle series that NHTSA has promoted. They are promoted as practical, buildable, salable cars. And we are criticized for not making them.

Senator STEVENSON. Would you feel better about this program if it were outside of DOT?

Mr. BIDWELL. I think with the conditions that the Office of Science and Technology Policy has established, we feel reasonably comfortable within DOT. It certainly is difficult, because looking at the organization of the agencies, DOT certainly has a large responsibility for our transportation system. And the automobile is a big part of that. And for that reason it makes some sense.

Senator STEVENSON. Well, let me ask you all how you feel about this. This is a regulatory agency, and it has no experience in basic research. NASA, on the other hand, does. Its relationship with the industry, so far as we can tell, has been very good. It has been very supportive and very productive.

Do you agree that the most appropriate agency in which to lodge this new commitment to basic research, as we now all define it, should be in the Department of Transportation? Or would it more logically and wisely be lodged in NASA, or in some other agency, including maybe a new creature along the NASA model?

How do you feel toward that?

Mr. KENNEDY. We believe that DOT would be a suitable lead agency for this, providing that it is expanded to include this basic automobile research program, as proposed.

In fact, we think it is probably a wise expansion, considering its responsibilities in the transportation area.

Senator STEVENSON. Suitable, or the best agency for this responsibility?

Mr. KENNEDY. A good one, as proposed.

Senator STEVENSON. Well, we want to do the best possible. Can you conceive of no better way to structure this?

Mr. KENNEDY. We think a basic research program is best handled outside of NASA, which, as we have already heard today, is not structured to handle that to the best advantage. And I heartily agree with that.

Senator STEVENSON. And in DOT? NASA isn't the only alternative.

My question raised a third alternative, a new creature, modeled along NASA lines, with no regulatory responsibility.

Mr. KENNEDY. In our opinion, DOT is the best of the three.

Senator STEVENSON. Do you all agree?

Mr. BIDWELL. Well, maybe we are putting too much emphasis on what the lead agency's responsibilities are. It is intended in CARP that there be more—or there may be more than one Government agency participating. The lead agency is simply to serve as a spokesman for the Government agencies involved. And I certainly anticipate other agencies would be participating in the program in those areas where they have particular competence.

They will propose basic research programs that will then have to be funded and reviewed by an oversight committee to assure that they really do meet the criteria that have been established.

And I don't really think that the lead agency is going to have an overwhelming influence in the whole program.

Senator STEVENSON. It will be the Secretary of Transportation who decides what the role of all the agencies will be. He is the head of a regulatory agency with no experience in basic research.

Mr. BIDWELL. I don't believe that he is going to be deciding the role of all of the other agencies. It's my understanding of the program—and I guess the Office of Science and Technology Policy people could better answer the question than I, but, as I understand it, the Government funding has not been established yet. But it would appear that participating agencies might have their own budgets for this program. It would not necessarily all come through DOT.

Senator STEVENSON. No; it wouldn't have to, to be controlled. It might be done on a reimbursable basis, just as NASA does for other agencies which are the lead agencies.

Any responses from the others?

Mr. STUCKY. We support DOT being the lead agency for the reasons that have been cited. And I think the lead agency is the key part of it. Certainly a number of other agencies, including NASA, would be involved and deeply involved in individual research programs.

We do emphasize the regulatory aspects of DOT and think the work that was done in establishing the organization proposal within DOT directs itself right at that problem very well.

And considering, as we would see the role of DOT relative to the automobile, we concluded that that is a satisfactory arrangement, recognizing that DOT will have to make some changes in its organization and management structure and must keep the basic research independent of regulatory agencies specifically.

After we went through the review we concluded that DOT is the best place at this point to identify the lead agency.

Mr. COMPTON. With the restructuring that has been promised by DOT, we feel very strongly that that is the best agency.

I would use, by analogy, the other Federal agencies, whose primary responsibility is to implement a specific mission. Each of the agencies that have really been successful in implementing their technologies have had their own basic research programs.

I would mention the Department of Defense. I would mention Health, Education, and Welfare. I would mention Agriculture. I would mention, more recently, the Department of Energy. Each of those agencies has the complete spectrum of research and development that they carry on within their agency. They may contract out for it, but they have the primary reponsibility. I think that this is a key issue. A mission agency should develop a proper posture in basic research.

With the organizational change that DOT has agreed to, we believe that that posture will be there.

Senator STEVENSON. Senator Schmitt.

Senator SCHMITT. Mr. Chairman, I'm a bit surprised by this universal support for a program of this kind in DOT. It seems to me it flies in the face of what you're saying, that the thing that you're most worried about is what this program will become. And I realize that OSTP's testimony says that, in giving the Office of the Secretary the lead agency responsibility, that the program will be structured in such a way as to avoid any substantive relationship with the NHTSA's regulatory programs.

But you all know, as well as I do, that the history of regulatory agencies in basic research is terrible. They are never able to divorce regulation from the research programs at their agencies. Name me one example of where that has happened? Can you? You all have have been around this game for a long time.

The Secretary cannot avoid looking at the basic research programs in the light of the other responsibilities of his agency.

Mr. COMPTON. Would you agree that the Atomic Energy Commission——

Senator SCHMITT. Failed miserably.

Mr. COMPTON. Not in research.

Senator SCHMITT. Failed miserably. I think they did, and I think that is the reason the nuclear industry is stagnant today. The regulatory responsibity of the AEC got in the way of building safe, reliable nuclear powerplants.

Now, there will be debate on that, but I believe that was the fundamental problem. I think it was recognized by the Congress when they broke up the AEC and created ERDA and the NRC as two separate agencies.

DOE right now controls what NASA does in basic automotive research. NASA does a good job with what they are allowed to do, but they do only what DOE is willing to fund. And DOE's attention is focused on the regulation of energy, not on basic research or the development of broad-ranged new energy programs.

Mr. COMPTON. But, Senator, I believe DOE has no role in the regulation in the automotive area.

Senator SCHMITT. But they have a role in regulation and conservation and in other issues that relate indirectly to what the automobile industry is doing.

Mr. COMPTON. DOT has the function, I believe, of establishing the regulations for automotive fuel economy.

Senator SCHMITT. But the indirect conservation of energy activities in this country, including those related to conservation, do bear heavily on the backs of all aspects of energy, the fuels you use, the fuel costs, the other aspects that generally come under the heading of conservation.

The main illustration of DOE is that basic energy research in general is not progressing nearly as quickly as it should in this country. It is in the hands of an agency whose major management attention is focused on the regulation of energy and not on the development of alternative energy sources for the future, whether they have direct responsibility for the automobile or not.

I think Mr. Stucky's testimony, as the chairman points out here, tends to agree that "under no circumstances should any automotive regulatory agency be allowed to participate either directly or indirectly."

And that sort of contradicts, Mr. Stucky, your support of DOT as the lead agency.

Mr. STUCKY. Well, what it comes down to is how closely organizations such as NHTSA get identified with a separate organization within DOT which conducts the research. And if the research program is established and staffed and managed the way the proposal is now developed, our conclusion was that it will remain independent of the main automotive regulatory agency.

Senator SCHMITT. But the Secretary is not and that is where the buck stops in any agency: At the top guy. He has to weigh the regulatory responsibilities with the research responsibilities, and the weighing of those has traditionally not worked in favor of basic research.

Mr. STUCKY. I certainly won't disagree with you, that all issues come together at the Secretary's office. And our assumption is that he can maintain a degree of independence in assessing research.

Senator SCHMITT. But you are flying in the face of history. There is no example of such independence—none. Why are you advocating this? Has the administration cut some deal with the industry?

It doesn't make any sense. Most of you are engineers, scientists. I mean, there is no logic to this. Can you tell me the logic of your support of DOT as the principal lead agency in this, based upon the history of basic research in the Government?

Mr. STUCKY. Our assessment is that we viewed the Department of Transportation as carrying the major role in terms of particularly the automobile.

Senator SCHMITT. But the FAA carries the major role of the regulation of the airways and nobody ever proposed, or at least I don't remember anybody ever proposing, the transfer of the NASA aeronautical research programs to the FAA.

As a matter of fact, it has been clear that that would have been the last thing anybody would want to do.

Mr. KENNEDY. Senator Schmitt, I would like to think that we are entering an era in which there is less emphasis on regulation and more on cooperation between the Government and the industry.

Senator SCHMITT. If you believe that, I will sell you some land on the Moon.

Mr. KENNEDY. I do believe that deeply. I think this is a good way to begin that cooperation. I don't think we should let the past failures——

Senator SCHMITT. I think that's a good way for everything you're afraid of, to come to pass.

Bureaucracy isn't going to change. The Congress is trying to apply some more restricted boundaries around it, but the basic tendency of a bureaucracy has always been the same. You have to live within those basic tendencies, as we in the Congress structure these new programs.

Mr. KENNEDY. I think we've seen a lot of progress in changing the emphasis from regulation to cooperation, and I hope this is another example of it.

Senator SCHMITT. Could you give us some examples of where there has been progress?

Mr. KENNEDY. This is a good one. This is perhaps the first.

Senator SCHMITT. But you said you've seen progress. And I would like to see some progress.

The last time I visited the Ford plant, in 1974 or 1975, the basic message that I was given was that they were limited in what they could transfer out of their basic research labs into useful products. This was because of the weight of Federal regulation in pollution control and other requirements that saturated their ability to apply anything.

I think at that point somebody said 100 different regulations had to be fit into the design of any modification they would make on any engine. Has that changed?

Mr. KENNEDY. We would like to think it will improve. And an example perhaps of where there has been some wisdom brought to the regulatory process is in OSHA, which has canceled a lot of regulations on small business in particular.

Senator SCHMITT. That's only because Congress took the hand. It wasn't because bureaucracy wanted to do it, but Congress took a hand and said, "Don't do it anymore."

Mr. KENNEDY. Does that not signify that there's a general realization that there's a better way to do things?

Senator SCHMITT. Yes; it does. But it also implies a recognition of where certain governmental management structures haven't worked. One of the things that I think most Congressmen, who I talk with anyway, feel is that there has been no evidence that it ever works when regulatory responsibilities and basic research were in the same agency. It just doesn't work.

Look at what is happening to the USGS. Do you want another example? Look what's happening to the USGS in the Department of the Interior. It used to be a more or less independent bureau, as was the Bureau of Mines in the Department of the Interior. It has gradually been brought under the regulatory structure of that Department, until now it is practically disappearing, like the Bureau of Mines, as a basic research organization. That is what will happen to this.

There is no example of a basic research program surviving in any kind of effective way within a regulatory bureaucracy—none.

Mr. BIDWELL. Senator Schmitt, I have to tell you that there was certainly a great deal of concern, certainly at General Motors—and

I expect other members of the industry—when we first considered the possibility of DOT serving in this lead role capacity, there isn't any question about that, we all, as a result of our past experiences, were very wary of that proposal.

I think, however, that there are several things that have happened that make it a feasible thing to operate. First, I think, is this thing we mentioned a couple of times about restructuring an office that reports directly to the Secretary. It is certainly true that he still has the regulatory responsibility, as well, but at least at quite a high level.

We would have someone in DOT who would have as his primary role heading this research activity.

Now, the further thing that I think makes a difference is the way the CARP program is structured itself. The activities both of the Government and of the industry participants is going to be looked at by an oversight committee of scientists who are unconnected with either the Government or industry. They are going to assess how well we are doing in this program and will criticize either industry or government, if they deserve it, as to selection of programs.

So I think there are some built-in controls that can make this a successful kind of a structure.

Senator SCHMITT. Well, I don't know what they have been offering over there in the White House for you guys to smoke.

But I am very suspicious. Because, again, the basic research activities of the AEC, of the Department of Energy, of the Department of the Interior, all are headed up by offices that report directly to the Secretary. In every case, this reporting has gradually had no bearing on the direction of those research programs. Those research programs have been controlled by the regulatory environment of the agency. Even today the Assistant Secretary of Energy and Minerals is not somebody who knows anything at all about basic research. They report directly to the Secretary of the Interior.

Mr. BIDWELL. Well, I think in this case the industrial members are certainly not going to continue to participate if it doesn't work.

Senator SCHMITT. Well, why don't we start with something that will work?

Mr. BIDWELL. I think we think this will work.

Senator SCHMITT. I think you're looking for the tooth fairy.

Mr. Chairman, I just don't understand this. Maybe I spent too long in science and in engineering and in research. I mean, you usually don't go out here and take giant steps like this away from the proven path of success.

Now, if I thought that the risks—or the benefits were worth the risks, fine. You do that all the time. But I can't see anything here that suggests that there are any benefits from a program like this in a regulatory agency. You don't even know who's going to be the head of that new office. The present director of the NHTSA might be moved over to head up that new office, and it wouldn't surprise me a bit if that is actually what happened.

Mr. Chairman, one final question, and then I hope these gentlemen will be willing to answer some questions for the record, because I went along too long on that track.

Do you have, within your research organizations, specific access to and tracking of the direct and indirect research results in NASA's aeronautics programs as they might apply to the automotive problem? Do you monitor that in any systematic way?

Mr. COMPTON. We have the formal structure that gives us access to all of that information, sir.

Senator SCHMITT. Is that true of all of you?

Mr. BIDWELL. Well, I think the question came up earlier: Would NASA be able to essentially join the club? And I think the answer is in the basic research area people in our research laboratories are members of the scientific community, they pay their dues by writing papers on the work they do and publishing. We do read papers that NASA publishes in areas that we have an interest in.

Senator SCHMITT. Materials science, combustion?

Mr. BIDWELL. Right. Things where we have a common interest. And as I say, we have, over the years, members of my staff and NASA-Lewis, who have common interests, have talked to one another on a reasonably regular basis. It hasn't been a structured kind of thing, but on an individual basis. I expect the experts in our research laboratories to know what's going on around the world. That is part of their task. It isn't simply to look inside, but to look outside as well.

Senator SCHMITT. The aeronautics industry has felt very free, of course, to go to NASA centers and work out joint test programs for various types of components and systems. These utilize either the facilities of the industry or the facilities of NASA, depending upon which one or which combination would work best. Has the automotive industry ever tried to work out those kinds of relationships with NASA?

Mr. BIDWELL. We have not done that in recent years. If I go very far back to the days shortly after Lewis was started and we were both working upon similar kinds of power plants back in the old days of piston engines, we did in fact cooperate quite a lot with them in the areas of lubrication and wear, for example.

Senator SCHMITT. So there is a history of cooperation there in the basic research test programs. That certainly could continue wherever this program ended up having its lead agency if the NASA centers were as involved as they are today. That relationship is not an unusual one for the automobile industry.

Mr. BIDWELL. I would not consider it so, no.

Senator SCHMITT. Thank you, Mr. Chairman.

Senator STEVENSON. Gentlemen, as you know, CARP proposes $800 million over 10 years. Is that enough for basic research?

Mr. KENNEDY. I don't think we know now what the right amount is. That will be reviewed and reestimated as progress is made.

Senator STEVENSON. Any other comments on the adequacy of the funding?

Mr. STUCKY. I think we have the same opinion as far as the specific number at this time. It's very difficult to define some of the capabilities that are available the next couple of years. More importantly than the precise number at this moment is getting the program in place and getting the structure in place and getting moving. That is kind of an open-ended answer. Saying what is a

precise number is very difficult to define over 10 years. Considering where we are coming from, that is a lot of money.

Senator STEVENSON. That's what?

Mr. STUCKY. That is a lot of money to absorb into the research area, considering where we are coming from. So, I say it is really more important that we get the organization established and the program moving and come back as quickly as we can and review the amount of money that can be absorbed into the program.

Senator STEVENSON. For an industry of this size, that doesn't seem like a lot of money to me, $80 million a year? Can't this great industry, with all its present incentives, come up with money of that magnitude?

Mr. KENNEDY. Do you want me to answer that—from Chrysler?

Senator STEVENSON. Anybody except you.

Mr. BIDWELL. Well, I think we have agreed that that is a reasonable objective. We have arrangements in this CARP program to take account of the fact that we don't really anticipate that the level of fundings are going to be exactly constant. There is a provision for a couple of years, carryforward, carryback of expenditures, to take account of some fluctuations in the general economy, too.

But to get to your original question, "Is it about the right amount of money," that's a problem research management faces every day: how to allocate its resources. And as has been pointed out, the ultimate benefits of basic research are not very solid. You do it on faith, so you end up recognizing that there is some level of effort in basic research that is probably optimum, but it is probably a pretty flat optimum, and if you spend a little more or just a little less, I don't think you are going to find you've gotten yourself in very serious trouble.

But to get back to your specific question of the $80 million, I suppose the way the program is planned at the moment is that the industry would end up at about $50 million, if I recall the numbers correctly, unless the administrative framework has been changed, $50 million industry, $50 million Government, funding, when we get all done.

Senator STEVENSON. Any further comments on that subject? [No response.]

What is to guarantee or give us some confidence that if the program is successful and it does produce important technological developments, that the Japanese and the Germans won't have the zeal and the capital with which to exploit them first and put the American industry at an even greater disadvantage?

Mr. COMPTON. There is no assurance. As a basic research program, the results would be published in the open literature, and the worldwide industry will benefit from it.

Senator STEVENSON. No assurance? I found myself quickly anticipating your answer to invite some reason for confidence on our part that we wouldn't end up advantaging our competitors.

Mr. BIDWELL. I am not so sure that we're all that far behind our competitors, Senator. For example, I suppose you would think that in the subcompact market, where the Japanese have been pretty strong, that we are weak. It turns out that the Chevette is the best-selling subcompact in the United States. You also have to remem-

ber who buys what kind of cars the other 75 percent of the cars are, that are being sold in the United States.

Senator STEVENSON. Is the Chevette a good-selling compact in Japan?

Mr. BIDWELL. No; it is not a good-selling subcompact. We don't market it in Japan, as a matter of fact. It is a good-selling subcompact in Germany and a good-selling subcompact in England.

Senator STEVENSON. I didn't mean to suggest that the industry was way behind technologically, or at least that the technology was not available to the industry.

The proposition I am raising is a different one. Let's assume it is available; let's assume you're ahead. If so, why don't you use it?

Mr. BIDWELL. Well, we are certainly strongly motivated to. I am not sure what technology you are thinking of that we aren't utilizing that is available. Certainly, the technology utilized in American cars is as good as any technology in the world.

Senator STEVENSON. Fuel efficiency.

Mr. BIDWELL. Fuel efficiency for the same size vehicles is not any different for our vehicles than for anybody else's.

Senator STEVENSON. Volkswagen?

Mr. BIDWELL. Volkswagen for the same performance levels, weights—it happens we don't market in this country vehicles that are directly competitive, in many cases, as we haven't assessed a sizable market.

Senator STEVENSON. Well, we've been told, and correct me if I am wrong, that this program, if successful, may produce fleet averages in the 40- or 50-mile-per-gallon range and that Volkswagen has a prototype—if that's the right technical expression—of a vehicle that it could now mass-produce in the 65-mile-per-gallon range.

Mr. BIDWELL. I am not familiar with that one. I would not make any guarantees for what this program has come up with. It certainly is not going to come out with the results that will permit us to build a 5,000-pound car that will get those mileages.

Mr. COMPTON. I just wanted to be sure that you understood that we do not believe that this program will necessarily contribute to an improvement in CAFE within the next 10 years. But we believe it is a useful and important step for the industry and the Government to take. CAFE, between now and 1990 or 1995, will probably be largely unaffected by a basic research program.

Senator STEVENSON. Well, we are worrying about the survival of this industry. It's not just CAFE; it's competitive position. Is it going to do nothing to improve that?

Mr. KENNEDY. I suggest, Senator, that the survival of this industry is not dependent upon a basic research program which bears fruit 10 to 20 years from now. There are a number of other measures which are far more important and would help nore quickly which can be taken by Congress.

Senator STEVENSON. I agree. That's why I am raising this question: Why bother? There are other measures that are more critical. Mr. Bidwell has just indicated that we are not behind, or suggests that we are not behind, technologically, so why bother; $80 million a year for this great industry?

Mr. STUCKY. I would say part of the answer to that is that——

Senator STEVENSON. It's a different issue; isn't it?

Mr. STUCKY. It's a different issue, and I would suggest that they sure aren't exclusive. What we're trying to suggest is some of the short-run applied—or whatever the words you want to put on them—issues certainly must be put in place and must happen.

The actions we've been talking about for the next 3 or 5 years must happen: the downsizing of cars, the technology applied to engines, transmissions—that all must happen. It's mandatory for the industry that we retain a very strong marketing emphasis in the short run.

But that should not be done to the exclusion of the long run. Perhaps that is some of the reason why we are not comfortable with the total basic research program in place today. We did not do these things 20 years ago. I am suggesting that this is a program that is certainly not revolutionary, and certainly we're not turning anything upside down in the next 10 years. But it is a very good base from which to build and escalate and, hopefully, in 10 years or 15 years, we will get very solid fruits of the program that can be reflected in the vehicles.

I don't feel that any fundamental technological gap exists in U.S. manufacturers' knowledge, compared to other manufacturers around the world, I don't feel that we have a basic technology problem gap, if you will, in knowing what to do. That's not the issue and not the problem. It is a case of implementing what is sitting on the drawing board and getting it implemented just as quickly as we possibly can.

Mr. KENNEDY. I believe we should all view this research program as a conservation measure, to reduce consumption of petroleum. And as an investment in that, it is a rather small amount of money.

Senator STEVENSON. We can do that by buying Japanese and German cars.

Mr. KENNEDY. At the expense of the U.S. industry.

Senator STEVENSON. That's right. It's a question of survival. That gets me back to my proposition.

Senator Schmitt.

Senator SCHMITT. Doesn't all of this talk about basic research pale into insignificance compared to what would happen if we restructured our tax law?

Mr. KENNEDY. That depends upon whether we're talking about conservation of petroleum or the economic——

Senator SCHMITT. You say the technology is there, that there are a lot of things on the drawing board or even beyond the drawing board that could come into the fleet. Aren't the costs—of retooling, a new plant, equipment, and investment, and the tax law—that discourages it from happening?

Mr. KENNEDY. It is, to a large extent. We did not say all the technology which can be developed is here today. I think we said that ours is as good as anybody else's.

Senator SCHMITT. If you thought that you could have accelerated depreciation on new plant construction at a significant level, investments were taxed at a lower level than they are today, don't you think the whole thing would start to move faster?

Mr. STUCKY. I would suggest that I think many of those decisions are probably behind us, because we must make those changes because of the market.

Senator SCHMITT. You're saying you don't need any tax law—tax law changes won't make any difference?

Mr. STUCKY. No, sir. The problem that that gets into then is the source of capital.

Senator SCHMITT. That's exactly what I am talking about.

Mr. STUCKY. The issue you're addressing is not whether it would be advantageous to the manufacturer, to make the decision. We have to do it. But the question then is how you're going to pay for it. So, yes, there could definitely be some advantages in that respect.

Senator SCHMITT. Thank you, Mr. Chairman.

Senator STEVENSON. Thank you very much, gentlemen.

The next witnesses are Dr. R. Eugene Goodson, director of the Automotive Transportation Center at Purdue University, and Dr. Michael Rabins, chairman of the Mechanical Engineering Department at Wayne State University in Detroit, and gentlemen, if you can summarize, your full statements will be entered in the record.

Dr. Goodson.

STATEMENT OF DR. R. EUGENE GOODSON, DIRECTOR, AUTOMOTIVE TRANSPORTATION CENTER, PURDUE UNIVERSITY

Dr. GOODSON. Thank you, Mr. Chairman. I appreciate the opportunity to appear at this hearing today. I come to you as director of the Automotive Transportation Center at Purdue University. We do basic and policy research. I have been chief scientist at the department of transportation, and I have under my jurisdiction at our university a coal research laboratory, and a wide range of other mission-oriented research programs.

I will immediately summarize my answers to the questions you specifically asked in your letter. To prepare for this, I read the CARP program background testimonies of March, April, and May last year before this committee and Congressman Harkin's committee. I have talked with several of my colleagues in universities and business, and I have been deeply involved in a technology innovation and regulation study by the OTA, where the automotive industry is one of the subjects.

The first question you asked is, is a federally-funded basic research program necessary? I believe it is necessary. The industry faces unprecedented challenges over the next 20 years, and the world auto industry is restructuring itself to compete in a saturating market with products which are increasingly similar. I think technological innovation is going to be the key to survival over the next 30 years. I think our industry needs the human resources which can be produced in a basic research program. This is one element I've seen missing in all of the discussions so far.

Human resources produced by research are absolutely essential over the next 20 years if we're going to be in a leadership position worldwide. So, training people to do research and having those educated persons go to the industry is essential. That's one of the benefits of basic research, in addition to the technological data.

Your colleague, Senator Schmitt, and yourself have raised questions about the Federal location of this program and whether Federal funds are necessary, as in your first question. I have great difficulty knowing whether the Federal Government ought to fund this. There is great pressure on Federal officials to demonstrate at appropriations hearings what great things they have accomplished and what greater things they will accomplish, given next year's money. A basic research program would always be providing a knowledge and educational base for 5 to 10 years in the future, so I don't believe such questions are appropriate to ask.

The bill, S. 1250, concerns me in this regard. It authorizes funding through only 1984. It takes 2 or 3 years to equip and staff a laboratory for research. It takes 4 to 6 years to earn a doctorate. We're talking about at least a 10-year, and more appropriately, a 20-year program.

The transition to a transport system which meets our needs over the next 20 years and does not consume excessive energy or pollute our environment is fundamental, and I believe research is an inexpensive way to increase the probability that we will have such a system at the end of the century and the beginning of the next.

Your second question: Should such a program be restricted to basic research or be extended to experimental components? I have strong feelings on this question.

The Federal Government in this program should not fund other than basic research. The automotive industry must be responsible for the development of particular components and vehicle concepts.

I do feel that the universities and the research laboratories must do experimental research, so I think the difference between—I would differentiate this from development—is that we must be doing laboratory research, but it should be restricted to basic research.

Should such a program be funded and carried out through Government facilities and educational and other nonprofit institutions, without direct involvement of the auto industry? This has a clear answer.

The program should be cooperative between the industry and the research organizations. The Government role would be only to manage the process and assure stability of funding. If the basic purpose of the program is to help insure a healthy and productive automotive industry with strong and continuing roots in the research community, the Government hand should be light and flexible.

Project selection responsibility, funding levels, areas of concentration, and development of centers would lie primarily with those whose duty it is to do the research and incorporate the resulting innovations into the manufacturing process and transportation system.

Question 4: Should a program be structured and administered within a Federal agency, and if so, which one?

Here, I guess, I would pass back to this committee and the Government this responsibility with two primary considerations. The first is a commitment and an understanding that basic research is the focus of the program. The second is that stability and continuity of funding are essential. All else is secondary.

It is your responsibility to choose the framework under which those principles will be honored. My great concern is that 2 or 3 years after the program has begun, the OMB and the congressional committees, this one included, will ask the following sort of questions: What has your research done that is now on the road? All I see are reports and papers in obscure journals; tell me what you have done to help solve our energy, safety, or environmental problems.

If the Government is to run such a program, it should minimize the effect of such short-term thinking. I personally don't believe the fact that it is in a NHTSA or DOT or NASA makes any difference. I have had direct experience with regulatory agencies, and they use information from other agencies in their deliberations on regulations with a will. Having it in a regulatory agency, I don't think is any worse than having it in the Government.

The question, I think, comes down to, can we separate as a government the regulatory from the basic research functions? If we cannot, it might be better just to give a tax credit for research outside of the industry to the industry and keep the Government hand out of it completely.

What Federal funding level would be required for optimal results in the decade of the 1990's?

This question might be simply answered by declaring that some percentage of forecasted automobile sales should go to basic research. This percentage could be 1, 2, 3, or a higher level. The Government could then assume whatever portion of this percentage it felt important.

Assume for the moment that the Federal percentage was 1 percent of sales in the 1990's. This would require some $200 to $400 million a year of commitment.

Many industries have adopted innovation as a corporate strategy and fund research significantly above 5 percent of sales. The electronics industry is an example. Our most competitive, innovative industries have expenditures significantly above what we are allocating to automotive research in the Government and in the industry itself.

The Government does not have to fund all the research; it should not. Appropriate tax incentives could be given to help the industry fund a larger portion.

In conclusion, I think, as your bill, Senator, addresses, innovation and productivity have declined in this country over the last 10 years. We are substantially behind Germany and Japan, our main competitors in the automotive arena. I have data which indicate that research and development expenditures as a percentage of GNP have increased by 33 percent in Japan, 42 percent in Germany, while declining 26 percent in the United States over a 12-year period.

There has been a steady decline in R. & D. spending and a shift away from industrial nondefense in the United States. Tax policies have not favored innovation, and let me give you a small vignette from Dr. Finnigan, who is an entrepreneur and an innovator and a doctor of engineering who developed a company to market a new mass spectroscopy device which we hope to use at Purdue in some of our fuels research.

He indicated that the innovations that he has incorporated in his products came out of university research, basic research, and that he favors a tax policy for research funding. I don't necessarily favor a tax policy or direct Federal expenditures; I don't know which one is best. That's not my area.

I do know that we are behind. We need the research, and myself and my colleagues at Purdue—and I'm sure my sister institutions and other institutions—stand ready to help you in any way we can.

[The statement follows:]

STATEMENT OF R. EUGENE GOODSON, DIRECTOR, AUTOMOTIVE TRANSPORTATION CENTER, PURDUE UNIVERSITY

Mr. Chairman, thank you for the opportunity to appear at this hearing today. My job at Purdue University is to initiate and foster basic research oriented toward national and regional problems. In the institute which I direct in addition to the Automotive Transportation Center, I am responsible for a Biomedical Center, a Coal Research Laboratory, a Computer Aided Design Laboratory, and an Earthquake and Ground Motion Studies Center.

The questions asked in your letter of April 9 inviting me to testify touch the core of those U.S. research issues. The first asks whether a federally funded program is necessary. The second asks if such a program should be extended to components and vehicles. The third questions the role of government laboratories, universities, and non-profit institutions vis-a-vis the auto industry. The fourth questions how such a program should be managed. The fifth asks what funding should be established.

Included with your invitation letter were three legislative proposals, each with alternative approaches, for a program of basic research. The Senate Bill S. 1250 approaches the problem of technological innovation in a generic sense not necessarily aimed at the automotive industry. This legislation would establish in the Department of Commerce an Office of Industrial Technology which would have the responsibility for centers for Industrial Technology.

The Bill, S. 2015, amends the Urban Mass Transportation Act of 1964 in Title III to establish a Basic Automotive Research Program. The House Bill would establish in the National Aeronautics and Space Act of 1958 a program of automotive research and technology development.

To prepare for this hearing I have reread the background of the CARP program and testimony given in March, April, and May of 1979 on the research and development needs of the automotive industry. I have also talked with several of my colleagues in universities and business. Finally, I have had the opportunity to serve on the Office of Technology Assessment Advisory Panel on Technology Innovation and Regulations. One of the case studies in this OTA study is the automotive industry.

Specific answers to the questions in your letter follow.

Question 1. Is a federally funded basic research program necessary for development and application of automotive technology in order to promote energy conservation, exports, safety, and environmental protection?

Answer. A program of basic research oriented to the automotive and transportation industry is necessary. The industry faces unprecedented challenges over the next twenty years. The world auto industry is restructuring itself to compete, in a saturating market, with products which are increasingly similar. I believe that technological innovation will be the key to automotive competition in the future. Those producers who can offer advanced technology at the lowest cost will survive best. The U.S. industry needs basic research in order to give it the human resources and technical knowledge to support innovation in its products and services.

I am less clear on the federal funding of a basic research program where the private sector is both the producer and consumer of the products. There is great pressure on public officials to demonstrate at each successive appropriations hearing what great things they have accomplished and what greater things they will have accomplished given next year's monies. A basic research program would always be providing a knowledge and educational base for five and ten years in the future.

The Senate Bill S. 1250 concerns me in this regard. It authorizes funding only through 1984. This is not sufficient time to initiate and develop a research program. It takes four to six years to earn a doctorate. It takes two to three years to equip and staff a laboratory for research. A program of at least ten years should be envisioned. A twenty-year effort would not be inappropriate. The research done in the next five to ten years will influence the transportation system which we will see

in the late 1990's. The transition to a transport system which meets our mobility needs over the next twenty years and does not consume excess energy or pollute our environment or unduly endanger lives will require enormous resources. Research now is an inexpensive way to increase the probability that the transport system we will be using in the 1990s will meet our needs.

Question 2. Should such a program be restricted to basic research or extended to experimental components and vehicles to verify the feasibility of newly developed technology?

Answer. I have strong feelings on this question. The federal governmental should not in this program fund other than basic research. The automotive industry must be responsible for the development of particular components and vehicle concepts. The industry would be responsible for manufacturing and marketing such components and vehicles. The government has no such responsiblilty (and presumably will not have). It is presumptuous, then, for the government to fund development of products which someone else is responsible to manufacture, market, service and buy.

The government does well when there are clear goals and when there is a clear technological challenge. It does poorly in multiple goal situations such as designing an automobile or truck or the manuacturing, marketing, and servicing systems required. In any case, the federal government would have to contract with a company in the private sector to do such automotive development. Would it contract with a non-automotive company? If it did, part of the benefit of the work would be lost because any knowledge gained in doing the work would not necessarily reside in the industry responsible for production.

Question 3. Should such a program be funded and carried out through government facilities and educational and other nonprofit institutions without direct involvement of the auto industry? Alternatively, should it involve a cooperative government/industry relationship for funding, project selection, and program management?

Answer. This question has a clear answer. The program should be cooperative between the industry and the research organizations. The government role would be only to manage the process and insure stability of funding. If the basic purpose of the program is to help insure a healthy and productive automotive industry with strong and continuing roots in the research community, the government hand should be light and flexible. Project selection responsibility, funding levels, areas of concentration, and development of centers would lie primarily with those whose duty it is to do the research and to incoporate the resulting innovations into the manufacturing process and transportation system.

The cooperative relationship must be between the research community and the industry. The government role as manager would be to insure continued and stable funding, to develop a process for determining research directions which would reflect the transportation system problems which will be important in the next two decades, and to foster communication and personnel migration among research organizations and the industry.

Question 4. Should such a program (a) be structured and administered within a federal department or agency, (b) be structured as a multi-agency activity, or (c) be carried out in some newly established institutional framework?

Answer. Government management of a program of basic research must embody certain concepts which would be important in structuring its management. There are two primary considerations. The first is a commitment and understanding that basic research is the focus of the program. The second is that stability and continuity in funding are essential. All else is secondary. It is your responsibility to choose the framework under which these principles will be honored. My great concern is that two or three years after the program has begun, the OMB and the congressional committees will ask the following sort of question. "What has your research done that is now on the road? All I see are reports and papers in obscure journals. Tell me how you have helped solve our energy, safety, or environmental problem."

If the government is to run such a program, it should minimize the effect of such short-term thinking. As such questions would tend to undermine the program after too short a time, it might have been better to give a tax credit to the industry for outside research and to take the government completely out of the management.

Question 5. What federal funding level would be required for optimal results in the decade of the nineties?

Answer. This question could be simply answered by declaring that some percentage of forecasted automotive sales should go to basic research. The percentage could be one, two, or a higher level. The government could then assume whatever portion of this percentage it felt important. Assume for the moment that the federal percentage was one percent of domestic industry sales in the nineties. This would

require some $200 to $400 million in research commitment each year, depending on the sales projections one makes.

Many industries which have adopted innovation as a corporate strategy fund research significantly above five percent of sales. The electronics industry is an example. If we want an innovative, competitive automotive industry, research expenditures significantly above the levels in either senate bill must be considered. The government does not have to fund all the research. It should not. Appropriate tax incentives for the industry along with direct government funding of basic research would, in combination, greatly contribute to innovation in the automotive transportation industry.

One point I would like to make concerns the flexibility of any basic research program which involves universities. I strongly believe in laboratory research. This type of research is expensive and requires front-end capital. This capital expenditure on equipment should not be tied to a particular research project but to a research focus. In this regard, I like centers of excellence. The concept of a center of excellence is to me the equipping and staffing of a laboratory to do research in a particularly important area. I recommend that this flexibility be in any program you establish.

In conclusion, innovation and productivity have declined in this country over the last ten years. We are substantially behind Germany and Japan, our main competitors in the automotive arena. From 1964 to 1976, research and development expenditures as a percentage of GNP had increased by 33 percent in Japan and by 44 percent in West Germany, while declining by 26 percent in the U.S.[1] There has been a steady decline in government R&D spending and a shift away from industrial, nondefense R&D expenditures. Tax policies have not favored innovation (the capital gains tax was raised in 1969 and not lowered until 1978).

I recently had the opportunity to meet with Dr. Robert Finnigan, who started a company to produce a new instrument for the mass spectroscopy field. In a paper he prepared for delivery at a University of Illinois meeting honoring him and others with College of Engineering Alumni Awards, Dr. Finnigan made several statements which I believe are significant for these hearings. I would like to paraphrase two of his statements. He noted the success of certain high-technology industries such as electronics, computers, analytical instruments, aircraft, and agricultural products. He stated that the key factor behind the success of such industries was their ability to innovate. He also stated that a "tax incentive for R&D cooperation between industrial firms and the university would result in a significantly higher level of R&D subsidy at universities by industry and the redirection of a substantial portion of university R&D to the needs of industry [which would lead] to further innovation." Dr. Finnigan told me personally that most of the innovation that he had incorporated into the products of his successful firm had come from universities.

I believe that innovation is the key to the future of the automotive transportation system in our country and that the universities can make a substantial contribution to the process of innovation by educating researchers and by doing experimental and laboratory research in areas and on problems important to the responsible industries. I believe that the government could help in this process, but it will take a strong commitment to allow the stability and flexibility needed. My colleagues and I at Purdue University and at sister institutions are most willing to work toward such a program.

Senator STEVENSON. Thank you, sir. Do you have to leave right away?

Dr. GOODSON. I can stay for a few minutes to hear Dr. Rabins' testimony. I did have an appointment at 12:15, but I can delay that. I have a hard time at 1.

Senator STEVENSON. Well, why don't we go ahead with Dr. Rabins, and then we will return to you with the first questions.

STATEMENT OF DR. MICHAEL J. RABINS, CHAIRMAN, MECHANICAL ENGINEERING DEPARTMENT, WAYNE STATE UNIVERSITY

Dr. RABINS. Mr. Chairman, thank you for the opportunity to testify. I will not read my testimony. Being toward the tail end, I have the advantage of being able to eliminate much of what I have

[1] "Science Indicators," Report of the National Science Board of the National Science Foundation, 1979.

in the written part of my testimony because it is redundant on many of the points that have already been put into the record. I would like with your permission, to comment on a few of the points that have come up in earlier portions of the testimony, which relate much of the presentation in my written testimony. And then I would like to end by briefly answering the five questions that you posed.

In the discussion you had with Dr. Frosch earlier in the morning, you raised the question that looking back 10 years from now, might we not wonder about our preoccupation at this point with the automotive problem?

I would like to quote Dr. Melvin Kranzberg, Callaway chaired professor at Georgia Institute of Technology. The oft-quoted marriage between Americans and their autombiles that is questioned in many quarters—well, it may be separable, but the price of the divorce may be unbearable. Further, again quoting Dr. Kranzberg, we all know that our children lust in their hearts after our family cars, and they're going to continue doing that for years to come in the future. If we don't address the problems of safety, energy, productivity, competitiveness now, the foreign cars that our children are going to be purchasing in the years ahead will create immense problems for our economy and our job market in this country. The net result will be that we will have paid a much larger price in the future for the problems that we will have created than the price it would cost now to support the basic research that would help alleviate those problems. The "bang for the buck" on doing basic research now in the automotive field can be tremendous in the future.

Dr. Frosch mentioned in his testimony that he had, in his view, in recent years been neglecting academia in support from NASA. I would just like to point out that my colleagues doing research in the fields that Dr. Frosch has been involved in through NASA told me that the problem is worse still because the money that would otherwise have been going to the university community for the past 5 to 10 years for the kinds of research that you talked to Dr. Frosch about earlier in the testimony have been going to NASA and not to the academic community.

I don't mean to present this in a self-serving light, but this is exactly the problem that my colleague, Dr. Goodson, was addressing—that if we don't support the basic research in universities now, the professors won't be there in the future working on the problems. They will work on other problems where they will have support. Their students won't be attracted to the field, and we will just be short circuiting the supply of researchers and industrial workers for the field, and this is shortsighted, in my judgment.

A final comment about the previous testimony: Dr. Compton addressed the point of 20-year leadtime between basic research and product development. We have had similar experience in the universities. I can cite examples from my sister institutions or my own institution.

For example, at Wayne State University, we have a Biomechanics lab which has been in operation for over 25 years and which has an international reputation. The work that was done there 20 years ago, basic research of thousands of hours of detailed, very

difficult work, has led to the establishment of what are now known as the Lisner standards for shatterproof glass in our automobiles, which has saved countless lives. But that started with basic research over 20 years ago.

As a further example in the present, we have a Center for Automotive Research which is now doing work on microprocessor based engine diagnostics, which has the potential for determining engine malfunctions, improving fuel economy, and improving fuel emission situations. That has been developed under funding from the U.S. Army and the Bendix Corp., but we would be surprised to see that appearing in industry for 10 years ahead. We think that would be fast.

The point I'm trying to make is that there is a separation between basic research and product development, and the basic research must be funded now, not only as Dr. Goodson points out to develop the students and the people working in the field, but also so that basic knowledge can be fed from the basic research to the experimental verification into the product development.

Now in answer to your questions in the letter, Senator Stevenson, they are not too much different than the answers that Dr. Goodson has given you. In answer to your first question—"Is a federally funded basic research program necessary?"—I would answer very strongly in the affirmative, provided that it is basic research we're talking about, and provided that it is cooperative with industry, provided that it includes the commitment of funding on a continuing basis and also large elements of student training, because that is our future resource.

In answer to your second question—"Should such a program be restricted to basic research or extended to experimental components and vehicles to verify the feasibility of newly developed technology?"—as I implied in the answer to my first question, I think I'm speaking on behalf of the research community in the universities if I strongly endorse an emphasis on basic research with the necessary experimental verification and development to verify the research, consonant with standard accepted practices of basic research.

I believe that between basic research and product development there is a continuous spectrum, that has to be developed over time. And the problem with getting the necessary funding right now for the starting basic research on that spectrum is twofold.

First of all, it is so unpredictable. You never know what is going to come out of the basic research. More often than not, it is negative results which are just as valuable; this puts aside an option.

Furthermore, you never know how economically "good" the basic research results are going to be even if successful. You cannot tell what the cost-benefit relationships are going to be at the beginning.

There are very few industrial concerns that can afford to establish large-scale basic research laboratories. One at which I had the privilege of working with for a while was the Bell Telephone Laboratories in New Jersey. They have a remarkably enlightened approach to the basic research problem. They will fund literally hundreds and sometimes thousands of simultaneous projects, knowing that maybe only one of them will pay off. But when that one

pays off, it pays off with a bang. Look what happened with the transistor that came out of those laboratories. There are very few companies, though, that can afford to underwrite such long-range, multiple-project efforts.

The automotive industry has not demonstrated the joint development of such a long-range basic research program. That is why I am so much in favor of the program that is being discussed in these hearings.

In question No. 3 you asked:

> Should such a program be funded and carried out through government facilities and educational and other nonprofit institutions without direct involvement of the auto industry? Alternatively, should it involve a cooperative government/industry relationship for funding, project selection, and program management?

There is a spectrum of possibilities here. My own judgment on this—and again, I trust I am speaking on behalf of most of my colleagues in the academic basic research community—would be that if the program is going to be productive, it is going to have to tilt toward the tail end of that spectrum, that is, the second alternative in your question. The program must involve some industrial cooperation so that the problems that are viewed are real world problems, so that there can be interaction, interchange of ideas, diffusion of knowledge and exchange of basic research results.

When I speak to my local colleagues in the automotive industry, I believe they will endorse this answer, but they will hasten to add, however, that it should be voluntary. I can understand the auto industry's concern in that regard, and as long as there is true cooperation between the industry and the basic research, Government, and academic communities, I think it can work with the active involvement of the auto industry.

Your fourth question, regarding "Who should run the program?" is one that I would prefer to let pass. I think it is a politically sensitive question that in my mind is not really a basic issue. I don't think it really makes much difference where this program is run or who runs it. I think the important thing is that the program be committed to, started, and led strongly and with strong oversight from the appropriate committees of Congress to make sure that it's doing its job correctly.

In that regard, I would like to comment on 2 years of experience I had in the Department of Transportation, running the Office of University Research under Secretary Coleman from 1975 to 1977. That program had an annual funding level of about $4 million per year, and I succeeded Dr. Goodson in the direction of that program.

We had a difficult time defending the basic research in that program all the way through, and it wasn't just because of the regulatory perceptions within DOT that you discussed earlier. It was within OMB, the Congressional Oversight Committee and the Senate Oversight Committee that we had most of our difficulty. The blame cannot be laid entirely on the Secretary of Transportation or his associates.

If we're going to support basic research, we have to roll up our sleeves and get to it together. With that, I think I will duck question 4. That's a question for you folks to wrestle with, and I think you will come up with a fine solution, whatever it is.

Senator SCHMITT. I don't think you ducked it at all. I think you helped us a great deal with that last comment.

Dr. RABINS. Question 5 on the funding level required for optimal results in the decade of the 1990's is a tough one. I had an experience this past year working for the Department of Energy doing a study for them on high-priority, energy-relevant basic research in the field of process and systems dynamics and controls. We were looking a decade or two ahead.

What we did was, get a panel of experts involved. We ran a workshop, analyzed the results of the proceedings, and wrote a report which has just this past month been published by the Engineering Societies' Commission on Energy on behalf of the Department of Energy.

One of the findings that we had in that study was that yes, you could identify specific research needs in the process and systems dynamics and control field—relative to energy; yes, you could categorize them, and you could even come up with rough costs on what should be funded, on what should be initiated, and you could even do a very rough estimate on, if you fund it at this level, what's the potential saving in quads—quadrillions of Btu's per year. And that could be turned into dollars—equivalent dollar savings.

And when we finished that study, we ended up with about four major subdivisions, about 10 further subdivisions, and about 40—40 or 50 specific research problems that needed about $10 million of funding, which could pay off annually with about $10 billion in savings. That's a 1,000-to-1 leverage, and those were conclusions arrived at by panels of experts.

A similar process is just now being started on the basic research needs in the automotive field. That is the problem of trying to make predictions of what research funding is needed, because that kind of a process hasn't really been completed.

However, you can come at it from a different angle. In the universities a research contract generally, on the average, is about $100,000 a year. And that supports a faculty member or two, two or three graduate students, computer time, and the necessary associated support services.

The CARP technical framework that has been developed is an excellent one. There are 12 broad research areas in that. If you make an estimate that just to get started in each one of those areas, we had better get going on 10 to 20 research proposals at $100,000 or so apiece, then add it all up, then that comes to about $20 million just to start the program up, just to get it going. And that doesn't include facilities or equipment or management. That is just to get it going.

But that is a guess from a cloudy crystal ball. And I hasten to put a reservation on that guess, that it is probably too low.

That concludes the answers to your written questions.

There is more detail, as I mentioned before, in my written testimony. I would be delighted to answer any questions after you have finished questioning Dr. Goodson.

[The statement follows:]

Statement of Dr. Michael J. Rabins

INTRODUCTION

Let me start by thanking the Subcommittee for the opportunity to testify as a witness at these hearings on legislation to establish a Federal program of support for basic research underlying automotive technology development. We are all concerned about the economic health of our nation, and that is enextricably bound to the health of the automotive industry. The underlying theme of my testimony is that the future health of our nation's automotive industry over the next decades will depend strongly upon the basic automotive research we can accomplish now to establish a knowledge base for future automotive technology development.

Therefore, my testimony will be in favor of establishing a federal program of continuing support for the basic research to gain better fundamental understanding of how future automotive technology development can produce the more fuel efficient, less polluting, safer automoibiles that we must have. As Professor Melvin Kranzberg of the Georgia Institute of Technology recently said in a talk at Wayne State University: "The oft-quoted marriage between Americans and their automobiles is still going strong—indeed the price of a divorce may be unsupportable. And to look to the future, how many of your teenage childen lust in their hearts after your family cars. (Mine certainly do!)" For the future economic health of our nation, today's teenagers will want to have available in the years ahead American made automobiles which are economically attractive and clearly superior to foreign made competition. The technological innovations that will be necessary to accomplish this in the decades ahead must be based on basic research undertaken now.

As you no doubt have ascertained from my bio, I am an academic, and for most of my career, except for periodic excursions into industrial consulting work, have been concerned with teaching, writing and basic research. For two years, while on leave from academia, I directed the Office of University Research in the U.S. Department of Transportation. That experience convinced me that there are not only many highly competent basic researchers in universities around the country capable of working on automotive problems, but that there are also many dedicated, hardworking and competent government employees working cooperatively with the university researchers to insure that we get the most out of the federally funded research. It also convinced me that, often, the most important product of that research is not only the mission-oriented objectives achieved but also the young minds trained for future work by the funded programs.

This experience was repeated and reinforced in a recent task force I chaired for the U.S. Department of Energy to identify high-priority and energy-relevent basic research needs in the field of "Process and Systems Dynamics and Control". So you can see I come before you with an acknowledged bias in favor of basic research and federal support of it. That bias has been further strengthened over the past three years through contacts with many automotive engineers in Detroit and discussion with them regarding the needs of the automotive industry.

My testimony can be divided into three parts: (1) Some thoughts on the nature of basic research, particularly as it relates to the automotive industry, (2) comments on some recent Executive branch governmental discussions (the Cooperative Automotive Research Program—CARP), and (3) answers to five specific questions regarding these hearings put to me in a letter from Senator Stevenson inviting me to testify.

BASIC RESEARCH

Because of the inherent unpredictability of basic research undertakings, most private industry can not afford to adequately support it. Only a handful of companies (such as IBM, Bell Telephone, and General Electric) have been able to, over the years, develop basic research establishments which are not directly subjected to the day-to-day pressures of the economic marketplace. These successful research laboratories have one thing in common; they are willing to pursue many simultaneous basic research tracks with full knowledge that only one out of a hundred or a thousand will eventually really pay off. Thus, for example, it took many, many simultaneous research projects going on at the Bell Telephone Laboratories for one of them to produce the transistor. That is not to say that all of the other projects did not pay off at all, but perhaps not as dramatically. Similar examples of major research breakthroughs abound in other technological areas such as integrated circuit chips, laser communications and coal gasification to name just a few. These accomplishments always result from years of hard work in the laboratory alongside countless other projects that had to be supported at the same time. No one could have predicted in advance which track to follow and which ones to discontinue. One

of the characteristics of basic research is that the results are often negative. But when one project is positive, it more than pays for all the rest.

Another often misunderstood characteristic of basic research is that it is not as purely theoretical and "ivory-tower" as is sometimes thought. As a matter of fact some of the best basic research ever accomplished is quite often accompanied by "hardware" simultaneously delivered out the back door as the theory is presented at the front door. In addition to the examples cited above, which are all increasing productivity/jobs/energy independence, recall our research efforts during World War II which in addition to producing the weaponry which helped win the war also contributed numerous research breakthroughs which established the United States as the innovative leader in World Technology; similarly, our man-on-the-moon program of the 1960's. Sad to say, the United States is losing its world leadership role in innovative technology. Just witness the productivity gains of Japan's automotive industry or West Germany's in high speed ground transport. And these economic and technological productivity gains rest securely on basic research, in which we are not keeping pace with our worldwide competitors.

The General Motors Technical Center, Chrysler Research Center and Ford Scientific Research laboratories consist of highly competent groups of automotive research engineers and their accomplishments are remarkable and well-respected. But, it is fair to say, that the research undertaken at all three laboratories must be, by the very nature of the industry, relatively short term and predominantly product oriented. When an automotive company must be concerned with the cyclical nature of auto sales, with current profit-loss statements, and the problems of next year's models which must be solved on an emergency basis, it is easy to understand why a successful and concerted long-range basic research program to investigate the fundamentals underlying automotive technology has not yet been produced by the industry acting on its own.

But if such a program is not successfully undertaken, the research underpinnings for the future technological advancements our automotive industry needs cannot materialize. The consequences are grim to contemplate:

Economically; if research driven productivity in the manufacturing arm of the industry does not improve, what will happen to our position in the world automotive market? To jobs? To our balance of payments?

From an energy perspective; if our basic research into the fundamentals of automotive propulsion systems does not produce major breakthroughs, what will happen to our reliance on imported energy? Further, what will happen when known energy resources as we now use them are depleted? (Most experts agree that will start happening in our lifetimes!)

From a safety point of view; if basic research into biomechanics and crashworthiness of automobiles does not produce important new insights, what will happen to the growing tens of thousands of Americans killed in auto related accidents each year? Can that number ever be reduced?

My testimony to you is founded on the premise that unless basic automotive research is significantly increased we are doomed to economic, energy and safety problems that will cost our nation much more than the cost now of supporting the necessary basic research programs.

Let me give you two brief examples, taken from our experience in the Mechanical Engineering Department at Wayne State University, which illustrate the relationship between present basic research and future automotive technology development. The Biomechanics lab at Wayne for over twenty-five years has been experimentally studying the crashworthiness of cars and passenger injury susceptibility. That work has been supported by the National Institute of Health, the U.S. Department of Transportation, General Motors, Volvo, and others. One of the early studies concerned the behavior of windshield glass upon impact. From those studies by Professor Lissner emerged much later the industrywide standards (the "Lissner standards") regarding shatterproof glass that have been credited with saving countless lives. More recently, work in the combustion engine laboratories of the Wayne Center for Automotive Research funded by the U.S. Army and the Bendix Corporation, has led to a highly promising computer-based engine diagnostic procedure. This procedure, the outcome of thousands of hours of basic research in the laboratory, holds promise for virtually instantaneous diagnoses of engine malfunctions and developing techniques to improve fuel economy and reduce undesirable emissions by relatively simple measurements.

The point of these two examples, one in the past and one in the present, is that tomorrow's technological innovations must rely on today's basic research. Without the basic research, the truly innovative technological advances cannot materialize.

It is worth noting that supporting a large scale automotive basic research program also produces a desirable and important side-effect. To perform academic

research requires people—professors and students. The bright youngsters who get attracted to the field by available research funds become a valuable resource to the universities and the automotive industry.

Let me end this section by quoting from an address given recently at Wayne State University by Duray E. Stromback, the President and Chief Operating Officer of the Burroughs Corporation, on the occasion of a Nobel Prize Reception in honor of Dr. H. Brown, a former Wayne faculty member. In his address, entitled "A New Partnership", Mr. Stromback stated:

"Businesses and universities have had a long history of cooperation. We need each other. Each has recognized mutual interests and we have worked together in such areas as recruiting, curriculum planning and cooperative education . . . (and) in the area of research. . . . If one looks back to our record of U.S. economic progress, the key to our outstanding success has been the development of new products, services and industrial processes based upon advances in knowledge. We must continue to explore, to discover, and to invent, because industrial innovations create profits which, in turn, create jobs and make our economy more productive . . . a major contribution to this effort can be made through a new partnership in research between businesses and universities. From this partnership can flow the new technology, the new processes and the new products which can be used to increase national productivity."

While Mr. Stromback was addressing us with the computer industry in mind, his comments are equally applicable to the automotive industry.

THE COOPERATIVE AUTOMOTIVE RESEARCH PROGRAM (CARP)

A little more than a year ago, U.S. Secretary of Transportation, Brock Adams, announced a joint federal-industry program to "re-invent the automobile", a notion that was not popularly received by the automobile industry. However, out of that initiative and following many government-industry discussions and meetings, has grown a quite different federal-industry effort to undertake a program of basic research underlying automotive technology. As I hope the previous section made clear, the latter cannot precede the former.

From the ensuing discussions, a multi-agency CARP committee was formed. The President's Office of Science and Technology Policy (OSTP) has taken a lead role in the developing deliberations. A conference was held in Cambridge, MA in April 1979 at the Transportation Systems Center of the U.S. Department of Transportation. This conference brought together the major basic researchers from industry, academia and government to discuss the necessary research priorities.

An OSTP memo on CARP, dated January 10, 1980 summarized the results of the many meetings and discussions. Twelve important basic research areas were identified, which if successfully pursued will lead to improved automobiles in the 1990's—more efficient, safer, less polluting and less costly to buy and operate. The twelve key areas are:

Combustion, thermal and fluid sciences; structural mechanics; electrochemistry; aerodynamics; materials science and processing; control systems; tribology; acoustics and vibrations; surface science and catalysis ; environmental science; biomedical science; and behavioral science.

Joint committees of peer experts have been considering these areas, and in some cases draft reports are under review. These reports will function as a Technical Framework which will lay out an agenda of research topics for each of these basic research areas. All concerned are in agreement that current government and industry investments in these basic research areas, in work related to automotive technology, are inadequate.

Thus, it is important to note, whatever CARP related legislation results from these hearings, a foundation of guidance has been laid which will be invaluable in implementing the legislation.

The January 10, 1980 OSTP memo goes on to discuss the nature of joint federal-industry funding (one-to-one matching dollars) and a proposed Administrative Framework to guide the participants (including an independent CARP Oversight Committee). However, the former issue is better addressed by other witnesses from the auto industry appearing before this subcommittee, and the latter issue gets into the pending legislation addressed in the next section.

PENDING LEGISLATION RELATED TO THE CARP

The three pending bills being reviewed by this subcommittee (S. 2015, H.R. 4678 and S. 1250) will be discussed in the context of five questions put to me by Senator Stevenson in his letter of April 10, 1980. Each question is repeated below, followed by a response and brief discussion.

Question 1. "Is a federally-funded basic research program necessary for development and application of automotive technology in order to promote energy conservation, exports, safety and environmental protection? Title III of S. 2015 proposes such a program."

Answer. For all the reasons stated in the previous basic research section of this written testimony, my answer to this question is strongly affirmative; provided that the research funded is basic to develop a knowledge base cooperatively with industry (see question No. 3 below), that it is committed as a continuing basis and that the program include significant elements of student training. However, S. 2015 has several unfortunate omissions as discussed below.

Discussion. If a federally-funded basic research program is not initiated, it is likely that the necessary underpinnings of a healthy U.S. automotive technology will not be in place in the 1990's. The aforementioned economic, energy and safety consequences are apt to be far more costly than any basic research program undertaken at the present time. Title III of S. 2015 appropriately addresses this need. However, Title III lists only nine of the twelve needed research areas identified in the previous section of this written testimony. Even though Title III states (on page 9 line 2) that the research shall "not be limited to" the nine areas thereafter listed, the three omitted are so important that it is recommended that they be listed as well. The three omitted research areas are: Environmental science; biomedical science; and behavioral science.

Without basic research in these three areas how will we be able to, for example, develop new understandings of the auto pollutants that are important, or to better safeguard our lives on the highway, or to understand how to behave more rationally when we drive. And without that understanding, how will the U.S. Congress be able to draft performance guidelines for the automotive industry. Research in these three omitted areas is as imperative as in the other nine areas listed in Title III of S. 2015.

Question 2. "Should such a program be restricted to basic research or extended to experimental components and vehicles to verify the feasibility of newly developed technology? H.R. 4678 includes such extension."

Answer. Again, for all the reasons stated in the previous basic research section of this written testimony, my answer to this question is emphatically that such a program be restricted to basic research with associated necessary laboratory testing and not extended to experimental components and vbehicles. In particular, Sec. 503.(a), paragraphs (1), (4) and (6) of H.R. 4678 (pages 3 and 4) are exactly antithetical to the needs of basic research in the automotive field. Other aspects of H.R. 4678 are discussed below in response to question No. 4.

Discussion. If the guidelines of Sec. 503(a) of H.R. 4678 were to be followed in regard to ". . . technology development . . ." (paragraph 1), in regards to ". . . solicit and evaluate ideas from inventors and to stimulate and facilitate the further development of those ideas . . ." (paragraph 4), and in regard to ". . . institute a policy of cost recoupment for government-sponsored automotive research and technology development activities" (paragraph 6), the whole thrust of the automotive research program would be changed from one of basic research to one of technology development and production of demonstration vehicles. As has already been argued in the basic research section of this written testimony, new technology cannot meaningfully precede the necessary basic research. Perhaps of equal importance, a single demonstration component or vehicle (even if it has improved performance) that is not based upon basic research results and which also prove that it can be mass-manufactured on a cost-benefit basis at a price that the customer is willing to pay demonstrates nothing but the unreality of the inventor. The U.S. government already has in its warehouses a number of excellent demonstration vehicles that cannot now be practically produced at a reasonable price.

Question 3. "Should such a program be funded and carried out through government facilities and educational and other nonprofit institutions without direct involvement of the auto industry? Alternatively, should it involve a cooperative government/industry relationship for funding, project selection, and program management?"

Answer. Considering the spectrum of possibilities delineated by the two alternatives in the question, for reasons given below I would recommend a position somewhere between the two but strongly tending to the cooperative government/industry relationship of the second alternative to insure full interchange of and cross-fertilization of ideas.

Discussion. Undoubtedly, most in the highly competitive automotive industry would prefer a laissez-faire approach by the U.S. government in regard to their internally funded research programs. But given the fact that the future presence of the U.S. government in these matters, for appropriate national concerns, is probably

a high likelihood, it is imperative that some cooperative government/academic/industry relationship be developed. In particular, it is important that project selection be coordinated and that program management insure cross/fertilization of ideas. Without these steps there will be the danger of either redundantly attacked problems or completely overlooked problems. Further, successful research rests on the minute accomplishments of many previous researchers obtained through open dissemination of research results subject to appropriate patent provisions. Thus, publication of research results in technical journals, personnel exchange programs, extramural funding of work and joint contractors conference will all be important to insure diffusion of the new knowledge to all those who can utilize it. On the other hand, the industry/government relationship should not be so constrictive as to limit the relative autonomy of project selection by each program participant. Otherwise a wide range of different ideas might not be funded, and such plurality of support is an important concept in basic research management due to the uncertain and judgmental criteria necessary for project selection. One might think of the analogy of the CARP Oversight Committee (mentioned in the previous CARP section of this written testimony) acting in the role of the master train dispatcher in a railroad switching yard with all of the separate program participants driving their different individual trains at different speeds on different tracks. Clearly, the dispatcher has to maintain productive order out of the potential chaos.

Question 4. "Should such a program (a) be structured and administered within a federal department or agency, (b) be structured as a multi-agency activity or (c) be carried out in some newly established institutional framework? S. 2015, H.R. 4678, and S. 1250 contain alternative approaches."

Answer. This issue behind this question is not, in my view, as important as the other four. If a cooperative government/industry/academia basic research program is supported on a continuing basis at a sufficiently high level, it is likely that any of the three alternatives of the question could work with proper leadership. But, inasmuch as the 12 research area key needs listed in the previous section of this written testimony span such a broad set of disciplinary backgrounds, I personally would recommend that the basic research program be structured as a multi-agency activity. However, for successful program management it is imperative that one office be designated as having the lead responsibility for implementing the program.

Discussion. Reviewing the aforementioned 12 key research areas, it becomes clear that a multitude of federal offices might have ongoing programs and/or expertise to bring to bear on successful implementation of a basic research program undelying automotive technology development. These might include the U.S. Department of Transportation, Department of Energy, Department of Commerce, Department of Defense, National Institute of Health, National Science Foundation, National Aeronautics and Space Administration the Office of Science and Technology Policy, the Environmental Protection Agency, and others. Placing control of the program in any one agency might be counterproductive in obtaining full cooperation of all of the others. Recognizing this as a politically sensitive issue, I would only recommend that whichever group eventually assumes responsibility for implementing the program it should be as broad based as possible with wide distribution of government agency representation, that it exercise full and final budgetary control over disbursement of funds for funded contract research, and that it report to as high a level as possible. I personally do not believe it appropriate or desirable to establish a new program within NASA (as in H.R. 4678). There have been a number of examples of new programs tacked onto existing agencies which have demonstrated that much valuable time is lost while the existing agency gears up its manpower and expertise. This is particularly important when dealing with the issue of basic research which needs sensitive and experienced staff attuned to the needs and pace of the basic research process. For similar reasons I also personally do not believe it appropriate or desirable to have the automotive basic research program reside under the auspices of the proposed "National Technology Innovation Act of 1979" (S.1250) within the U.S. Department of Commerce. While the latter proposed act is excellent, I believe, and desirable on its own merits, and for different needs, it is not directed at basic research needs and it is more oriented towards technological development in much broader sense. I therefore conclude that S. 2015 most closely meets the needs of alternative (b) of question No. 4 above (i.e., structured as a multi-agency activity).

Question 5. "What Federal funding level would be required for optimal results in the decade of the nineties?"

Answer: This is the most difficult question of the five to answer since it involves extremely broad "guesstimates" and crystal ball gazing into a cloudy ball. The ball will remain cloudy until concentrated studies are initiated to identify the basic research needs in each of the 12 broad areas listed in the previous section. But I will

pick a number and try to justify it below: a minimum of $20 million/year (exclusive of program management, equipment and facility costs) initially, growing to twice or three time that level within 5 years, and then sustand for another 5 years.

Discussion. In a recently completed study I chaired for the U.S. Department of Energy on high-priority energy related basic research needs in the "Process and Systems Dynamics and Control" area (including automotive engine control, incidentally) it was concluded that $10 million/year spent on four specific major research areas over the period of the next 5–10 years has the potential of saving as much as $10 billion/year after sucessful implementation of the research and application of the results. That is a leverage ratio of $1,000 saved in energy costs for each dollar expended on research. These figures were substantiated by a detailed examination of the individual potential savings in each specific research area by knowledgeable panels of experts. Until such a study is undertaken on the 12 key research areas in basic automotive research identified earlier, and concrete justification criteria established for expending research dollars, the choice of a minimum of $20 million/year initially must be viewed as somewhat arbitrary advice.

However, assuming from past experience that each research grant or contract would, on the average, be of the order of magnitude of $100,000/year, the recommended funding level translates into 200 research initiatives each year (some of which would undoubtedly be renewals). Considering that there are 12 key basic automotive reserach needs already identified, each rather broad onto itself, this is indeed a modest and minimal funding level. One caution: starting the program at a low level with plans to later increase the budget substantially in large step usually results in the program staying at its original level for a long period; so the original funding level should be realistic.

CONCLUSIONS

In summary, the above testimony recommends:

1. A federally-funded basic research program necessary for development and application of automotive technology in order to promote eventual energy conservation, exports, safety and environmental protection is definitely necessary.
2. The program should be restricted to basic research and not extended to experimental components and vehicles.
3. Such a program should involve some measures of cooperative government/academia/industry relationship for project selection and program management, but the industrial program participants should maintain a high degree of autonomy.
4. Such a program should be structured as a multi-agency activity (such as allowed and implied in S. 2015) with a single office maintaining a strong leadership role in implementing the program. That office should report to as high a level in the government as possible.
5. For optimal results in the decade of the nineties, the federal funding level for the Cooperative Automotive Research Program should be at least $20 million/year for ten years.

Senator STEVENSON. Thank you, sir.

I didn't mean to question the need for basic research or the need to develop the human resources, which you both referred to. In fact, I am all for basic research and developing the scientific human resources that the country needs.

I am trying to raise a question about priorities for basic research and technology development. And that brought me to the suggestion that we may 10 years from now look back and wonder why our preoccupation with the automobile.

A few years ago we weren't preoccupied, when we should have been. Now we may be preoccupied when it's too late. And I say that because we are not prophets in this country. We are notoriously bad at looking into the future and anticipating it and acting before it's too late.

No one, no historian I think of repute, no one with knowledge of the dynamics of this world could rule out the very grim scenario that may produce an involuntary divorce, not a voluntary divorce.

I don't deny your question either, that love affair with the automobile. But this scenario includes depression on a global basis. It

includes global upheaval, including interruptions in the supply of fuel. It includes $10, $15 gasoline; or just as a result of rationing, no fuels for discretionary drivers.

And, not withstanding all of that, a shrunk interdependent world, desperately in need of efficient means for transportation of people to and from work, and military personnel and equipment, too, for that matter.

So, what I've been trying to suggest is that maybe the automobile isn't the highest priority, or at least that the priorities for basic research should be designed in such a way as to take more account of all of the possibilities in the future, even the grimmest, than they have in the past, and therefore try to broaden this effort to include transportation and basic research geared to the most efficient modes of transporation, some perhaps that we can't even conceive or begin to visualize.

But I'm not likely to include the automobile, the most obvious being rail transportation for people at the moment. Maybe there are other modes, however, that aren't even perceptible at this point.

Should we be giving some thought to making this a broader commitment into more forms of transportation, recognizing also that there is some synergism at work here between modes?

Dr. GOODSON. I thought seriously about the question you are raising about whether it should be directed toward the automotive industry or more, like I guess in S. 2015, should it be a general technology, innovation, productivity thrust?

Two points on that I think are significant. If you're going to marshal the resources of the research community, is it going to be toward the manufacturing industries? Or is it going to be toward service industries?

If it is to be toward manufacturing industries, which are basically the major productive industries in our country, I really don't think it makes much different that it is oriented toward the automotive industry. That is our major manufacturing industry. The problems they have are materials, combustion, fuels, computers, controls, all sorts of things, which are all generic to the manufacturing industries.

So, I support a program of basic research which would feed into our major productive enterprises. And I think the automobile industry is a good place to start. I believe the synergism will be great, because we will be producing human resources, also.

They will not all go the automobile industry. Some of them will go to consumer-goods-producing industry. Some of them will go to the computer industry. Some of them will go to NASA. Some of them will go to teach at universities.

So I think, as long as we are marshaling our resources toward manufacturing industries and the research problems associated with materials and energy, that they will feed into the transportation and the productive industries that we have in our country.

So I reached a conclusion that we've got this going, it is not inappropriate, it is not very much money after all. If we want to go into other areas, we can afford to do that. This is less money than we're talking about, on one-half of one synthetic fuel plant. It is sort of a small deal. It is a big deal to the research community; but

as far as the problems of our country, it is small. Let's get on with it.

Senator STEVENSON. While we are reduced to one passenger-rail equipment manufacturer, and that is German controlled, market penetration by the foreign producers is far larger in the case of rail equipment than it is in the automobile industry.

We haven't—we have just left the development of commuter aircraft and a huge market to the Brazilians and the Russians, and the British, and the Canadians. And heaven knows what we haven't even conceived of.

Senator SCHMITT. If the chairman would yield, I would just add our merchant marine to that list, if there is such a thing any more.

Dr. GOODSON. One can put a very long list down, sir.

Dr. RABINS. That market in high-speed ground rail goes back to a decision—I guess it was the early 1970's—to get out of high-speed ground transport research, basic research.

Senator SCHMITT. May I suggest the decision went back to the 1954 regulation of natural gas that began the decline of the coal industry, which began the decline of the rail system?

But you are right, we have made other bad decisions along the way.

Dr. GOODSON. I think that, sir, if you don't mind, that comes back to this as one set of policies which the Federal Government has to look at. There are tax policies. This research program will have small but important leverage for the future. It will be fundamentally important to the university community, but we have got to get the other policies in place simultaneously if we're going to turn around the productive portion of our economy.

Senator STEVENSON. This question oversimplifies the issue, but you heard the industry representatives saying that American automotive technology was not behind foreign technology.

You, Dr. Goodson, said something that very much sounded in conflict. Is the U.S. auto industry technology behind the technology of the foreign manufacturers?

Dr. GOODSON. I think that is a complex answer. Let me try to simplify it very quickly. I think the technology we're seeing on American automobiles right now, one could make the judgment, is behind the technology of the average we're seeing on foreign automobiles.

I think the technology base that could be gotten into production, with many billions of dollars, is not all that different. So the question of what we're seeing now on automobiles versus what is available, there is a disparity.

But what is available I don't think is all that different, and we're talking about, again, the research at $1, the development at $10. And putting it into productive automobile results is a factor of $100 or $200 in expenditures.

So we're talking about not what's available in technology to pull off the shelf; I think that is there, it is common. They can put in all the technology we have. But, to back away from that, I'm not sure that our home manufacturing production capability in this country in machine tools and in the whole productive enterprise is not at a point of highly competitive structure with respect to the rest of the world.

We may be lagging over a wide industrial base. And that's why I think this is so important, to get started on some of these areas now.

Dr. RABINS. Let me give a specific example of the kind of the thing that you have to start on now or else you can't either put it aside or follow up on it.

There is a young man who came from England, who's now at the University of Michigan, who is doing research on electronic-controlled electric field enhancement within the combustion chamber to improve fuel economy and to improve fuel emissions. It is an innovative idea. He is doing imaginative work in the laboratory that is years ahead of what anyone else is looking at. It is very original and creative, and everyone else is very interested in keeping an eye on what this young man is doing.

But that's the kind of far-range, long-view basic research that our automotive industry perhaps has not had the luxury or the wherewithal to be able to fund to any great extent.

And the point, I think, of these hearings is that the Federal Government must step in to support those kinds of youngsters, students, faculty members to look at these far-out ideas way down the road. Maybe they will work; maybe they won't. But we have to look at them.

Senator STEVENSON. Senator Schmitt.

Senator SCHMITT. Thank you, Mr. Chairman.

Isn't the basic problem that we have that any time an industry is healthy and moving, that they normally do not divert their resources to basic research?

Do we have any good examples—we have to leave the aeronautics industry aside, because that is unique—but where an industry that was vibrant, healthy, making good profits, was putting money into basic research at the time for the hedge on the time when they might not be so healthy?

Dr. GOODSON. The whole electronics industry, computer industry, and even the drug industry spends a lot of their money for basic research.

Senator SCHMITT. Why? Why are they different?

Dr. GOODSON. They have incorporated innovation as basic, competitive strategies.

Senator SCHMITT. But why did they come down in a different way than the auto industry?

Now, I want to be fair to the auto industry. I think the GM representative and others have had basic research labs for a long time. Partly because of proprietary shields, we underestimate what has been going on in the auto industry. I think all of us do, particularly the academic community, because we interact so much and there are no proprietary restrictions except in our own minds.

But still, the investments were not being made to implement the new technologies in a systematic way; in these other industries you mentioned, even with the proprietary shields, they were doing the basic research. At the same time, they were forecasting the need for investments that were going to be required to extract good from that basic research even though they didn't know what the good was going to be.

Now, why did the auto industry not do that?

Dr. GOODSON. I have an opinion on that. And we have certain data. I don't think the industry had to incorporate innovation as a corporate business strategy on their major propulsion system until the 1970's. And it takes 15 years to turn that corporate innovation strategy around.

They are in the process of doing it. They are becoming successful. It's going to take another 5 to 10 years to do that.

And as the gentleman from Chrysler said, then they're going to start running out of technology, and it's time now to renew that technological data which resides in research but has not been put onto the vehicles.

So I think we have not demanded, as a country, innovation in our consumer products in the automobile until the past 10 years. And it takes 15 years to do that.

Senator SCHMITT. You're saying the demand was there and obvious in these other examples?

Dr. GOODSON. And it was not there in automobiles.

Senator SCHMITT. The Americans would buy any automobile put before them, whereas they were demanding better drugs, better communications; is that what you're saying?

Dr. GOODSON. That is what I'm saying. I sold automobiles. My father was an automobile dealer. He recently bought another share in an automobile dealership. And I love cars.

I could never get the car I wanted because I was an innovation nut, and other people wanted color or vinyl or what have you. So the market was not going the way I wanted it to, as an engineer or scientist, and I could not get the product I wanted at the price I wanted.

Dr. RABINS. There was also an FCC and an FDA providing those industries with some guidance. And it wasn't until this past decade or so that there was any guidance out of the Federal Government that gave anything but the marketplace demands to the automotive industry at the corporate level as a driving force.

Styling was the issue and model changeovers. And only in the past decade or so has Detroit become the city of the engineer. And that's partly in response to the guidelines put out by the regulatory agencies in Washington.

Senator SCHMITT. But wouldn't you agree that many of those guidelines had to do with things other than what we've been talking about here in these hearings? They had to do with cleaning up the tailpipe?

Dr. GOODSON. But the research stimulus and innovation stimulus given by those regulations has been immense, and it has changed.

Senator SCHMITT. So even though there may have been misdirected regulations, they had a net positive effect?

Dr. GOODSON. Well, I think so. And the regulatory process is an expression of market demand, given a different way, and we're just learning how, as a country, to do that efficiently.

And we did it very inefficiently through the 1970's, regulations on our major industry. The Government knew very little about the manufacturing industries and demonstrated that.

Senator SCHMITT. Do you have a positive feeling about the Government's historical interaction with the aeronautics industry and research efforts?

Dr. GOODSON. Certainly.

Dr. RABINS. The NASA research reports are some of the most highly respected in the research field.

Senator SCHMITT. So that at least it is a model we should consider. Whether we adopt it or not is another thing.

Dr. GOODSON. Let me go directly to your question, Senator Schmitt, on where this should reside. I don't think there was any place in Federal Government you could put a basic research program—in NASA, in DOT, in EPA, in a separate agency—that would shield that program from being used by the regulatory agencies.

The President has responsibility for those. And if I might be so bold and so daring and so foolhardy to say so the Commerce Committee itself has responsibility for not only these hearings on basic research but on the fuel economy standards itself. That would seem inappropriate, under these strictures, for the Government to look at a basic research program.

I am not sure you yourself can divorce consideration of the regulatory responsibilties from the research responsibilities.

So I think it comes down to a generic problem: Can the Government keep a continuous funding and basic research thrust going? I think DOT is perfectly capable of doing that. The problem is not that DOT tainted research with regulations; the problem is regulations played absolutely no attention to research.

Dr. RABINS. Amen.

Dr. GOODSON. I would be extremely thankful if DOT got some research results into the regulatory process. The regulations never tainted the research results, so that's one of the reasons that I don't think the industry made a statement that I think they could have. We would like to see some research results in the Department of Transportation which would be available to the Secretary on a direct basis.

I have little hope that a basic research program would influence those in a major way, but I have absolutely no worry that the regulatory program would influence the research program.

I think the basic question is: Can you get a stable funding mechanism, wherever it is in the Government, so that someone isn't asking, "Is what you've done last year on the road today," because the answer will be "no."

Senator SCHMITT. Well, I'm afraid that you have been shielded from some of the influences that the regulations have had on other agencies.

Dr. GOODSON. I have been deeply involved in the automotive area with EPA—Eric Stork, who directed the mobile source emissions program in EPA for 8 years.

Senator SCHMITT. EPA has not had a strong research base either.

Dr. GOODSON. I know.

Senator STEVENSON. If Senator Schmitt would yield, I have a slightly different concern. And that is that it just gets lost, basic research, in an agency that is oriented to regulation, as DOT is in its other occupations.

Something as long term and highly subjective as basic research gets lost. And you see it happening now in the Department of Energy. And there the mandate is much clearer.

Dr. GOODSON. I don't understand that. Thank goodness it would get lost, because if it's doing its job right, it's out in the research community and the affected industry, and not back here worrying what regulation should be.

Senator SCHMITT. That's not where it's getting lost.

Senator STEVENSON. No. It's just getting ignored. It gets dropped.

Dr. GOODSON. That's the fundamental question: Can you keep the money going?

Senator STEVENSON. It is not going in the other industries.

Dr. GOODSON. Then that's something you have to address.

Senator STEVENSON. It is being cut from mass transit in the Department of Transportation now. It's being cut for basic research also.

Dr. GOODSON. We're feeling that right now. When the budget-cutting exercise comes along, the first thing that goes is research.

Senator STEVENSON. NASA, on the other hand, has a strong mission orientation. Research and development doesn't survive intact. But I think, relatively speaking, it does better in pulling and hauling. It develops a constituency in the Congress and in the country. And also it is better capable, because it is not supported or coordinated at deputy assistant secretary level to attract the most qualified people in the country.

Dr. RABINS. The point has been made that there is no basic research capability within DOT. I would contend that there is some. And I would make the point that there should be a great deal more.

And heaven help us if the agency that's dealing with our lives on the roads and our kids' lives on the roads doesn't have a sound foundation of understanding and a knowledge base for the problems they're dealing with.

Senator SCHMITT. I agree, in theory, that this is ideal. But I started dealing with DOT in 1974, in trying to convince them that they should have a basic research program and that NASA would be happy to cooperate with them in those programs under their guidance.

Dr. GOODSON. You and I met on that issue.

Senator SCHMITT. They didn't want to do it. I mean, you and I had a good conversation, but when it started to work up a little bit higher, it just sort of died on the vine.

Dr. RABINS. There is an excellent report that has been referred to that you have in your records now—the OSTP panel report, chaired by Dr. Stever, February 1980—on the steps that should be undertaken within the Department of Transportation to establish a basic on research capacity. It is an excellent report. Really top-notch people worked on that and report came up with excellent findings and results. What concerns many of us is that it is not going to happen unless you watch it carefully.

Senator SCHMITT. That is very possible. I think the basic bureaucratic problem is that once an agency is the size of DOT or DOE and has a regulatory function, that regulatory function, under pressure from the Congress, the President, and the public, just grows and grows and grows until it overwhelms, in management's attention span, the basic research program. It overwhelms the

OMB in terms of how they allocate their resources that they propose to the Congress.

Historically, the Congress has been reluctant to be innovative in science and technology. We modify the budgets by 5 to 10 percent but really, when you look at the history of NASA, the AEC or any other programs, Congress has pretty much gone along with the lead of the administration.

Unfortunately, the lead of an administration that has to take agency inputs from agencies that are predominantly regulatory, is going to shortchange the research budgets.

Dr. GOODSON. One point on the OMB——

Senator SCHMITT. Not just the budgets, but the research emphasis, the planning, the programmatic planning, what are you trying to do, how are you going to get there, what are your project goals, if not programmatic goals are, over time. They just get shortchanged.

Dr. GOODSON. One of the reasons I supported it being inside of DOT is precisely the OMB problem. I had fights with EPA on the regulatory issues. Data helped. If there were basic research data, OMB would play one agency off against the other and try to arrive at some more rational decision.

And I have supported very strongly that there be a research program generating basic information within the Department of Transportation which would make that agency expert on the whole transportation picture in basic research and all the way through the applications area. That makes an agency honest, and that is why I think there ought to be a basic research arm in the DOT which is continually generating information.

I think it is an obligation. If there is a much larger program we're talking about, maybe NASA should be part of it, maybe DOE should be part of it, maybe the NSF should be part of it. So maybe we should talk about making this a collective, catholic program which addresses a wider point of view; but put some responsibility in DOT for generating basic research and nurture that.

Senator SCHMITT. Do you think that the alternative developed with respect to the FAA, which is part of DOT now, where their basic research arm was NASA? Is that an alternative?

Dr. GOODSON. FAA does basic research on its direct product, which is the microwave landing system, and not on the aircraft, which it doesn't have responsibility for. And I think that is appropriate. It does that well, more or less, and does a very fine job of that. So FAA is a mission agency which is charged with directing and following the landing system and the control of the airplanes, and it doesn't——

Senator SCHMITT. But in terms of the safety characteristics of aircraft, they are the basic research arm.

Dr. GOODSON. It is a regulatory agency in that sense.

Senator SCHMITT. But it has a basic research input.

Dr. GOODSON. And they do very well, I think. So that model works in a cooperative way.

Senator SCHMITT. Gentlemen, we thank you for your testimony. There may be some few followup questions for the record.

Our final witness today is Dr. John Gibbons, Office of Technology Assessment.

STATEMENT OF DR. JOHN H. GIBBONS, DIRECTOR, OFFICE OF TECHNOLOGY ASSESSMENT; ACCOMPANIED BY ROBERT MAXWELL, MANAGER, TRANSPORTATION PROGRAM; AND LARRY JENNEY

Dr. GIBBONS. Thank you, Senator Schmitt.

If I may, I would like to bring to the table with me the manager of the transportation program at OTA, Mr. Robert Maxwell, on my left; and Mr. Larry Jenney, on my right, who is the director of the OTA assessment comparing automotive technology and synthetic fuel production and costs, and the economic tradeoffs between these two major strategies. We have drawn in part on that assessment for the testimony today.

I would like to submit the written testimony for the record and simply provide some comments, especially in view of the lateness of the hour.

Senator SCHMITT. Please do, and any comments you have on the questions that have been asked and answered up until now would be appreciated.

Dr. GIBBONS. Thank you.

Clearly, in earlier times, especially prior to 1972, the automotive industry saw falling prices for fuel and therefore saw little incentive, without greater perspective than most of us have had, to invest in increasing automotive fuel efficiency. Now the rationale for accelerating efforts on a worldwide basis, and especially within the United States, toward a vastly increased efficiency in transportation is quite clear and no longer a matter of argument. The rationale grows daily.

As I see the rationale, it contains at least four elements. One is the much higher price of liquid fuels. The present marginal cost for a significant increase in world oil has been estimated as in excess of $16 per barrel. That new level of cost of energy clearly is the very signal we need to want to improve auto efficiency. The true total cost of energy, if one incorporates national security issues—even as soon as the latter part of this decade—may be much higher than that number.

The second part of the rationale is that much technology exists today that can and certainly will be utilized in making more efficient cars. That was the thrust I think you heard this morning from the industry. But in addition, substantial new opportunities do exist for great increases in efficiency of fuel use in automobiles. That is, the limits of natural law are far from being reached by existing technology. We know the opportunities are there. Downsizing is not our only option.

And last, the total cost to our nation of not introducing a rapid increase to higher efficiency in our transportation system could, I think, as you have said so well yourself, Senator, be devastating to the Nation. Therefore, there exists a clear basis for a large and sustained effort by the public as well as private sector, hopefully in concert, to address the problem.

The second point made in my testimony is that the goal of much higher fuel efficiency must be kept in context with other associated goals. These include the capability to shift to different fuels, auto safety, emission control, industrial competitiveness, and especially the total cost of mobility for the American consumer.

So one needs to keep in context these multiple goals and, by addressing them simultaneously rather than working on them in isolation, we should certainly hope for a more salubrious outcome.

The third point of my testimony has to do with the areas of basic but relevant research that one can identify rather clearly, and we mention several. They include materials sciences, combustion processes, electronics, energy storage, behavioral sciences. And we elaborate a bit on these in my testimony.

Research widens our options. It requires long-term and sustained support. Development then takes advantage of those options in various ways. The kinds of research that we have mentioned in the testimony are applicable, it seems to me, to a great variety, if not all, of the modes of transportation, rather than just the automobile.

The next part of my testimony has to do with the process of innovation. That process contains at least three intimately related phases: research, development, and production. I would add a fourth, which is service (repair and maintenance), and I think the notion of service is very importantly related to the goal of performance, including fuel efficiency as well as total cost.

Now, concerning the relationship between those activities, there is a traditional Federal role, and that is of basic research—basic yet relevant to the long-term requirements, basic research but not product development. Successful development—that is, carrying research on toward a product and then marketing the product—is clearly linked to the production and marketing part of that process of innovation. And it is that latter part which is clearly the logical role for the private sector.

The U.S. auto industry, for a variety of reasons, has focused upon using existing technology. It has also focused on the period of the 1980's. All too little attention, it seems to me, is given to the 1990's and beyond, despite the fact that successful production of autos involving new technology will require at least 5 to 10 years to put into place. So 1990 is essentially the next level or wave of technological innovation in the auto industry.

It can be argued that other institutions, including Federal agencies and universities, should be more directly utilized. But industry should be involved in all of these phases, since the industry is the are the ultimate recipient of the new knowledge from research, and the one that has to carry it on to the marketplace and compete successfully in the world.

In my testimony I refer to some of the criteria for the structure, the administration and the assurance of productivity of various cooperative ventures and Federal initiatives in this area. These include a stress on the continuity and stability of funding—that was stressed by earlier witnesses this morning—as well as review processes and a capability for risk-taking and for changes in direction when research results give that indication.

I then provide some thoughts about defensible levels of funding. The potential return for research investments in automotive research is literally staggering, especially when measured in terms of national benefit. The present level of research seems startlingly low compared with the magnitude of not only the challenge, but the manifold opportunities that exist.

In my conclusions, I urge that careful attention be given to developing a strong and effective working relationship between Government, industry, and academia. The job is certainly big enough to merit a deep involvement of all of us.

Now, with respect to the issue of the locus of the Federal activity, I would make just one or two brief comments, Senator. If a comprehensive mission responsibility is laid upon the Department of Transportation, it seems to me a new organizational commitment could orchestrate a very innovative and productive program, utilizing other Federal as well as private institutions.

But that commitment is going to require more than just a senior adviser, as was mentioned in the OSTP report. The potential advantage, of providing the locus for the program in DOT is that one might find an opportunity to integrate across the multiple goals in transportation, rather than simply addressing one particular goal, say of fuel efficiency.

It seems to me, therefore, that the issue has to do with the establishment of a clear mission that cannot be easily distorted in an administrative way and then making sure that management follows up that mission.

That is the end of my summary of my testimony, Senator. I or my colleagues would be happy to try to answer any questions.

Senator SCHMITT. Has OTA examined in an empirical way the NACA/NASA aeronautics experience as a model?

Dr. GIBBONS. Let me ask Mr. Maxwell to answer that. He has been there longer than I have and I think could give you a better answer.

Mr. MAXWELL. Senator, I do not know that we have specifically examined it in an empirical way, but we have certainly used NASA as a model in examining a number of technological issues. I am personally very familiar with NASA and of course supportive.

Senator SCHMITT. Does OTA have within its existing files discussions related to the NACA aeronautics area that would help us in our deliberations, that you could supply for the record?

Mr. MAXWELL. We do have in a study which we have just completed, which is an examination of the impact of advanced technology in commercial air transportation, a discussion of the NASA role in aeronautics and how we believe it does fit into the future. We have made copies of that report available to your staff already.

Dr. GIBBONS. Senator, I have one background paper presently out on review, which I think may have some relevance to the issue. It is probably too long for you to include in the record, but it has to do with the role and effectiveness of various kinds of national laboratories—NASA, DOE, and others. And I would be happy to furnish your staff with a copy of that draft if you think it would be helpful.

Senator SCHMITT. Do you, Dr. Gibbons, concur in the industry's presentation that their basic research efforts have been extensive through the years, more so than they are given credit for?

Dr. GIBBONS. I do not believe that I could personally defend the claim by industry of a high level of basic research. Surely, the industry has been spending, I believe, nearly 3 percent of their sales on research and development, at least in recent years. I am not sure how much of that can be called basic research versus

policy-driven research and development to satisfy emission and safety requirements.

Certainly, the history of the industry in research is less impressive than that of electronics and other kinds of industries.

Senator SCHMITT. Well, I don't think that I would argue with you that in the seventies a great deal of research was driven by Congress and by the regulatory agencies. However, the previous witnesses suggested that even though some of this research may have been misdirected in terms of its net benefit to society, it did have the result of beginning to lay a base of engineering and research competence in Detroit which had been allowed to wither on the vine in preceding decades. Would you agree with that assessment?

Dr. GIBBONS. I would certainly agree.

Senator SCHMITT. I always look for silver linings around every gas cloud I see.

Dr. GIBBONS. I think we are finding almost a new direct corollary to looking at the tailpipe. That is, in looking at the tailpipe the industry soon found themselves looking into the combustion chamber and began to experiment with new ways of controlling combustion in order to influence what comes out of the tailpipe.

The most recent example of that is industry looking at toxic and hazardous wastes. I talked with a number of colleagues in industry, and they indeed find that, rather than looking at the outflow of wastes, they are now moving back into the process in order to affect what comes out. So I believe we find a parallel of a regulatory forcing process that causes industry to look at its tailpipe, as it were. The result is not all that disadvantageous. Ultimately, industry will go back upstream from emissions to the process that makes the most sense in terms of fixing the problem.

Senator SCHMITT. It may not be the most efficient way to regulate or to get the job done, but it has had its positive effect.

Dr. GIBBONS. Yes, sir.

Senator SCHMITT. I don't think the Government, when they established those regulations, really realized what the net result of the process would be. But it may have helped.

Dr. GIBBONS. It may be a form of the invisible hand.

Senator SCHMITT. What about the area of quality control? I recently read a discussion or a comparison of the differences in approach to quality control and quality assurance that the Japanese are using in their automobile industry and other industries versus that which we use. Theirs is more of preventive quality control where ours tends to react to a problem once it appears.

Do you concur in that comparison? And if so, do you think part of the research program should be aimed at how to establish managerial and engineering controls, so that you get preventative quality control?

Dr. GIBBONS. This relates, Senator, to the point I wanted to make about service, in the sense of making sure that the product does stand up and gives the least amount of incremental cost to keep it in use once the product is on the marketplace. As we move toward higher efficiency in automobiles, the automobile will become more complicated, in the sense that we will, for example, put in a microprocessor to help optimize the flow of fuel and the mixture of air. In so doing, we place additional requirements for training, exper-

tise and sophistication, not only in the production process but also in the servicing sector. I believe it will automatically call for higher quality and better trained people. After all, you don't get something for nothing. To get the same utility from the automobile with much less fuel consumption simply means we have to spend more money and care in the way we design, build and service it, and correspondingly less money going to the OPEC countries.

So I think quality control will be an increasingly important issue, along with technological sophistication. The Japanese have chosen to move much more rapidly toward robotics and other automated devices as a means of quality control.

Senator SCHMITT. Should that be part of any research program in the automotive area, robotics?

Dr. GIBBONS. I believe we have perhaps understressed the role of robotics, particularly in this decade, when extremely smart devices can be built. It will be within this decade, for example, that one can store a megabit of information on a single chip of silicon. This means that during this decade one can begin to build machine intelligence into robots in a way that we really hadn't thought of before. I am sure you have thought of it before, but most people have not.

[The statement follows:]

STATEMENT OF DR. JOHN H. GIBBONS, DIRECTOR, OFFICE OF TECHNOLOGY ASSESSMENT

Mr. Chairman and members of the subcommittee, I am pleased to have this opportunity to appear before you today to speak about research needs and opportunities in the field of automotive technology and about actions that the Federal Government might take to influence or to support technological development. We are all now painfully aware of the need to reduce petroleum consumption by passenger cars and trucks and, eventaully, to develop substitutes for petroleum-derived motor fuels. The events of the past year have brought home sharply the problems resulting from our dependence on petroleum. We have also been reminded of the intimate relationship of the automobile to the state of our economy, employment, and the mobility that we enjoy so much. Automotive technology has undergone a great change over the past decade. Greater changes are coming in this decade. But the transformation will be far from complete by 1985 or 1990, and I firmly believe that we need to look at the end of this century and into the next to appreciate the nature and magnitude of what must and can be accomplished through technological improvements. While none of us can foresee with certainty what specific form these changes will take, we can start from the premise that technological development will greatly depend upon an expanded base of knowledge derived from research.

GOALS FOR AUTOMOTIVE RESEARCH AND DEVELOPMENT

Before addressing questions of Federal initiatives to support automotive research, I would like to state briefly what I consider to be appropriate goals for the overall effort to improve automative technology, of which research forms an integral part. Unless we are clear about the goals for improved automotive technology, it is difficult, if not impossible, to mount an effective research plan.

1. There is a need to preserve and expand personal mobility. We must seek to maintain and to extend the benefit of personal mobility, such as the automobile affords. This has clear implications for the cost and utility of future passenger vehicles.

2. We must reduce substantially the amount of energy consumed by automobiles, especially the portion of that energy which is derived from imported petroleum. Thus, a sustained and intensive effort to improve automotive fuel economy is of pivotal importance.

3. Ultimately, automotive technology must evolve to the use of alternate energy sources. This entails not only substitute liquid fuels also the development of electric vehicles and perhaps eventually engines fueled by hydrogen.

4. We must continue to improve automotive safety. In the effort to achieve other goals, we must also take measures to improve occupant protection and vehicles crashworthiness.

5. Likewise, we must take care to protect human health by controlling automotive exhaust emission to the lowest practical level.

6. Finally, we must seek ways to encourage the competitiveness and viability of the U.S. automotive industry in both domestic and international markets.

OTA ASSESSMENT OF AUTOMOTIVE TECHNOLOGY AND ALTERNATE ENERGY SOURCES

As you know, Mr. Chairman, the Senate Committee on Commerce, Science, and Transportation has asked OTA to examine many of these concerns in an assessment of automotive technology and alternate energy sources. This study—now in progress and scheduled for completion early next year—has three objectives.

The first is to assess prospective improvements in automotive fuel efficiency and the technology of alternative energy sources. The second is to evaluate the cost, benefits, timing, and impacts of automotive fuel economy improvements compared to those of developing alternative energy sources, such as electricity and liquid fuels synthesized from shale, coal, and biomass. The third is to examine policies and institutional arrangements that the Federal Government might consider to influence the direction and pace of technological development and application.

In conducting this assessment. OTA recognizes that the introduction and use of new automotive technology is not simply a matter of research and development. A technology that has been shown to be technically feasible and amenable to mass production must pass several more tests before it can enter the marketplace. Further, the rate of commercialization and the extent to which it replaces existing technology are conditioned not only by market forces but also by such factors as capital formation, industrial capacity, and corporate strategy. In part, it is a matter of how industry preceives cost—not just in monetary terms (although this is very important), but in the larger sense of risks, penalties, the competitive position of the corporation, opportunities realized, and opportunities foregone.

Thus, the OTA approach to assessment of automotive technology considers not only technical questions of fuel economy but also the industrial and economic factors that could influence the nature and rate of change. Attention is also being given to long-term trends of the automobile transportation system as a whole, especially the relationship between vehicles and fuels and the energy demands of transportation in the context of overall U.S. energy consumption.

While it is premature to discuss the results of this OTA assessment project, an outline of the findings as they relate in research and development has begun to emerge. Therefore, I have used the expertise being developed in the project as an input to my remarks today.

NEED FOR BASIC RESEARCH

It is clear that attainment of the goals I described earlier involves far more than research. In other words, research is necessary but not sufficient and must not be viewed in isolation. We must be concerned with the broad course of activities that spam from the laboratory, through the manufacturing and production process, to introduction in the marketplace. On the other hand, while the road to improved automotive technology does not end at the laboratory and research center, it certainly begins there. Much of what eventually reaches our streets and highways, and when it reaches there, will be strongly affected by the quality and extent of the research in progress and to be conducted over the next decade.

The research agenda laid out by those who have formulated the Cooperative Automotive Research Program (CARP) is comprehensive and detailed, and they are to be commended. However, the size of this agenda also indicates that we know surprisingly little about the fundamentals of a technology so familiar and ubiquitous as the automobile. Clearly, one reason for this situation is our legacy of past decades when the real price of fuel fell steadily, making automotive fuel-efficiency a matter of minimal concern. Among the areas overdue for attention that I would like to single out are:

Materials science, where there is a need to know much more about the properties and processing techniques of conventional materials (iron and steel) and of substitutes such as aluminum, magnesium, plastics, ceramics, and composites; combustion processes, where the understanding of fundamentals and the properties of various fuels and mixtures of fuels needs to be strengthened; electronics, where the advent of microprocessors and improved sensors and activators opens up attractive opportunities for control of the engine to improve fuel economy and to minimize harmful emissions; energy storage, which is crucial to any subsequent development of the

electric vehicle as a viable alternative to the conventional automobile; behavioral science, which is still in its infancy insofar as achieving an understanding of how to achieve synergism between the driver and the vehicle and how to safeguard against the consequences of equipment failure or human error and inattention.

In some cases, research is needed because the basic requirements for automotive technology have changed and new technology is needed. In other cases, research is needed to compensate for want of sufficient attention in the past and to fill gaps in our knowledge base. In still others, recent advances in science and technology present opportunities calling for additional research—a case of technology begetting new technology.

In this situation, it appears that the Federal Government might assume three important roles. First is providing leadership and stimulation of a broad and accelerated research effort by industry, universities, and research organizations. Second, because the slate of topics is large and the need is urgent, the Federal Government could provide a part of the necessary funds and resources. Finally, in view of the breadth and diversity of the required undertakings, the Federal Government could assume the role of a coordinator to assure a balanced and effective research program.

BEYOND RESEARCH

As I indicated earlier, research is but the first part of the process of innovation. The history of technology development and application has shown that there are three major phases of this process:

Research—study and investigation to establish facts or principles, i.e., a knowledge base.

Development—application of the knowledge base to the design, construction, and test of components and major system elements to demonstrate projected capabilities

Production—the engineering and fabrication of commercial products.

Traditionally the Federal Government has carried the major burden of the cost of basic research, on the basis the results would benefit all of society. However, in order to achieve the broad objectives outlined above it is essential that the steps beyond research be pursued at an appropriate level of effort and with proper timing. Concerning the *development* phase the question is "What is the role of the Federal Government, if any, and what is the appropriate mechanism, type of support and funding to carry out this role?" Development activities leading to improvements in the automobile of the 1980's are being actively pursued by the automotive industry. However, indications are that the industry has very little development effort directed toward the vehicles of the 1990's. Some Federal efforts are underway, sponsored by DOE and DOT, in the area of alternate heat engines and integrated safety vehicles, which may have potential application in this time period. We believe that the case can be made that exploratory and advanced development efforts, by both industry and government, are inadequate for the longer range evolution of automotive vehicles to meet national needs and foreign competition.

To cite just one example, we all recognize that the single most important factor affecting automotive fuel economy is vehicle weight. The existing knowledge base includes a great deal of information on new materials (composites, plastics, high strength steels, aluminum and magnesium) and vastly improved techniques in structural design and manufacturing processes. These and other technologies, which are available today, but which are not being agressively utilized, should be applied in a continuing program of exploratory and advanced development to establish the practical base for the vehicle of the 1990's. If the industry is not prepared to pursue application of these technologies alone, a cooperative industry-government automotive *development* program could be considered to assure that the goals of the domestic automotive system are to be realized. It should be made very clear that an exploratory and advanced development program, while utilizing the results of CARP, should not infringe on *research* objectives and the method and pace of executing research. It is important that the resources allocated to basic research not be diverted to development and demonstration activities. It should also be made clear that the role of the government in automotive tehcnology and advanced research and development should be that of leadership, coordination and support. Product development and commercialization should, of course, remain the domain of private industry. The decisions to commercialize particular technological improvements and the choice of the rate and scale of introduction in the market are matters that should be left to the marketplace, albeit influenced by public policies.

INDUSTRY PARTICIPATION

It is our view that there should be industry involvement in all phases of automotive research and development. Furthermore, this involvement should be one in which the proper incentives for industry participation are provided from the outset without the threat of unforeseen new government regulatory requirements. The management and administrative problems associated with this degree of government and industry cooperation are significant, but the potential rewards for industry and society are so great that we must address them in the most effective way possible. This leads to consideration of how both research and development efforts could be implemented.

CRITERIA FOR PROGRAM STRUCTURE AND ADMINISTRATION

Rather than comment on specific legislative proposals, I would like to outline some "rules of thumb" that I believe should be considered by Congress in selecting among various management and administrative options.

Focus and relevance.—A mechanism should be devised to make certain that the projects undertaken and the research methodology employed are relevant to the broad objectives of the program. At the same time, the projects should be sharply enough focused to provide a means for evaluation in a reasonable length of time.

Flexibility and freedom of choice.—The administrative structure should be as simple as possible. We should recognize that research and development efforts, to be successful, must allow the individual and the executing organization flexibility in their approach, freedom to choose among various paths to possible solutions, and the opportunity to change course if and when found to be appropriate.

Coordination and information exchange.—The broadest exchange of information at all steps in the research and development process is essential to avoid unnecessary duplication. A certain number of parallel paths are desirable, however, in order to verify the results, to select the optimum solution, and to provide competition.

Proprietary interests.—The proprietary interests of individuals and organizations must be adequately safeguarded if the proper incentives for involvement are to be preserved.

Stability and continuity of funding.—The budget procedure must recognize that research and development activities need stability and continuity which may not be consistent with an annual authorization and appropriation process. Projects must not be subjected to a continual process of rejustification, and continuity of funding should be assured as long as reasonable and progress is being made. This is not to say, however, that oversight of individual projects on a periodic basis is not essential, but risk taking, based on sound judgment, needs to be fostered, not penalized.

Excellence of performance.—The highest level of excellence must be maintained in the conduct of the research and development activities. A system to reward excellence and to weed out poor work is essential.

In view of the above, I would suggest that the Congress examine the various legislative proposals to determine which management, administrative, and organizational approach appears to be most suitable in meeting these criteria.

FUNDING LEVELS

I would now like to speak briefly on the matter of funding that would be required for cooperative research and development programs. OTA has not studied this question specifically; therefore, I will confine my remarks to some observations on the appropriate order of magnitude of such funding.

The authorization specified in S. 2015 is $800 million over a period of 10 years, with a matching amount to be contributed by the automobile industry. This would be an average annual expenditure of $160 million and would constitute a substantial increase over what is now being spent by government and industry on basic research in the automotive field. As large as this sum is, it is only a very tiny fraction of the annual revenue from sales of automobiles and trucks, which in 1978 amounted to about $130 billion. Thus, the combined industry and government expenditures for an average year under the proposed CARP program would amount to about one tenth of one percent of automobile and truck sales. Industry's share of this would represent less than 2 percent of their 1978 profits.

In 1978 the automobile industry spent about $4 billion (3 percent of sales) on research and development activities, the preponderance of which was for product development to meet near-term goals of fuel economy, emissions and safety. A long-term research and development program such as I outlined earlier, which would include exploratory and advanced development but not product development and production engineering, might require a combined Government and industry ex-

penditure of an additional $1 billion per year for a period of 10 to 15 years. If so, this would amount to an annual increase of about 25 percent in total automotive R&D expenditures. As a percentage of sales, this would increase annual R&D cost from the present 2.8 percent to 3.5 percent—which would bring automobile industry expenditures up to a level about the same as the 1978 average for ten high technology industries in the United States, including aerospace, chemicals, drugs, electronics, and semiconductors.

If the results of an R&D program were to result in an improvement in fuel economy of as little as five percent, and if this improvement were to be introduced into the entire domestic automobile fleet, over $3 billion per year would be saved in fuel costs.

SUMMARY

To conclude my testimony, I would like to reiterate three major points:

There is a clear need for a broad program of basic research in automotive technology. There are manifold opportunities that could lead to significant improvements in fuel economy, emissions, and safety and could reduce initial and life cycle costs. Participation by the Federal Government in this program is desirable both as a stimulus to the industry and as a way of assuring an appropriate level of effort and rate of progress toward meeting national needs.

Research is but the first step in the more extended process by which new automotive technology will reach the marketplace. The support of the Federal Government also seems appropriate for a program to develop this improved technology and bring it to a state of readiness for commercialization.

There are many legislative actions that could be taken to promote and support automotive research and development. In choosing among them, the Congress should seek to create a strong working relationship among Government, industry, academic institutions and the research community and should strive to foster clear sense of how a cooperative effort can serve the national interest.

Senator SCHMITT. Thank you, Doctor, and your colleagues. We appreciate it. And I'm sure, as these hearings and our deliberations develop, we will have more questions for you.

The committee will recess until May 9, when we will continue the Senate hearings, although as I understand it along a somewhat different line, with fuel efficiency standards and so forth. Thank you again.

[Whereupon, at 1 p.m., the committee was recessed, to reconvene on Friday, May 9, 1980.]

AUTOMOTIVE TECHNOLOGY AND FUEL ECONOMY STANDARDS

FRIDAY, MAY 9, 1980

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met at 9:30 a.m. in room 235, Russell Senate Office Building, Hon. Adlai Stevenson (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR STEVENSON

Senator STEVENSON. The subcommittee will come to order.

Today we begin hearings on the automotive fuel economy program for 1985 and beyond. The Motor Vehicle Information and Cost Savings Act enacted in December 1975 set standards for model years 1978, 1979, 1980, and 1985. The standard for 1985 is 27.5 miles per gallon. That act gave authority to the Secretary of Transportation to set standards for the years between 1981 and 1984 and model years following 1985.

Senator Jackson has proposed Congress establish an average fuel economy standard of 40 miles per gallon for model year 1995. His amendment would continue the Secretary of Transportation's authority to set standards for the intervening model years 1986 through 1994.

To support the activities of the Secretary and for the establishment and administration of standards beyond 1985, it has also been proposed that the National Highway Traffic Safety Administration be authorized $200 million during the 1980's for automotive fuel economy technology assessment.

For years the industry's advertising helped shape the consumer preference for large energy inefficient cars. Now the industry seeks protection from the consumer preference for foreign-made small fuel-efficient cars and trucks. Congress is invited to sacrifice consumer choice and energy conservation and trade to aid this large and troubled industry.

Fuel efficiency standards are but one part of the quandary which invites tradeoffs between conflicting economic interests, but it may be that a balanced policy can serve the interest of consumers, the domestic automobile producers, and the national interest in energy conservation and trade all alike.

Such a policy would involve fuel efficiency standards that required the production of efficient vehicles for the mid-1980's and beyond when gasoline sells for $3 per gallon or far more, if it's available at all for discretionary driving. It might also involve

Federal assistance for capital formation in this industry and research and development for automotive and advanced manufacturing technologies.

Instead of bailing out Chrysler, the Congress might more wisely facilitate its reorganization, aid the survivors, if they are willing or required to produce fuel-efficient automobiles before the world runs out of oil.

We have held hearings on the automotive technology issue in this and other committees. We will address all parts of this problem. The Chrysler syndrome is reaching into all the automobile companies and beyond the automobile industry to others. Senator Schmitt.

OPENING STATEMENT BY SENATOR SCHMITT

Senator SCHMITT. Thank you, Mr. Chairman.

I won't take long this morning. I think it's clear that from a technological point of view the only things that lie between us and the proposals we have heard for much more fuel-efficient cars is time, imagination, and capital.

The fuel question is a real question. But it is my personal belief that from a geological and technological point of view the fuels will be there. Oil will be there at high cost if we continue to encourage its production. Domestically, over the years the fuel of the future will probably be a combination of synthetic, hydrocarbons, hydrogen, and very probably electric through battery-powered short-distance vehicles.

I'm not nearly as concerned about what is technologically feasible as I am about the politics of making that technology available in the shortest possible time.

Mr. Chairman, I'm looking forward to hearing Senator Jackson's testimony.

Senator STEVENSON. Senator Magnuson.

OPENING STATEMENT BY SENATOR MAGNUSON

Senator MAGNUSON. Mr. Chairman, I have a short statement I'd like to make.

An ever-growing number of consumers are turning to the fuel efficient vehicles produced by foreign automakers as fuel prices rise and supplies remain uncertain. As a result of this trend, domestic car sales have fallen and more than a quarter of America's automakers have been laid off their jobs. We had a good example of that early this morning in the U.S. Senate where we had a long debate and a vote on coming to the aid of the automobile industry. Clearly Detroit must begin producing fuel-efficient cars to meet the challenge of their foreign competitors.

Our national security also dictates that American built cars attain improved fuel efficiency. Automobiles alone account for 30 percent of the petroleum consumed in this country. Despite the progress we have made in encouraging the development of domestic energy resources, we are likely to remain dependent on foreign oil well into the next decade.

The 40-mile-per-gallon 1995 goal established in the legislation which Senator Jackson and I have introduced is reasonable. The Congressional Budget Office will soon release a report that con-

cludes that 1995 model year domestic cars could achieve at least 37 miles per gallon without any advances in technology. A number of foreign automakers already offer cars which meet the goal set in our legislation. While questions remain about the economics of extending fuel economy standards beyond 1985, it is certain that U.S. automakers will not survive without substantially improved fuel economy.

Senator Jackson is to be commended for introducing this legislation, of which I am a cosponsor, which recognizes the long-range needs of consumers, U.S. automakers, and our national security, and I urge my colleagues to give their attention to extending fuel economy standards beyond 1985.

Senator STEVENSON. Senator Cannon.

The CHAIRMAN. Well, thank you, Mr. Chairman.

I don't have any comments to make other than the fact that I think it's been adequately pointed out the importance of the issue and I'm here principally to listen to the people involved and see what they say can be done and how they are going to do it.

Senator STEVENSON. We are very pleased you would join us this morning, Senator Jackson. Please proceed.

STATEMENT OF HON. HENRY M. JACKSON, U.S. SENATOR FROM WASHINGTON.

Senator JACKSON. Thank you.

Chairman Stevenson and members of the committee, on April 24, 1979, more than a year ago, Chairman Cannon of the full committee sent me a letter reporting on a hearing held by the Commerce Committee on March 23, 1979, on the future automotive development needs. This committee was investigating the call of the then Secretary of Transportation Brock Adams to redevelop the automobile so as to achieve a 50-mile-per-gallon average fleet fuel economy rating. The result of this hearing was:

> The hearing was inconclusive as to the technological or economic feasibility of redeveloping the automobile as the proper solution to projected petroleum shortages. That matter will be evaluated through further studies and possibly hearings to be conducted by the committee.

However, a concern did emerge among all witnesses that the Nation must move aggressively to develop synthetic fuels and these would be needed regardless of fleet fuel economy performance.

The chairman of this committee called for a national program which would coordinate these efforts, provide adequate overall direction and funding, and, more importantly, set priorities and a timetable for results.

Mr. Chairman, I want to report to the members of this subcommittee and to the Commerce Committee as a whole, first, that we have taken your advice.

As you know, after considerable effort and aided by the views of many knowledgeable groups, including this committee, the Energy and Natural Resources Committee reported a synfuels bill, S. 932, which is now proceeding through conference. All the major issues regarding the synfuels portion of the bill are resolved. The Nation will have a synthetic fuels program with a commitment behind it rivaling that of the Manhattan project and the Apollo project.

However, Mr. Chairman, I also want to report to the Commerce Committee on a second matter. In the course of listening to the testimony of the Nation's expert energy analysts, the members of the Committee on Energy and Natural Resources made an unpleasant discovery.

The United States will remain dependent on millions of barrels per day of imported oil, including OPEC oil, for two, perhaps three, decades to come. This is true, whether or not we have a massive synthetic fuels program.

It is clear to me and to my colleagues on the Energy Committee that we do not, as some of us once thought, have the luxury of choosing between synthetic fuels and enhanced automobile fuel economy, between nuclear power and solar power, or between gasohol and electric vehicles. We will need the contribution of every energy source to the limits of economic prudence, if we are to secure any respite from unpredictable, jolting price hikes and oil supply disruptions. I would remind you that the goal in S. 932 is to produce 1.5 million barrels per day oil equivalent by 1995 and a good portion of this will be gas, not liquid fuel.

And so we must turn once again to a second round of energy conservation, not for a solution to the energy crisis, but in order to mitigate our continuing dependence on foreign oil. Senator Magnuson, former chairman of this committee and senior member of the committee, can take credit for establishing what is probably the most important single energy law on the books. DOT estimates that the EPCA auto fuel economy standards will result in savings of 1.1 million barrels per day in 1985 and 1.9 million barrels per day in 1990, as compared to the fuel consumption that would have occurred had the 1977 fuel economy levels continued. I would interpolate here, if you look at those numbers, that is more conservation than we will be achieving at an expense in current dollars, Mr. Chairman, for the entire synthetic fuels program, which we estimate around $100 billion. So the conservation here saves more than what we will be producing out of our synthetic fuels program. There is no doubt in my own mind that the standards pushed Detroit faster into higher fuel economy than would otherwise have been the case.

Those standards will level off in model year 1985. Therefore, Senator Magnuson and I and a number of our colleagues introduced amendment No. 1664 to S. 2015, which calls for a 40-mile-per-gallon corporate average fuel economy by 1995.

On April 30, the Committee on Energy and Natural Resources held an oversight hearing on the potential for enhanced auto fuel economy. Several conclusions emerged.

First, there was a consensus from DOT, the Congressional Budget Office, DOE, Ford, and GM that a 1995 CAFE—that means corporate average fuel economy—of 40 miles per gallon is technically feasible. Charles Gray, chairman of the transportation task force of the Solar Energy Research Institute/Conservation study, called for a 50-mile-per-gallon standard in 1990 and an 80-mile-per-gallon standard in 1995.

Technological feasibility, I submit, is not really at issue. The only dissent came from AMC who admitted that 35 miles per gallon was

technically feasible by 1995, but given their present product plans they could not achieve 40 miles per gallon by 1995.

Second, the potential oil savings from enhanced automobile fuel economy are enormous. DOT stated in its answers to questions submitted by the committee that a 40-miles-per-gallon CAFE for cars and 30 miles per gallon for light trucks would save, as compared to the existing standards, 560,000 barrels per day in 1990, 1.4 million barrels per day in 1995, and by 2000 the incremental savings would be 2 million barrels per day.

The third conclusion reached by this hearing was that such large improvements in fuel economy are cost effective for the consumer. Senator Stevenson and I jointly asked CBO to study what is currently known about the potential for improved automobile fuel economy. Their testimony before our committee shows that assuming the use of today's fuel saving technology, cars could achieve 37 miles per gallon by 1995 and the consumer would save twice as much in reduced gasoline costs as he pays for that fuel saving technology in a 37-miles-per-gallon car.

And, of course, this analysis ignores any benefits to the Nation in the form of enhanced national security, improved balance of trade, and reduced unemployment in Detroit.

There is a fourth conclusion. If the Congress determines to extend the fuel economy standards beyond 27.5 miles per gallon by statutory amendment, then the auto industry will need as much as 5 years leadtime. DOT will need at least 1 year to propose interim standards, have public comment, and issue a final rule. Therefore, from the standpoint of lead time, if the Congress is going to adopt post-1985 standards by statutory amendment, they must act no later than the next Congress, preferably next year.

Finally, I would add another point from our hearing. Even if a 40 or 50 miles per gallon new car fleet is technically feasible; cost effective for the Nation in 1995 from the standpoint of the cost of imported oil and synfuels; cost effective for the consumer; and even if such fuel economy levels are essential for our national security, there is no guarantee that every automaker can raise the capital to produce these cars.

I believe that the Federal Government should provide financial assistance to Detroit to enable them to tool up to meet the standards, if that assistance is necessary. In that vein, I offered amendment No. 1665 which would have provided accelerated depreciation to the automakers on equipment used to produce very fuel-efficient automobiles. Clearly, that provision presumes the existence of auto company profits and so it will not be enough.

The members of this committee are well aware that Detroit is in trouble. Chrysler lost over $400 million in the first quarter of this year. Ford had its worst quarter ever. GM has slashed its dividend. Registrations of imported automobiles in January reached an all-time record of 27 percent, while 10 years ago import registrations were only about 15 percent. Volkswagen of America is working overtime while the other domestic automakers have laid off over 200,000 workers. I believe that figure is now about 250,000.

The recession and high interest rates are part of the problem, but there is no doubt that the success of auto imports is the problem that will remain when the recession is over. Fuel economy

is the primary difference between the imports and the domestic automobiles.

There are six foreign-made automobiles on the market today in the United States that get more than 40 miles per gallon. I asked the four domestic automakers if any of them have any plans for an automobile that gets 40 or more miles per gallon. They were all silent.

I believe the Congress would agree to help Detroit if in return Detroit would commit to achieving the high fuel efficiency levels that are in the national interest.

The administration appears unwilling to discuss policy options until completion of their auto industry study in January 1981. I only hope that such a delay before serious discussion begins will not be lethal.

Mr. Chairman, I have sponsored four amendments, but clearly the focus of this hearing is amendment No. 1664 which would increase the CAFE standards to 40 miles per gallon. I would like to reserve the opportunity to offer at next week's hearing a prepared statement on the amendments that would mandate labeling of motor oils and tires as to their effect on fuel economy.

In closing, I would harken back to the letter from the chairman of this committee, my good friend, Senator Cannon. Speaking of the synfuels program, he called for a national program which would coordinate these efforts, provide adequate overall direction and funding, and, more importantly, set priorities and a timetable for results.

This we have done for synfuels. Now it is time to do the same for automobile fuel economy and get this industry back on its feet. I would hope that the Energy Committee and the Commerce Committee can work together in this effort.

Senator STEVENSON. Thank you, sir.

You said the Congress should be willing to provide assistance if the industry is willing to make a commitment to the production of fuel-efficient automobiles. At the much publicized breakfast just a few days ago, the industry representatives—and they included all the large automobile manufacturers—were asked to make that commitment and they refused. The representative of one of the largest said that the plans of the industry were to offer the consumer a choice. That's a code word for large automobiles as well as small fuel efficient automobiles.

Is that why you suggest standards?

Senator JACKSON. Yes; I think it's very clear——

Senator STEVENSON. It has to be a requirement?

Senator JACKSON. Yes, Mr. Chairman. It's very clear to me that had we not put the provisions, as you recall since you worked hard on the EPCA, for the 27.5-mile standard by 1985, we wouldn't be moving in the direction that we are moving; but it's clear that it's simply inadequate.

Clearly, the American automobile makers, except for AMC, have failed in appreciating the attitudes of the consumer in the marketplace.

Now there are all sorts of proposals to put on tariffs and quotas which I oppose. Certainly, the American people are entitled to get the most fuel-efficient car as the price of gasoline soars, and you

know this country may not be the greatest in every area of industry, but certainly when it comes to technology we have led the world, and the ability to produce fuel-efficient cars should be ours and not left to the foreign automakers.

Senator STEVENSON. Now you're the chairman of the Senate Energy Committee. What will the consumer price be by the mid-1980's? What will the price of gasoline be by then? Let's make an optimistic assumption that there is no interdiction of supplies of fuels from the Persian Gulf. With that optimistic assumption, what will gasoline prices be in the United States by the time new production would come on here?

Senator JACKSON. Mr. Chairman, a year ago in January I predicted we could have $1 a gallon gasoline within a year. I was wrong. We had it within 4 months. The facts are that OPEC, as you know, is meeting this week and we expect an announcement next month on a new round of price increases. There's a lot of speculation as to what that price increase is going to be. It's obvious and I previously suggested that we could have—especially if you have cutoffs and you have a huge increase in the price of oil—we could have $2 a gallon gasoline by the end of the year. I don't think we are headed that far at this time, but certainly we are going to have $2 a gallon gasoline in 1982.

Senator STEVENSON. By 1985?

Senator JACKSON. Oh, we'll have it before 1985.

Senator STEVENSON. $3 or $4?

Senator JACKSON. I don't think there's any way—it depends—let me state my premise. How we manage our foreign policy will determine the availability, the reliability, the supply, and the price of petroleum over the next 10 to 15 years. Now how are we going to manage it?

Senator STEVENSON. That suggests maybe $10.

Senator JACKSON. Well, I was waiting for you to comment but that is the key here, because one can almost determine the prime rate of interest, Mr. Chairman, by watching the Rotterdam spot market. I was doing that for a while. Of course, the spot market is going crazy, but the point is that whether we like it or not, assuming that we do all these things—synthetic fuels, solar energy, nuclear, coal, and a massive conservation program—we will be running and running hard in order to stand where we are now, to stand still on imports.

Senator STEVENSON. One final question. I don't want to press on my colleagues' patience. Next year Chrysler reintroduces the Imperial. You have indicated that the consumer choice is going to be even more so than now for fuel efficient automobile standards in the 1980's and beyond. It will be a long time before we develop our own sources of fuel and relieve ourselves on these undependable very expensive increasingly expensive foreign sources. Why do you choose 40 miles per gallon? You have admitted that's technologically feasible. Why not go for a much higher standard, require a higher standard of efficiency, and then provide the capital assistance and technological assistance if that's necessary with which to meet it, and save this industry from itself as well as the consumer?

Senator JACKSON. Yes; well, I have been saying over and over again that we are trying to save Detroit from themselves. What we

are trying to do is not to be punitive but helpful. It's very distressing when the Congress has to indicate to the industry what the attitudes are and going to be in the marketplace, but we can do a lot better than the figure that we mentioned here. All we are doing is nudging—nudging—telling the direction that we should be going, and clearly this country has the technological capacity and the innovative ability to provide for a larger car with less horsepower, weight reductions, which the industry is starting to do, but we need to move with dispatch, Mr. Chairman. That is my concern. We've got to move fast or there will only be one company and even General Motors is having financial problems. In the third quarter, Mr. Chairman, allowing for—if you pull away the tax carryforward, they had a deficit. It was a small one in the third quarter. This quarter their earnings were way off. At $55 a share, their dividend was $1.65 for the same period year previous and they ended up cutting the dividend to 60 cents, and their own statement indicates that they may have a loss in the second quarter. That was the largest industrial corporation in the world. It's now second to Exxon I believe.

Senator STEVENSON. Senator Schmitt?

Senator SCHMITT. Thank you, Mr. Chairman, and thank you, Senator Jackson, for this excellent discussion.

I'm not sure where I stand on this question. One thing I would like to see us do is begin development of new technology through a partnership between industry, government, and academia similar to what we have had for aeronautics technology development. This relationship has resulted in the much more timely introduction of the jet engine and its efficiencies than would have otherwise occurred. There are many other specific benefits of that kind of a program.

Also, I think the Nation's tax and regulatory policy could be used to encourage industry to develop necessary capital for technology advancement. I am also concerned—and I don't believe you and I fully see eye to eye on this—but I frankly believe that from a theoretical point of view the concept that gasoline will always be expensive is a myth. It may turn out that way because of politics and bureaucracy, but there are no geological or technical barriers that I'm aware of that would prevent this country from having decades of low-price gasoline produced from crude oil. Clearly, that is not the case today and clearly the trends are in the other direction, but there's a tremendous resource base of crude oil available to this country at prices much less than what OPEC is going to charge in the foreseeable future.

What do you think would be the consequences if low-priced gasoline did come about by us getting our political and bureaucratic acts together and doing some of the right things that would open some new resources of crude oil for the production of lower cost gasoline? I think we ought to continue with an efficiency program, but do you think it would be possible in such an environment?

Senator JACKSON. To proceed with a fuel efficiency program?

Senator SCHMITT. With a static or actually decreasing gasoline price?

Senator JACKSON. Yes, I would certainly think so, because I would like to be optimistic in that regard. I guess I don't have that

degree of optimism that you have. I hope you're right and I'm wrong.

Senator SCHMITT. Well, I'm afraid you're going to be right if we don't change our policies.

Senator JACKSON. But you see, we have not had, Senator Schmitt, any new great oil finds in the United States since Prudhoe Bay. We have been working hard on the various potential areas—two great areas and you know one of them touches your State and that's the Overthrust Belt which indicates some promise. The cost of those deep wells—that's the secret of it, as you know—are enormous. The great fields that we have had, of course, primarily east Texas and it's extended on to New Mexico date way back to 1929. Now the other area is Alaska in the immediate areas of the Beaufort Sea, but there again, cost and lead time really eat into it.

I have yet to see any projections that would indicate that we can do much better than be importing by 1990 or 1995 the same amount of oil that we are now importing. I wish it were otherwise, but those are basic projections really agreed to by people in your discipline, in geology, and the industry people as well. It's a combination of long lead time items and the need, of course, to have more exploration.

I agree with you that worldwide there's an enormous amount of oil. I would point out to you that in the case of the Soviet Union, our indications are—and they seem to be correct—I was skeptical, I'll admit at first—but it seems more and more likely that they are going to be moving into our marketplace starting next year. I think there is evidence that the Kuwaitis have been in touch with the Soviets and likewise the Saudis. So we are going to see movement of oil in the mid-1980's out of the Persian Gulf for the first time into the Soviet Union. Those indicators are there. So I would throw that into this equation as well, and I think we should proceed—you know, China has got probably 100 billion barrels of oil. No one knows because geological information is pretty sketchy, but I think we should be diversifying. Clearly, we all know about Mexico. I think we can have better relations with Canada. There's an enormous amount of oil there. That should be part of the effort. And the Third World generally offers a lot of promise.

Senator SCHMITT. Well, Senator, my concern is that there isn't a realization of what the true potential is for the yet unexplored and even some of the explored areas. You mentioned the Overthrust Belt. We have no idea what its potential is, but it's extremely favorable. The discoveries are quite promising. The unfortunate thing is that a great deal of the land in the Overthrust Belt is Federal land and not now available for exploration at the level that would be possible. There are 13 or 14 additional basins in Alaska that are essentially unexplored that are comparable in their potential to what Prudhoe Bay was at the beginning of its exploration. The Beaufort Sea, as you mentioned, has a tremendous potential. The area north of the magnetic North Pole is showing promise. There are offshore regions available to us domestically. The new geophysical prospecting techniques that are being developed using low noise electronics combined with amplitude enhancement and other computer techniques are causing people to go back into old fields with very specific targeting of the wells. So there

clearly is new potential there. Secondary and tertiary production in known areas has tremendous potential. Mexico is now in the process of completely reevaluating their resource base on the basis of just a few discoveries in the last few months. I think it is as much a mistake to underestimate as it would be to overestimate, and I'm afraid we have been in the business of overestimating.

But be that as it may, and there's reason for legitimate differences of opinion—geologically, I think for us to say, that we have to run out of crude oil in the near term is wrong. That doesn't mean I don't fully support everything you and others are trying to do to save this very natural valuable chemical for other purposes. There's no question we must do that.

But my question is, what if we began to do things that are possible technically and scientifically and had cheap sources of fuel? Would it be your recommendation that we continue to have fuel economy standards?

Senator JACKSON. Absolutely. You can make model changes later. For the next 15 years anyway, the need for fuel efficient automobiles is going to be enormous. In Europe, as you know, they had it long before it became popular here. In fact, it's a curious phenomena, but the people who have the small fuel-efficient cars for the most part economically are the upper middle class. It's not the poor who are driving fuel-efficient cars, and that's an interesting commentary because of obvious recognition of the need I think to conserve as part of an ethic, as part of good commonsense. But I don't see any danger of the industry being hurt by moving to fuel efficient cars. I see the industry in serious, serious trouble. If you look at the financial background of the auto industry, it's pretty grim even for the best. General Motors' stock I think reached a peak in the early 1960's of $112 a share and it hasn't even come close to that in recent times. Ford is now recognizing that if it hadn't been for their overseas operation last year their loss would have been even greater. They had a plus overseas.

So I think, Senator Schmitt, that for planning purposes, no matter what one may project in bringing the price of fuel down, certainly because of lead times, in the next 15 or 20 years there's going to be this enormous need.

I agree with you we have a lot of oil in place. One of the main problems in the Soviet Union is they lack the technological base. They lack the ability to move the oil by secondary and tertiary recovery in the way we have developed it here. So when you say there's a lot of oil, it's true, in place, but a lot of it, as you know, raised the question of the cost of getting it out. And something you know a lot about, and that's the various technologies that can be employed to move the oil. That's a major problem of the Soviet Union. They wouldn't have to import oil if they had the ability to take it out. It's that that other more advanced countries technologically are doing now.

Senator SCHMITT. Your preference is for some kind of nudge in the form of fuel economy standards, but that does not necessarily mandate or encourage higher prices for fuel—or do you think both are required?

Senator JACKSON. I think on the other you don't have to worry about it. The law of supply and demand and the cartel—and I underline the cartel—is going to push it on an upward trend.

Senator SCHMITT. But we have contributed to that with a 10-cent tax on the gas.

Senator JACKSON. It will when it hits next week or so, but let me just point out the rate at which the price of oil has gone up. The average price per barrel a year ago January was about $13.50 and in the first quarter of this year it was averaging $32.50. That's one and a half times. And the pervasiveness of those upward price adjustments in the economy as a whole have been devastating. I don't think there's any question that western financial institutions cannot go on absorbing that kind of price increase, and you can watch very closely what will happen in June if there's a large price increase what that will do in the United States and in other Western countries.

I'm not smart enough to predict, but it's certainly going to aggravate and bring on, in the midst of our recession, stagflation on a very large scale. In other words, the economy stagnating and prices going up, which is the worst of all possible worlds.

Senator SCHMITT. Thank you, Senator.

Senator STEVENSON. Senator Magnuson.

Senator MAGNUSON. Well, I think our bill to achieve 40 miles per gallon by 1995 is technically feasible, is it not, Senator Jackson?

Senator JACKSON. Yes; there isn't any, I don't think major dispute on that point.

Senator MAGNUSON. It looks like it's technically feasible and, of course, I think the problem is whether or not it's economically feasible. That's what we have to address ourselves to.

Senator JACKSON. Senator Magnuson, I think what is really needed here is for the industry to come in and indicate to the Congress what kind of a financial situation they see facing them. Now they are in different positions. Chrysler, I don't know where to place Chrysler. American Motors is heavily dependent on the big two for a substantial amount of the parts that go into AMC cars, whether it's motors or what not, transmissions. I believe they get them from the larger companies. General Motors obviously is in a different financial position than Ford and so on.

But I do think all of us are committed to the need to help restore economic competitiveness for the American automobile industry and to make it possible for them to function effectively. The auto industry affects every aspect of our economic life. It reaches into such a large part of our economy that we are seeing now dramatically what happens when the auto industry is in trouble what it does to the rest of the economy and it's like pulling one of the main elements out of our industrial society.

Senator MAGNUSON. I have no further questions.

Senator STEVENSON. Senator Cannon.

The CHAIRMAN. Thank you, Mr. Chairman.

Senator Jackson, you have made two good points here I think. One, of course, is technology is available to make some substantial advances and, second, I think the point that we are going to have to help drive the American public out of the big automobiles.

But I'm wondering to what extent you think we have maybe helped force this condition a little ourselves by requirements that we have imposed on the industry.

In the State of Nevada I was driving out there a 1969 automobile that I finally sold and replaced with a smaller car than my 1969 automobile. The heavier car that I had was getting better mileage than the one I replaced it with.

This is due in part at least to Government regulation and standards in areas other than fuel economy that we have imposed on the industry.

How do you see this interfacing with the requirements that we are going to impose now to simply get better mileage when we are hitting them over the head with the hammer on one hand and telling them to do something else which interferes with fuel economy.

Senator JACKSON. Well, Senator Cannon, it's a fleet average standard, as you know. So they can sell cars that are bigger and get less fuel efficiency as long as they average out at 27.5 miles per gallon by 1985.

The CHAIRMAN. But the point I was making is that the bigger cars that I was driving a number of years ago I got better mileage on than on the smaller cars that I'm driving today.

Senator JACKSON. Yes. Well, I mean, you know, there's flexibility because of the fleet average. If Chrysler feels there's a market for the larger ones, they can try it in the marketplace.

The point is, the bigger ones are not selling and the fuel efficient cars they tell me—you can ask the automobile witnesses, but as I recall the testimony we had, there's several months waiting time now for some of the General Motors cars that are highly fuel efficient. They just can't turn them out fast enough to do it.

Then I would finally point out that the foreign cars, of course, meet all the same regulations that the American industry meets. I just want to emphasize as strongly as I can, I don't want to do anything that's going to be punitive to the industry, but somehow, as Senator Schmitt mentioned, there needs to be a better partnership relationship because to paraphrase Justice Brandeis, it is a business affecting the public interest. I mean, the impact in the automobile industry and our whole economy is so enormous, and the American industry has simply missed the boat in terms of the marketplace. That's my point.

What can we do to help? What can we do to preserve the jobs and the businesses that are involved? You look at the number of automobile dealers in this country that are going broke for a variety of reasons, and it's rather appalling. That's the thrust of it and I would agree with you completely, any kind of revision that will make the operation of the law less onerous—and the industry will indicate what those problems are—I think we can all do a lot better, but I emphasize that the foreign manufacturers are doing very, very well in this market and this is the biggest market for automobiles in the world. I think it's tragic—the one thing, among others, that we are very, very good at, and that is mass production, technological innovation, all those things—we're missing the boat and the industry has simply miscalculated. They couldn't believe what was going to happen to the price of oil and that's why, as I

said a moment ago, foreign policy is a key ingredient in all of this and how it's managed will determine what the economic weather vane is going to look like here in the United States.

Senator MAGNUSON. May I ask a question?

Senator STEVENSON. Senator Magnuson.

Senator MAGNUSON. Some years ago this committee took up the question of auto safety which the Senator will recall, and we finally ended up not passing a law but we prevailed upon the Government, which is the biggest purchaser of automobiles—the biggest purchaser—to provide certain fundamental safety standards like four-wheel brakes and safety glass and things of that kind, and when the car didn't come up to those standards it couldn't be sold to the Government. So the automobile manufacturers started to put in the safety standards.

So there were eight basic safety standards that weren't on cars delivered to the public but to Government. Have you ever thought about the idea of requiring the Government, by administrative action, to meet these standards?

Senator JACKSON. You mean on fuel efficiency?

Senator MAGNUSON. Yes. We used it on safety and we could use it on fuel economy also.

Senator JACKSON. Well, under——

Senator MAGNUSON. Because if they can't sell to the Government, they're going to be in worse shape.

Senator JACKSON. I would point out that under existing law, under EPCA, the administration could come up tomorrow and propose a change in the law in effect or regulation, and they could raise it from 27.5 miles per gallon to 30 or 35, and the only way that that could be blocked would be by a one-House veto. So there is the authority now in the executive branch to move on this.

Senator MAGNUSON. Well, I think that's a possibility to lead the way. Let the Government do it. It's the biggest purchaser of automobiles in the country. It could lead the way.

Senator JACKSON. We didn't mention anything here, Mr. Chairman, about the balance-of-payments problem either.

Senator MAGNUSON. We started the auto safety legislation by getting the Government to do that long before we had Nader, long before Nader.

Senator JACKSON. The pervasive nature of this problem——

Senator MAGNUSON. It led the way.

Senator JACKSON. The pervasive nature of this problem we found in the balance-of-payments deficit, this year we anticipate a loss of $100 billion to purchase petroleum, depending, of course, on what the final price increases are. As you know, we have almost $1 trillion sloshing around, almost $1 trillion, over $900 billion in Eurodollars, and last year the total balance of payments deficit as a result of imports was $15 billion for automobiles. That is another aspect of it which I obviously didn't have time to get into.

Senator STEVENSON. Thank you, Senator Jackson. We look forward to continued cooperation with you and your committee.

Senator JACKSON. Thank you very much.

Senator STEVENSON. Our next witness is Joan Claybrook, Administrator, National Highway Traffic Safety Administration. I will invite all of our witnesses today to summarize their statements, if

possible, and if so, they will be entered in the record. We are glad to have you back with us Mrs. Claybrook. Please proceed.

STATEMENT OF JOAN CLAYBROOK, ADMINISTRATOR, NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION; ACCOMPANIED BY HOWARD DUGOFF, ADMINISTRATOR, RESEARCH AND SPECIAL PROJECTS ADMINISTRATION; KENNERLY DIGGES, DIRECTOR, OFFICE OF PASSENGER VEHICLE RESEARCH; AND STEVE WOOD, ASSISTANT CHIEF COUNSEL FOR RULEMAKING

Mrs. CLAYBROOK. Thank you.

Mr. Chairman and members of the subcommittee: We are pleased to appear before you today to discuss automobile fuel economy in the period after 1985. I am accompanied today by Howard Dugoff, Administrator of the Research and Special Projects Administration, and Mr. Kennerly Digges, Director of our Office of Passenger Vehicle Research, and Mr. Steve Wood, Assistant Chief Counsel for Rulemaking.

The materials accompanying your letter of invitation specified that this hearing would take up the following issues relating to the automobile fuel economy program:

One, the necessity or desirability of new legislation extending mandatory corporate average fuel economy standards beyond 1985;

Two, the level at which such standards should be set;

Three, the inclusion of provisions relating to the effect on fuel economy of motor oils and tires; and

Four, the level of appropriations needed in future years to support administration and management of the fuel economy program by the National Highway Traffic Safety Administration (NHTSA) of the Department of Transportation.

First I want to assure the committee that the Department of Transportation shares the concern of the Congress about the need for energy conservation, particularly in the automotive sector. At the direction of Secretary Goldschmidt, we are working to develop a sound base to exercise our authority to mandate post-1985 fuel economy standards. In reaching decisions in this area, the Department is considering a broad range of factors, including potential future energy shortages, capital requirements and other economic demands, as well as the effects on workers and the safety of the driving public. Before any particular fuel economy standard is mandated, these matters and their interrelationship need to be explored.

The Department of Transportation is proud of the fact that the automotive fuel economy program has produced great benefits. Largely as a result of the federally mandated standards, we anticipate an overall savings to this country in the next 5 years of approximately 53 billion gallons of gasoline compared with the average fuel consumption of 1977 model year vehicles. And gasoline consumption is going down. Between 1978 and 1979, for example, gasoline consumption decreased by about 3.7 billion gallons.

To the extent that past experience may serve as a guide, there are strong arguments for standards beyond 1985. Analyses of the cost-effectiveness of the pre-1985 standards show, for example, that the higher "front-end" costs of fuel efficient cars are repaid many

times over by the fuel savings. For example, the purchaser of a 1985 model car will realize a net savings over the vehicle's lifetime of $1,540 compared to a 1977 model. Also, the domestic manufacturers, despite their current economic difficulties, were in a better position to compete with fuel-efficient imports in 1979–80 than they might otherwise have been if they had relied solely on the marketplace to determine their product plans. Since the future may bring further severe and unexpected dislocations in the marketplace, there is a need for continued long-range planning for the Nation and the industry.

That there is a strong national interest in higher levels of automotive fuel efficiency is beyond debate. The Nation's vulnerability to oil import disruptions and the direct importance of such considerations to our Nation's economic welfare and national security require such direct governmental concern. It is clear, therefore, that the Federal Government has a role to play and must use an effective combination of options to perform its proper role in this difficult area. What that combination of options should be is now the only relevant question.

The task we face as a Nation is the crafting of a multidimensional response that makes the most sense in employing regulations, tax incentives, employment and labor policies, trade policies, capital investment strategies, innovation and technological advancement and other tools to safeguard our energy security and our economic competitiveness.

While we believe that a corporate average fuel economy of 40 miles per gallon or higher is technologically feasible by 1995, technological changes required in order to attain that level have to be considered together with many other concerns, including economic practicability as required by the law.

A difficult and complex set of questions surround the economic and social consequences of post-1985 fuel economy, regardless of whether the drive comes from Federal standards, market forces, or a combination of the two. What capital resources can the industry call on to produce the necessary fuel-efficient vehicles? How should we treat manufacturers with limited product lines? How will plant closing and modernization affect employment patterns and the economy of different regions? How will we make sure that the occupants of the new smaller fuel-efficient vehicles will be given adequate safety protection?

These questions illustrate our belief that there is now, more than before, a need to consider the broader picture. We all recognize that the domestic automakers are experiencing financial difficulty in a world where the fundamentals of energy cost and availability and international economic competition have recently undergone unprecedented redefinition.

In the next 5 years, they will spend an estimated $70 billion to retool the auto industry. These expenditures, moreover, will be made during a period when profits are down, thus increasing the need to borrow at higher interest rates. The market for large cars has shrunk significantly thereby reducing the segment of the new car market which might, in other times, have been relied on to support industry profitability. In 1977, sales of full-sized cars in the United States held a solid 30 percent of the market. Today, that

share has shrunk to 14 percent. Sales of small cars today, on the other hand, account for 60 percent of the market and nearly half of these small cars are imports.

The result of this shift in the market has been reduced profitability for the industry, and financial uncertainty for the workers, for the regions in which the companies' operations are located, and for the Nation as a whole.

In recognition of far-reaching energy and economic concerns, the Congress, as a part of the Chrysler legislation, directed the Department of Transportation to examine the future of the auto industry. Specifically, under the terms of the Chrysler Loan Guarantee Act of 1979, Secretary Goldschmidt is required to make an assessment of the impact of likely energy trends on the auto industry. The Secretary is required to include information on long-term capital requirements, rates of technological change, shifting market characteristics, regional employment impacts, and the capability of the industry as a whole to respond to the requirements of the 1980's. This study, which is due in January 1981 is to be followed by annual reports on the state of the auto industry and its interaction with the economy.

In addition to that change, the Department received direction from the White House Domestic Policy office to examine this set of issues in its broadest context—looking at the industrial base, trade, productivity, employment and more—to develop policy choices for the Government which could assure the production of fuel-efficient vehicles as well as the future health of the auto industry and or manufacturing base.

We believe that these studies now underway in DOT and others at DOE can point the way to the kind of integrated strategy we need. The role of fuel economy standards in the future will be determined within this overall framework.

In adddition to specific studies, there is a continual need to collect data and conduct on-going analyses of the technology available for further fuel economy improvement and what improvements are economically practicable. The National Highway Traffic Safety Administration is the agency responsible within the Department for these activities. As a result of this responsibility, we have established a technology assessment program to complement the existing automotive fuel economy research program and to address technologies emerging in the next 5 to 10 years. The plans for this program include the evaluation, testing, and demonstration of a full range of options for the improvement of fuel economy of motor vehicles and motor vehicle components. The resulting data from this program will illustrate what can be achieved with known technology.

The three major parts of the program deal with: (*a*) Improved engines and drivetrains; (*b*) structural design improvements; and (*c*) fuel-efficient prototype vehicles. We need to look at as many options for improvements in engines as we can to evaluate means for dealing with the problem of diesel emissions and for maximizing the fuel economy potential for both spark ignition and diesel engines and other components for both passenger cars and light and heavy duty trucks. Use of improved power trains may make it

unnecessary to make drastic reductions in the weight and size of vehicles to meet the goal of high fuel economy.

Furthermore, there are many new materials such as metal plastic composites and concepts of structural design such as monocoque construction that should be looked at not only from the point of view of saving weight, as well as crashworthiness, durability, productibility, and the cost of future motor vehicles. Once promising technology options in power trains and structures have been identified and evaluated, they must be synthesized in prototype vehicles of different concepts to demonstrate their performance and productibility.

In the materials accompanying the invitation, you mentioned the availability of improved motor oils and tires. Both can improve fuel economy, although we defer to the Environmental Protection Agency as to the best method of improving motor oil. The DOT has done extensive work on tire safety, quality, and fuel economy potential. Tires can make a significant contribution if properly designed and maintained. We have already considered including tire rolling resistance as a factor in the uniform tire quality grading system under the existing authority of the Motor Vehicle Safety Act.

Because of the critical need to restrain Federal spending, our request for appropriations to carry out this program in 1981 has been canceled. However, the President's proposal for $200 million dollars over 8 years for this technology assessment program will be initiated with our appropriations request for fiscal year 1982. It will be requested under the existing legislative authority of the Department which is sufficient to carry out the program. Originally, new legislative authority had been requested as title IV of S. 2015, the "Transportation Energy Efficiency Act of 1979." This legislation was contingent upon the establishment of the Energy Security Trust Fund, but since it will not become law, we no longer seek this legislation.

This concludes my statement. We would be pleased to answer any question you may have.

Senator STEVENSON. Thank you, Mrs. Claybrook. That's a thoughtful and balanced statement, but the bottom line is missing. Did somebody cut it off?

Mrs. CLAYBROOK. No.

Senator STEVENSON. As Senator Jackson indicated, there's lots of lead time involved in the development and production of automobiles and you, like us, want to be as helpful as we can to this industry. We are considering legislation to establish standards for the period beyond 1985 and we still don't have the recommendation from the administration with respect to standards.

I recognize, as I think we all have so far, it's a very complex question which involves not only technical feasibility but also economic feasibility, but if we get started perhaps on standards, couldn't we then be in a position to fill in some of the other parts, including what other technical or technological or capital assistance was needed?

When are we going to get a position on standards?

Mrs. CLAYBROOK. The Secretary of Transportation feels it's important to do an assessment of the automotive industry as a whole

and its effect on the economy, its capital requirements for improving fuel efficiency, before actually initiating the rulemaking process.

There are really two options, Mr. Chairman. One is to do that kind of work with advanced notices for proposed rulemaking, which is one way of achieving it, soliciting information and assessing it. Another way, and the one he's selected, is to do it through this study. His intent is to submit that report, as the statute requires, by next January, at which time the Department's position on issuance of fuel economy standards in the post-1985 era will be elaborated.

Senator STEVENSON. Are you saying that there will be standards; it's just a question of what they should be?

Mrs. CLAYBROOK. No, I'm not saying that. There are very strong arguments, as our statement points out, for the issuance of standards. There's clearly a strong case for that. But the Secretary believes that it's important to reserve a final decision on exactly what steps the Department would recommend or take until he finishes this study.

Senator STEVENSON. How do you feel about short-term protection in the form of import quotas or tariffs to help this beleaguered domestic industry?

Mrs. CLAYBROOK. The administration's position on import tariffs is to oppose them, and the Department has not taken any separate position from the administration.

Senator STEVENSON. Can you tell us anything about a Volkswagen designed vehicle that achieves very high fuel efficiency that's been reported somewhere in the range of 65 to 80 miles per gallon?

Mrs. CLAYBROOK. There are two. One is a Volkswagen diesel Rabbit with a turbocharger that was put together in cooperation with the Department of Transportation. That was 2 years ago. It's called the IRVW. It's an advanced vehicle both in terms of safety as well as in terms of fuel economy. The fuel economy achieved on that vehicle was 60 miles per gallon and the safety provisions were for 40 miles per hour crash survivability, which is 10 miles per hour in excess of our present standards.

Volkswagen is presently working on further advances for a vehicle that would get 65 to 80 miles per gallon. I believe that on that particular vehicle the safety would not be enhanced, which concerns us; but they have announced publicly that they are going to design such a vehicle. This vehicle is experimental as is the first one we mentioned. They are not production vehicles.

Senator STEVENSON. What did you say the mileage of the second one was?

Mrs. CLAYBROOK. I believe it was 65 to 80 miles per gallon.

Mr. DIGGES. It's up to 65 to 80 miles per gallon. That particular vehicle is being developed in cooperation with the German Government.

Senator STEVENSON. And is that a Rabbit kind of configuration?

Mr. DIGGES. It's a more advanced vehicle than the Rabbit. It's the next generation vehicle. It has the option of a diesel or a gasoline engine. The diesel engine gives the higher fuel economy. It also has an advanced transmission and a very advanced engine.

Senator STEVENSON. Why don't they put one or another of these into production? No competitive requirement?

Mr. DIGGES. I'm sure they will at the time the competition demands it.

Senator STEVENSON. They will stay ahead of us unless we somehow or other leapfrog down?

Mr. DIGGES. I think that's their strategy.

Senator STEVENSON. I think that's pretty close to what they have indicated to us. In fact, it is what they have indicated to us.

Mrs. CLAYBROOK. That is true of the Japanese as well, Senator. The Japanese Government has indicated that it will have fleetwide average for their companies by 1985 of 30 miles per gallon.

Senator STEVENSON. By 1985?

Mrs. CLAYBROOK. By 1985. That is fleetwide average, which applies to vehicles that are heavier than those sold in the United States. The fleet they would be exporting to the United States would probably be higher than 30 miles per gallon.

Senator STEVENSON. And the capabilities to on pretty short notice put into production vehicles with still greater mileage capacity?

Mrs. CLAYBROOK. I don't think there's any question but that the Japanese are working for greater fuel efficiency beyond 1985 or planning for that.

Mr. DIGGES. We've not seen the Japanese plans to the degree we have the Germans because the German program is a public program and they have published papers on it. We haven't seen similar papers on the Japanese.

Senator STEVENSON. This is one of the things that troubles me most about the whole subject. I think we are playing a very weak game of catchup and what's needed is a very strong game of leapfrogging. But without a mandate to this industry there will be not even a catchup, and that mandate I think is going to have to be accompanied by federal assistance for the research and the capital with which not only to develop and produce the technology for automobiles, but the technology for manufacturing the automobiles, which is also I believe more advanced certainly in Japan.

Do you have any opinion about the manufacturing procedures in those countries as compared with us?

Mrs. CLAYBROOK. For one thing, the automotive industry is retooling its plants and we should certainly expect to see increased productivity as a result. It may well be that our industry can catch up and surpass the capability of a number of foreign companies because of the enormous expenditures that are being made here. The expenditures of our companies are far in excess of many of the foreign companies.

Senator STEVENSON. I'm told Mitsui produces about 1,300 Datsuns a day of high quality energy efficient automobiles with a total of 67 production line workers. Is that true, do you know?

Mr. DIGGES. I don't know.

Senator STEVENSON. Senator Cannon.

The CHAIRMAN. I have no questions.

Senator STEVENSON. Mrs. Claybrook, it's been suggested and I'm sure will be again that one of the reasons for the plight of this industry is the regulations which impose safety and emission stand-

ards on American vehicles. Senator Jackson pointed out that the same requirements apply to the foreign produced vehicles. They do, do they not?

Mrs. CLAYBROOK. Yes, they do.

Senator STEVENSON. How do you respond to this suggestion that to help the industry we ought to give them relief from regulation?

Mrs. CLAYBROOK. There are two questions there. One is whether or not it's been the source of the problem, and there's no evidence that I know of that it has been. The problem the American manufacturers face right now is in the marketplace. It's a product problem. They don't have a sufficient number of fuel efficient vehicles to compete with the imports.

The cost of the safety standards to the car buyer are very, very small. In a most conservative way we have estimated something under $300 a car for all the safety standards that have ever been put in since 1967. The savings in life achieved from these safety-standards is something like 65,000 lives. The methodology for this estimate was developed by the GAO, which concluded that about 10,000 lives per year are being saved by those safety standards, and the cost of many of them is quite minimal, very minimal in fact. The emissions standards I don't have the exact figures on, but we would submit that for the record if you wish.

I have visited some foreign countries recently that do not have emission standards for their vehicles and the air pollution was just awful. In 1970, I was in Tokyo when Japan had not yet imposed auto emission requirements. The Japanese Government realized they were going to ruin their country if they didn't impose some kind of emissions requirements. They set about a national program to do so and did so in 5 years. It's made a dramatic difference.

So these standards have tremendous payoff. They are really quite minimal and I don't think they are even relevant to the particular problem that the automobile industry is having today in the marketplace.

The other question is whether or not the elimination of regulations provide some kind of financial relief for the motor vehicle manufacturers. The administration has taken a look at that. To the best of my knowledge. I don't think it would provide very much relief. There are a lot of other ways of assisting them on something that's relevant to the problem; the problem being their marketplace situation and some very near-term issues of credit and so on.

If you did remove auto safety regulations, for a very short-term, very minimal financial relief, you would be sacrificing the lives of the public, and I just could never recommend that.

Senator STEVENSON. Have the Japanese developed and produced automotive technologies that reach comparable emission standards with less loss of fuel efficiency than the U.S. technology?

Mr. DIGGES. Some of the Japanese engines are among the most fuel efficient and low polluting engines that are available. They have done a very good job at it and probably have certainly some of the best small engines as far as those combinations of qualities.

Mrs. CLAYBROOK. But I would also point out that when comparable American and Japanese cars are compared by weight, that the American cars are highly competitive in fuel economy. In fact,

some American cars are a little better than the Japanese on fuel economy.

Senator STEVENSON. If there are no further questions, thank you very much.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question 1. What do you project will be the corporate average fuel economy of each domestic automobile manufacturers in each of the model years 1981 through 1985? What projections for foreign imports?

Answer. The January 1979 Department of Transportation Automotive Fuel Economy Program Report to the Congress contained projections of fuel economy capability for domestic manufacturers for 1981–85 as follows:

CORPORATE AVERAGE FUEL ECONOMY (CAFE), MPG

Manufacturer	Model year—					
	1980 [1]	1981	1982	1983	1984	1985
American Motors	21.5	23.6	24.6	26.8	28.7	29.5
Chrysler	20.3	24.3	25.9	26.8	28.9	30.1
Ford	21.6	24.7	25.3	27.6	29.1	29.7
General Motors	21.4	23.7	25.3	26.4	28.6	29.6

[1] Manufacturers' estimates.

These projections included the use of diesel engines by GM and Chrysler and PROCO engines by Ford. The possible restriction of the use of diesels for health reasons has still not been solved.

Recent production plans submitted by Chrysler show slightly lower numbers than shown above but still above the standards. AMC predicts show a slight shortfall with respect to the standards in model years 1982 and 1983. But, if the recent recommendations of the Department for legislative changes to the Motor Vehicle Information and Cost Savings Act (i.e.—three year carry-forward and carry-back of credits and penalties) are adopted, AMC would generate sufficient credits so as not to be subject ot a penalty.

Studies relating to achievable fuel economy after 1985 have not been completed. We do not have difinitive projections at this time.

Import manufacturers are expected to exceed the standards through model year 1985 by a comfortable margin with the exception of those importing larger vehicles such as Mercedes-Benz, Volvo, Peugeot, and Jaguar-Rover-Triumph. By 1985, Mercedes-Benz and Peugeot will require the inclusion of diesels to meet the current standards, and Volvo and Jaguar-Rover-Triumph may have to include diesels. No projections have been made for imports beyond 1985.

Question 2. What is the potential for reducing oil imports through improved automobile fuel economy in the next 15–20 years?

Answer. Existing passenger car and light truck fuel economy standards are expected to contribute substantially to U.S. petroleum conservation goals. Compared to a continuation of new 1977 car and light truck fuel economy (the year before the first standards), the existing standards will result in saving of 1.1 million barrels per day in 1985 and 1.9 million barrels per day in 1990. These savings are likely to translate directly into reduced petroleum imports. Total 1978–2000 fuel savings achieved by fleets produced from 1978 to 2000 (assuming 27.5 mpg fuel economy from 1985–2000) would be equivalent to a five-year consumption of gasoline for the passenger car and light truck fleets.

It is difficult to project the extent to which fuel economy would imporve beyond 1985 under current policy. Some share of these calculated savings would likely occur without further government action. In any case, increasing vehicle fuel efficiency after 1985 will create significant additional savings. If passenger car fuel economy increased to 35 mpg in 1995 (and light truck fuel economy increased to 25 mpg), the saving over a permanent 27.5 mpg would be 370,000 barrels per day in 1990 and 950,000 barrels per day in 1995. These calculations assume linear improvements in the fuel economy for passenger cars between 1985 and 1995 and for light trucks

between 1982 and 1995. By 2000, the incremental savings would be 1.4 million barrels per day.

If passenger car fuel economy increased to 40 mpg in 1995 (and light truck fuel economy increased to 30 mpg), the savings a permanent 27.5 mpg standard would be 560,000 barrels per day in 1990 and 1.4 million barrels per day in 1995. By 2000, the incremental savings would be 2.0 million barrels per day.

These savings are summarized in the attached tables.

TABLE 1.—POTENTIAL PETROLEUM SAVINGS DUE TO IMPROVED PASSENGER CAR AND LIGHT TRUCK FUEL ECONOMY

[Thousands of barrels per day]

	1985	1990	1995	2000
1a. Current standards compared to continuation of model year 1977 fuel economy:				
Passenger cars	820	1,450	1,700	1,830
Light trucks	270	480	610	690
Total	1,090	1,930	2,310	2,520
1b. 1995 fuel economy of 35 mpg for cars and 25 mpg for trucks compared to permanent 27.5 mpg fuel economy:				
Passenger cars	0	170	510	770
Light trucks	40	200	440	620
Total	40	370	950	1,390
1c. 1995 fuel economy of 40 mpg for cars and 30 mpg for trucks compared to permanent 27.5 mpg fuel economy				
Passenger cars	0	260	760	1,130
Light trucks	60	300	630	890
Total	60	560	1,390	2,020

TABLE 2.—RANGE OF PETROLEUM SAVINGS COMPARED TO CONTINUATION OF MODEL YEAR 1977 FUEL ECONOMY

[Thousands of barrels per day]

Fuel economy in 1995 passenger car/light truck	1985	1990	1995	2000
35/25 mpg	1,130	2,300	3,260	3,910
40/30 mpg	1,150	2,490	3,700	4,540

Notes.—
1. Estimated 1977 new domestic model fuel economy was 17.6 mpg for cars and 13 mpg for light trucks.
2. Current standards affect model years 1979–82 light trucks and 1978–85 passenger cars.
3. 1995 cases assume continuation of 1995 fuel economy in later years.

Question 3. What studies are underway at the Department on the subject of the technical or economic feasibility of improved auto fuel economy and what are the final completion dates for these studies?

Answer. Several studies are underway within the Department which relate to the subject of technical and economic feasibility for post-1985 fuel economy. The recent Chrysler legislation mandated a six month study of Chrysler's long term viability. That study is underway and will be completed this summer.

Another study was chartered by the President in January to examine the auto industry and its associated broad industrial network in order to determine the best choices for achieving our environmental, energy, and social goals while simultaneously insuring the future health of the industries affected. It is anticipated that this study will be completed by the end of this calendar year. In addition, the NHTSA has a continuous program of collecting data, and is conducting ongoing analyses related to technology available for further fuel economy improvement and the economic practicability thereof.

Question 4. How does the projected cost of synthetic liquid fuels and imported oil compare with the cost to the nation of improving the fuel economy of new automobiles beyond 27.5 miles per gallon after 1985? Based on your best available estimates at what average fleet fuel economy would further improvements in the fuel economy of domestically-produced new automobiles impose more of a cost to the

nation than producing more synfuels or importing more foreign oil? If you do not have these estimates, when will you have them?

Answer. The cost of synthetic fuel is estimated to be in the range of $45–50 per barrel. The current average cost of imported oil is approximately $30 per barrel and will certainly rise. DOT estimates for each barrel of oil saved due to the 1981–85 passenger car fuel economy standards, the new car buyer will pay an extra $15.40 (1980 dollars) for a new car bought between 1981 and 1985. The cost-per-barrel-saved for new car buyer for post-1985 fuel economy improvements have not yet been developed. At this point, the Department cannot estimate the fuel economy level at which the development of alternate fuels is more economically attractive than further fuel economy improvements. This question is being studied by the Department in its ongoing studies of the auto industry which should be concluded this calendar year.

Question 5. Would meeting the 1995 CAFE standard of 40 mpg be technically feasible? How much change would be required from the "mix" of car class size that you project will be offered in model year 1985? How do the answers to these two questions change if the 1955 CAFE standard were 35 mpg?

Answer. For domestic manufacturers, both the 35 mpg and the 40 mpg CAFE standard for 1995 appear technologically feasible. Import manufacturers are currently (1980) offering passenger cars with average fuel economy of 28.2 mpg. Some imported models have fuel economy as high as 40 mpg.

We do not yet have sufficient data to predict the "mix" of car class sizes needed to meet a 40 mpg or 35 mpg standard in 1995. Based on preliminary analyses, we project the "mix" of car sizes for 1985 designed to meet the 27.5 mpg standard will be similar to the mix of car sizes actually sold during the summer of 1979. Please note, however, that though class names remain the same, the sizes of the cars in each class will decrease as a result of another round of downsizing. Breaking down 1979 summer sales, 45 percent of the cars sold were subcompact and smaller cars, 10 percent were compact cars, 30 percent were mid-sized cars and 15 percent were large cars. The mix of car sizes recently projected by NHTSA for 1985 is 39 percent for subcompact and smaller cars, 16.5 percent compact cars, 26.5 percent mid-sized cars and 18 percent large cars. We will not have predictions for the 1995 mix of car sizes until our ongoing studies of the automobile industry are completed late this calendar year.

Question 6. What problems of capital formation do you for see for the auto industry in meeting a CAFE standard of 40 miles per gallon in 1995? 35 miles per gallon in 1995?

Answer. The auto industry's ability to improve fuel economy in the post-1985 period will be affected by financing actions taken to comply with the pre-1985 passenger car and light truck standards. Major shifts in demand toward smaller cars and trucks during 1979 and 1980 have resulted in significant market share losses for U.S. auto manufacturers. If this continues through the early 1980's, funds provided from operations will be sharply curtailed for these firms. The combination of these reductions in internally-generated funds with the great capital investment increases needed to convert facilities to small car and truck production will result in a need for large amounts of externally supplied capital. Much of this probably would be new debt, added at a time when interest rates will probably be extremely high. Other funds may be generated from internal cost-cutting activities and, potentially, sales of assets. The additional of new debt to these firms' capital structures will create a schedule for repayment obligations for each company which will cut further into funds available for improving fuel efficiency in the period beyond 1985.

The Department has made a rough calculation of the investment funds needed by the auto industry to meet a 40 mpg standard in 1995. Our Transportation Systems Center estimates in an October 1979 report that the industry will need $67 billion (1978 dollars) to build a non-diesel fleet of 40 mpg passenger cars and 25 mpg trucks. The Center also estimates the same $67 billion, if the industry relies on diesel engines, could be used to build a fleet of 50 mpg passenger cars and 35 mpg trucks. The capital requirement is both diesel and non-diesel scenarios could reach $100 billion if research, engineering and other preproduction costs are added.

DOT does not have data on the capital required for a 35 mpg CAFE standard in 1995. The Department continues to study the capital requirements of the auto industry and the different levels of investment generated by the 35 mpg, 40 mpg and other mpg standards and expect to develop this information by the end of this calendar year.

DOT would like to emphasize that ability to finance these fuel economy improvements must be evaluated on a company-specific basis, rather than for the U.S. industry as a whole. Companies vary in their financial capabilities and this must be

considered when examining the cost and impacts involved in increasing fuel economy. DOT has not yet performed such an analysis for post-1985 standards.

Question 7. Suppose the Congress were to enact legislation creating new corporate average fuel economy standards for the post-1985 era by establishing a standard for 1990 or 1995 and directing the Secretary of Transportation to establish interim standards for 1986 through 1990 or 1995. How long would the Department of Transportation need to develop interim standards for 1986 and beyond? How much leadtime would be appropriate for 1986 and beyond? How much leadtime would be appropriate for the automobile makers to achieve the 1986 standard?

Answer. The Department expects to have completed the studies necessary to propose standards for 1986 and beyond by January 1981. Allowing time for public comment and review, it is estimated the Department of Transportation would require a year from that time to develop suitable standards. The Department would require at least two years to develop fuel economy standards from scratch.

It would be desirable to provide automobile manufacturers between 3 to 5 years of leadtime for a 1986 standard. A 1986 standard, therefore, should be issued as a final rule at the latest by mid-1982. Standards for the 1991–95 period would not need to be determined until calendar years 1985–87.

Question 8. What is your position with respect to the Amendment No. 1664 to S. 2015 introduced by Senator Jackson and Senator Magnuson? What alternatives to this amendment, if any, would you advocate?

Answer.

(I) FUEL ECONOMY PROGRAM

The Jackson Fuel Economy Amendment (Amendment No. 1664 to S. 2015) proposes to extend the fuel economy standards program beyond 1985 by legislatively establishing the 1995 standard for passenger cars at 40 mpg and requiring the Department to set interim standards each year from 1986 to 1994. Under the existing fuel economy statute, the Department of Transportation already has the administrative authority to raise the fuel economy standards for post-1985 passenger cars (as well as light trucks) subject to a legislative veto.

The Department cannot support the 40 mpg standard proposed or any other legislatively proposed fuel economy standard for passenger cars until it completes ongoing studied on the auto industry.

These studies are designed to identify which fuel economy alternatives offer the best prospects for insuring the present and future health of the auto industry and its broad industrial network while simultaneously achieving the Nation's environmental, energy and social goals. Alternatives being studied include an extension of mandatory year-by-year standards (as proposed by this amendment), modification of standards such that they are established only for multi-year intervals (for example, every five years), voluntary targets, economic incentives, combinations of the above and reliance on market forces. While we know that the technology will be available to enable the automobile manufacturers to attain an average fuel economy well beyond 27.5 mpg by 1990, the department must consider the financial demands that higher standards present to the manufacturers. The Department will be better able to make an informed judgment on whether regulations alone are the best approach after the ongoing studies are completed by the end of this calendar year.

Below are additional comments on the specifics of Amendment No. 1664:

(1) 1995 CAFE standard

The proposal, though establishing the 1995 CAFE standard for passenger cars at 40 mpg, allows the Secretary to lower the standard as much as 5 mpg (to 35 mpg) if he believes it necesssary. We believe the discretion should be expanded to allow the Secretary to raise the 1995 standard above the level set by statute.

(2) Interim standard

The amendment would give the Secretary the authority to set interim CAFE standards for each year from 1986 to 1994. Rather than directing the Department to issue year-by-year standards, we believe that the amendment should grant the Department the discretion to determine the timing of interim standards (e.g., each year, every other year, or every five years).

(3) Additional fuel economy criteria

The proposal sets forth five additional standards-setting criteria to govern the Secretary's determination of maximum feasible fuel economy standards:

(1) The Nation's excessive dependence on foreign oil;
(2) The disparity between EPA measured and on-the-road fuel economy;
(3) The effect of changes in the EPA test procedure;
(4) The availability of diesel engines for cars; and
(5) The consumer's willingness to switch to small cars.

The criteria are already implicitly included in the existing criteria and, therefore, their listing is arguably unnecessary. The codification of these five concerns in a statutory checklist will reduce, not increase, the Secretary's discretion to consider new problems as they arise.

(4) Periodic review of EPA testing procedures

The amendment requires EPA to examine its fuel economy testing procedures to reduce the disparity between the EPA mpg ratings and on-the-road mpg experienced by the public. We support this requirement and think that the 1995 standard, at whatever level set, should indicate on-the-road fuel economy. This objective, however, is not readily obtainable and the proposal should, in addition, specifically authorize funds for research and development to find ways to correct the EPA test procedure.

(5) Carry-forward credit

We prefer the Administration carry-forward carry-back provision, S. 2191, (which was passed together with an AMC provision by the Senate on April 16, 1980 as S. 2475) to the Jackson carry-forward provision. While the Jackson provision encourages early conservation, it does not give the auto industry as much flexibility as the Administration bill to defer spending during a general period of economic stagnation or decline.

(6) Inclusion of light trucks

Though the Department already has the authority to establish post-1985 fuel economy standards for light trucks, the Jackson proposal should be amended to include light trucks as well as passenger cars. Any change in the passenger car fuel economy program wrought by the Jackson proposal should also be made in the light-truck fuel economy program.

(II) ACCELERATED DEPRECIATION

Closely tied to the Fuel Economy Program Amendment No. 1664 is the Jackson proposal (Amendment No. 1665) to offer the auto manufacturers accelerated depreciation on machinery and other capital equipment used to produce higher fuel efficient automobiles. Improving the fuel economy of new cars beyond 27.5 mpg will strain the automobile industry's ability to make the necessary capital investments. This amendment seeks to ease the strain and create an economic incentive for capital investment by offering the auto manufacturers a 5 year accelerated depreciation on new equipment used to produce cars that exceed the fuel economy standard by at least 5 mpg. We believe that the enactment of such specific incentives at this time is premature. The Department is conducting, pursuant to the Chrysler Corporation Loan Guarantee Act of 1979, a major study of the impact of energy trends and regulation on the automobile industry and will consider various economic incentives to help the industry.

Question 9. What steps, if any, should the Federal Government take, such as tax credits, loan assistance, etc., to assist the automotive industry in making the investments required for improved fuel economy in the 1990's?

Answer. The domestic automotive industry will require large amounts of capital to retool in order to meet improved fuel economy standards in the 1990's. Preliminary estimates by our Transportation Systems Center indicate that the domestic industry will need $67 billion (1978 dollars) to build a diesel fleet with 50 miles per gallon passenger cars and 35 miles per gallon light trucks, or a nondiesel fleet with 40 miles per gallon passenger cars and 25 miles per gallon trucks. The magnitude of this capital requirement may seriously strain the financial resources of the domestic industry. We do not currently know, however, to what extent the domestic automobile manufacturers are capable of financing the capital investment needed. Certainly the sharp decline since 1979 in sales of the manufacturers' more profitable middle and large size passenger cars has diminished their ability to generate capital internally and may force them to borrow more heavily to raise the capital.

The Administration has just begun studies of the potential for improved automotive fuel economy in the post-1985 period. The studies will cover a wide range of Federal policy alternatives to promote fuel economy including direct or indirect governmental assistance and economic incentive mechanisms. The health of the American Auto Industry is of prime concern to this Administration. The question of governmental assistance to help the industry adjust to the energy and trade realities of the 1980s and 1990s is very important. We will be able to provide the Congress with policy recommendations on incentives and assistance once these studies are complete.

Question 10. What is the potential for increased penetration of the world auto market by domestic manufacturers? How will movement toward a "world car"

affect the ability of the domestic auto industry to assemble the capital to finance production of more fuel efficient cars in the United States?

Answer. Traditionally, the American auto companies have not manufactured cars in the United States with the intent to export them. The cars they build in the United States were designed with the preferences of the American consumer in mind. These domesticaly manufactuered cars have normally been larger, more expensive and less fuel efficient than cars manufactured overseas and unlikely to sell overseas where fuel has been much more expensive. Viewing the American market as distinct, the American companies catered to needs of the rest of world through foreign subsidiaries that manufactured overseas smaller, more fuel efficient cars.

The differences in taste that have distinguished the American car buyer, however, are steadily diminishing as the cost of energy climbs. The trend in this country is now toward smaller cars. In addition, major American and foreign auto manufacturers designing cars for the 1980's in uniform sizes with uniform components (dubbed the "world car") that will be manufactured in several countries at the same time. In model year 1981, Ford's world car, code named the Erika, will go into production both here in Europe. In the spring of 1981, General Motors world car entry, currently known as the J-car, will go into production in the U.S. and perhaps nine other countries. The Renault-AMC merger has expanded the market for the Renault world car in the U.S.A.

The movement toward a smaller, uniform world car will benefit the American domestic manufacturer in their effort to assemble the capital needed to produce these more fuel efficient cars. A world car that is manufactured in several countries with the same components, chassis, engines and drivetrains makes possible greater economies in production. It also lowers some costs and allows investment and marketing efficiencies to be achieved through common vehicle design and component programs. In sum, the world car, through common vehicle design and component programs, spreads investment costs across many plants in several countries and will reduce the level of capital required of domestic companies.

The emergence of the world car and the general trend toward smaller cars in America, however, will probably not lead to increased exports of these cars by domestic manufacturers. Because of varying national regulatory requirements and import control policies, a world car manufactured in the U.S.A. is not likely to find its way to a foreign consumer. For example, specific requirements for 5 miles per hour bumpers, side guard door beams, headrests, emission controls and after treatment systems are unique to the United States. Also, due to different design philosphies on motor vehicles that have evolved in different countries, overseas engine and ride characteristics are different from those in the United States.

Senator STEVENSON. I will invite all of the next witnesses to come forward. They are Dr. David S. Potter, vice president and group executive, General Motors Corp.; Mr. Will Scott, vice president, North American government affairs, Ford Motor Co.; Mr. Chriss Kennedy, director, Federal Government affairs, Chrysler Corp.; and Mr. Frederick A. Stewart, vice president Government affairs, American Motors Corp.

Dr. Potter, we'll start with you, and I understand you may have to leave after your statement. If not, we will continue with all of the statements and come back to all of you with questions, but we will try to accommodate you.

STATEMENT OF DAVID S. POTTER, VICE PRESIDENT AND GROUP EXECUTIVE, GENERAL MOTORS CORP.

Mr. POTTER. Mr. Chairman, I will do whatever seems to be in the best interest of this hearing.

Senator STEVENSON. Well, let's proceed. We'll play it by ear.

Mr. POTTER. I'd like, Mr. Chairman, to give an abstracted version of my submission for the record if you would include it in its entirety.

Senator STEVENSON. It will be entered in the record.

Mr. POTTER. Mr. Chairman, I am David S. Potter, vice president of General Motors Public Affairs Group. I am pleased to have this

opportunity to provide you with our views on automotive fuel economy—particularly with respect to the post-1985 period.

Let me emphasize at the outset that we have a recognized current shortage of capacity to build smaller, more fuel-efficient cars. We are correcting that situation, however, as rapidly as possible.

For several years we have had to predict well into the future how car buyers might react under circumstances that do not fully reflect reality. In large measure, public policies have shielded the consumer from significant international trends with respect to higher fuel prices and reduced availability that otherwise would have exerted a more predictable influence on buyer behavior. As a result of these price control policies, well-intentioned as they may appear, consumers' purchase decisions, rather than being based on long-term reality, have been based on artificially low fuel costs and the illusion that the supply of fuel was secure and virtually unlimited.

Under these circumstances it is understandable that a traditional consumer preference for larger cars has prevailed in this country and that the domestic manufacturers have responded to this demand. In retrospect it is now clear that controls on the price and allocation of fuels has left the domestic industry vulnerable to sudden market shifts such as occurred after the oil embargo of 1973 and the Iranian crisis in early 1979.

What has happened can only, and should only, point the way to policies for the future, and reaffirm the need for removal of gasoline price controls and allocation schemes. For our part, we are committed to meet or exceed the Federal fuel economy standards through 1985, as we have done to date. In the 1980 model year we expect to exceed the standards by more than 1½ miles per gallon, bringing our improvement to about 80 percent over the 1974 base year. We continuously modify our forward programs to produce the kinds of cars we believe people will want to buy in the years ahead.

GM's product programs to date could be characterized as phase I. Now we are entering phase II. Looking ahead to the mid-1980's GM will redesign all of its products—most for the second time—to satisfy consumer demand for increased fuel economy. From 1974 to 1979 phase I cost GM almost $21 billion in worldwide capital expenditures. Phase II will cost us $38 billion in capital expenditures worldwide.

During the 1980 model year, from October through the end of April, the Chevette was the largest selling car in the United States. Right behind the Chevette, the Citation is in second place. Our capital expenditure program will provide GM with the capacity to build more than 90,000 fuel efficient transverse front-wheel-drive cars in North America in 1980. In 1981, our planned capacity to produce such vehicles will climb to 1.3 million units. Our planned capacity will increase dramatically to 2.7 million transverse front-wheel-drive vehicles in 1982 and to nearly 4.8 million units in 1983. Along with these major redesign programs we expect to make continued technological progress in improving fuel economy.

Technology, however, is not likely to be the major source of fuel economy gains in the 1980's. The major increases in new car fleet fuel economy will come about largely through weight reduction and reduced engine size. Many consumers will, we believe, change

the relative importance they give to overall vehicle size including passenger and luggage capacity, performance and towing capability, versus fuel economy.

Turning now to the legislation, introduced by Senator Jackson, under consideration by the committee, in our view, it is neither necessary nor desirable to have new legislation extending mandatory CAFE standards beyond 1985.

Standards are not necessary because consumers are purchasing smaller, more fuel-efficient vehicles in response to increasing fuel prices. In addition, the public is driving less and probably more conservatively in their present vehicles. The result has been that, overall, fuel consumption in 1979 declined by 5 percent compared to 1978 and is now running at a rate almost 10 percent lower than a year earlier. Automobile fuel consumption is expected to continue to decline in the years ahead.

The real price of fuel remained relatively constant until 1979. As we move toward the decontrol of fuel prices, it is reasonable to expect that prices will continue to increase, and consumers will continue to demand higher fuel economy in order to reduce their own fuel costs and hence consumption.

The competition for fuel efficiency will become even more intense worldwide. General Motors is willing to compete in that framework and is convinced that customer value will be optimized if fuel prices increase and the free market is allowed to respond.

As to the specific level of fuel economy standards beyond 1985, there are numberous questions that virtually preclude a responsible commitment by anyone—whether in industry or government. There are so many external factors of unknown dimensions that could influence consumer purchase decisions that it becomes an exercise in pure speculation as to what level of fuel economy will be closest to what consumers demand. What the free market mix of cars will be several years in the future is highly uncertain and, therefore, resultant mileage values remain in question.

While no one, including the Department of Transportation, knows the answers at this time, there are several major studies underway that will attempt to assess the future and certainly, much useful data will be forthcoming from these studies.

Because of the uncertainties that lie ahead, we believe it is not desirable to enact legislation mandating new post-1985 fuel economy standards. We suggest that policies related to fuel economy beyond 1985 remain flexible and that you resist the urge to regulate rigid standards thay may not be in keeping with market demands 15 years from now. Standards that are too stringent will result in products that will be unacceptable to a large segment of buyers. Standards that are too low are obviously unnecessary. In our view, it would be inappropriate for Congress to set post-1985 standards at this time, especially in view of the fact that the current law allows for such standards to be set by DOT and further provides for Congressional review.

The committee has asked about the effect of proposed fuel economy standards, presumably 40 miles per gallon in 1995, on the availability of full-size or family-size automobiles. Clearly, the greater the passenger capacity the larger, and consequently heavier, an automobile must be. Being heavier, full-size cars will tend to

be at the lower fuel economy end of the manufacturer's fleet. The availability of such new cars will depend on the numbers and fuel economy of the remaining vehicles in the fleet.

In any event, consumers needs for such automobiles will be satisfied. If people are not able to buy enough new full-size cars, they will extend the useful life of those cars in the existing fleet, similar to our experience during World War II.

Finally, the committee requested our views on the provisions relating to testing and labeling of motor oils and tires for fuel efficiency. GM has been actively pursuing the use of fuel efficient oils and lubricants as a way to improve the fuel economy of cars when they are new and as they are driven. We are also concerned with the other important factors such as the effects of these oils on engine durability and wear. GM has been participating in an ASTM, SAE, API program on oil classification since April 1978. GM intends to use fuel efficient oils as factory fill in 1981.

From our perspective, and in light of the progress already underway, we believe that a voluntary motor oil grading procedure based on the ASTM, SAE, API work would be the recommended course of action. However, if it is determined by Congress that legislation is needed, GM would not oppose a program as set forth in title V.

GM believes that information on tire related fuel efficiency would be helpful to consumers when they replace the tires on their vehicles. Toward this end, GM is planning to update its TPC system to include tire rolling resistance as one of the tire performance criteria. This will enable consumers to achieve the same benefit of reduced rolling resistance with their replacement tires as they had with the tires originally included on their vehicle.

Currently, there are rolling resistance requirements for GM original equipment tires on all new vehicle development programs and state-of-the-art low rolling resistance technology tires are now being used on over 50 percent of all GM passenger cars. They will be available on over 95 percent of all GM passenger by 1982.

We believe it is important, however, to not let fuel economy concerns completely overshadow safety-related tire characteristics such as handling and traction since these characteristics are not necessarily independent of rolling resistance. We urge caution be exercised when considering any tire fuel economy grading system to make sure that it does not conflict with other necessary tire performance areas. We would also emphasize that the most effective action drivers can take is to keep their existing tires—whether they be fuel efficient or not—properly inflated.

In summary, marketplace demand has moved decisively toward higher fuel economy in the new car fleet and will continue to do so as fuel prices rise. General Motors intends to meet that demand. Allowing the marketplace to operate freely is the most efficient way to meet the Nation's goal to reduce fuel consumption. In this framework, we feel congressionally mandated fuel economy standards are not necessary or in the ultimate best interest of the consumer or the industry.

Mr. Chairman, that concludes our statement. If you have any questions, I would be pleased to respond.

Senator STEVENSON. Thank you, Dr. Potter. If you can stay, we will proceed with the others. Mr. Scott.

STATEMENT OF WILL SCOTT, VICE PRESIDENT, NORTH AMERICAN GOVERNMENT AFFAIRS, FORD MOTOR CO.

Mr. SCOTT. Thank you, Mr. Chairman.

I am Will Scott, vice president, Ford Motor Co. The issue before the committee today is post-1985 fuel economy. Our view is that further fleet fuel economy increases are both necessary and certain. We believe, however, that legislation establishing a second round of progressively more stringent annual EPCA standards is not a desirable way to achieve such goals.

There is no question that much has been accomplished since the mid-1970's when the Nation rebounded from the oil embargo and Congress enacted EPCA.

Our 1980 new cars on average are over 600 pounds ligher than their 1974 counterparts.

By 1981 all of our U.S. cars will have been totally redesigned once for improved fuel efficiency and some will undergo another major change before 1985.

As a result of these changes, Ford's fleet average fuel economy has improved over 50 percent.

On a domestic industry basis, the annual fuel savings of today's new car fleet—as compared to 1974—is more than 4 billion gallons of gasoline.

By 1985, we will have more than doubled the fuel economy of the new U.S. car fleet. In sharp contrast to the kinds of cars we have known for the past generation, the average 1985 car is likely to have four- or five-passenger capacity, be some 500 pounds ligher than today, and probably will be powered by a four-cylinder engine. There will be new, if any V-8's in Ford's fleet, and front-wheel drive configurations will probably dominate industry sales.

In other words, the 1985 scenario will be much different from the environment of 1974-75 when EPCA was launched and industry mileage was in the low teens. After the embargo, most consumers returned to their earlier patterns of car buying and energy usage, essentially believing that if an energy problem existed at all, it was only temporary. I think it's fair to say Government policy abetted this view by holding gasoline prices below market levels and shielding American car buyers from the realities of the world energy market. As a result, industry sales of larger cars increased as did profits and employment—which reached an all-time high in 1978.

Looking ahead, it's clear that consumers certainly have the energy message now—at least after Iran and last spring's gasoline lines. Gasoline prices are twice what they were just 2 years ago. This has caused an abrupt acceleration in market demand for more fuel-efficient cars which has outpaced our planned product tooling and facilities conversions. According to DOE, gasoline consumption has decreased about 8 percent so far this year as compared to the same period last year—due to a combination of new car improvements and changed consumer habits.

The small car share of the U.S. market rose to over 60 percent in the first quarter, 1980, up 20 percent from a year ago. The simple fact is that the public is demanding even more efficient cars than the law requires us to build—we clearly are market driven and there is little evidence to suggest that the future will be appreciably different.

So with respect to the years beyond 1985 there's no question in our mind that there will be further increases in fleet average fuel economy as the average car continues to get smaller and potential technology advances—such as turbocharged diesels, PROCO engines and perhaps even some electrics—permit the introduction of some very high mileage cars.

To us, then, the question is not what's technically feasible or what is the right fleet average requirement for the future, but, rather, how we can best proceed as manufacturers and as a nation to develop more fuel efficient cars to meet the Nation's mobility requirements. And we thingk equally important factors in the equation are the financial integrity of the industry and the costs to consumers versus the benefits and tradeoffs they'll be asked to make.

Certainly 40-miles-per-gallon cars are feasible—some are available today—but a 40-miles-per-gallon fleet is another story. It is difficult to envision the product characteristics of a fleet at that level because there are no fleets approaching that today—even in countries with decades of high gasoline prices.

Emphasizing again that the 1985 fleet would have a substantially different complexion than today's—with virtually no family-sized cars as we know them today—further efficiency gains will require some combination of more downsizing and premium-priced advanced technologies. The fleet would also reflect important tradeoff decisions on the part of individual buyers as they make their own evaluations of their needs and costs versus benefits of meeting them. For example:

The willingness of consumers to accept compromises in utility—to give up full-sized station wagons, trailering capability, six-passenger cars, luggage capability or performance in exchange for efficiency. Not all buyers, of course, need all of these features historically available in many U.S. cars.

The willingness of consumers to give up comfort options for improved fuel economy—such as air-conditioning and automatic transmissions, typically installed on 75 percent and 90 percent of all cars.

The willingness and ability of consumers to pay premium prices for advanced engines and other high technologies, versus selecting a smaller conventional vehicle to achieve the same fuel efficiency.

There are also technical unknowns such as the ability of diesel technology to meet long-term emissions requirements and the feasibility of alternate engine concepts. With these uncertainties, to set a standard now in the area of 40 miles per gallon would effectively determine the future—since CAFE levels in that range come close to becoming product specifications, rather than performance objectives. You asked whether there would be any family-sized cars and our answer is "Not really"—if one thinks in terms of products available today. In a 40-miles-per-gallon fleet with, for example, half of the fleet powered by higher cost advanced engines—such as diesel or PROCO—the average car would have a curb weight somewhere around 2,000 pounds, which in 1980 terms would describe a Chevette or a Datsun 210. Some larger cars could be offered, of course, but only if they were offset by cars with fuel economies above 40 miles per gallon or with much greater use of advance

technology. For example, even if a family-size wagon were improved to a 30-miles-per-gallon level—through the extensive application of high-cost light weight materials and the incorporation of an advance powertrain—it would take a 60-miles-per-gallon vehicle to offset the wagon to achieve a harmonic average of 40 miles per gallon, as specified in EPCA.

We'd like to think that U.S. industry/government relations have reached the point where approaches other than rigid regulation would be considered in looking toward our Nation's goals. Europe and Japan do it differently—their governments have negotiated with manufacturers a voluntary, but nonetheless compelling, commitment to increase fuel economy levels, For example, in Europe all producers—Ford among them—have committed to make specific percentage improvements in fuel economy by the mid-1980's. This avoids the rigid year-over-year increases of EPCA that in our view have forced us into uneconomical ways of meeting near term requirements and even forced the use of soon-obsoleted technologies. We simply cannot afford escalating requirements year after year. It should be remembered that it takes five years or more to develop, tool and produce an engine—not to mention the product life needed to recover the investment.

We would hope that this committee will examine these and other alternatives to regulation in looking at post-1985 fuel economy goals. In this regard, measures that deal with the 117 million cars on the road will have quicker, more far-reaching energy conservation effects. For example, fuel prices not only impact the kinds of cars people buy but cause all car owners to consider changes in driving habits, life-style, commuting modes, and even geographic location. We note that this legislation does contain two labeling measures—oil and tires— that are directed at the total car population. Further, we urge simultaneous action to ensure that petroleum alternatives are brought on-stream as quickly as possible as conservation is, of course, inherently limited as an energy strategy.

Finally, we would hope the Congress would look to establishment of a climate more conducive to capital generation for business in general and the auto industry in particular. This would involve eliminating costly regulatory burdens that yield relatively little benefits to the Nation, setting trade policies that do not disadvantage domestic manufacturers and putting in place mechanisms to encourage capital investment, productivity improvements and R. & D., all of which should accelerate the willingness of the private sector to take risks. We hope that the study DOT is conducting will address issues such as these. In short, what we need most from Government is that it establish a constructive environment in which the domestic automotive manufacturers can restore their earning power to meet the challenges of the next decade.

Senator STEVENSON. Thank you, sir. Mr. Kennedy.

STATEMENT OF CHRISTOPHER KENNEDY, DIRECTOR, FEDERAL GOVERNMENT AFFAIRS, CHRYSLER CORP.

Mr. KENNEDY. Thank you, Mr. Chairman. I am Christopher Kennedy, director of Federal Government affairs for Chrysler Corp. I will submit the full statement for the record and I will abbreviate it.

Senator STEVENSON. Thank you. It will be entered in the record.

Mr. KENNEDY. Chrysler Corp.'s program to improve the fuel economy of its fleet is on track. Five months from now, we'll take a major step forward in that program when we introduce our second generation of fuel-efficient front-wheel-drive cars—Plymouth Reliant and Dodge Aries.

We will offer a 2-door model, a 4-door sedan, and the first front-wheel-drive 4-door station wagon made in America.

Compared to the Volare and Aspen models they replace, Reliant and Aries will be about 2 feet shorter, 1,000 pounds lighter, and 33 percent more fuel efficient.

With the Omnis and Horizons we already produce, these new compacts will enable Chrysler to offer about 1 million front-wheel-drive small cars a year, beginning this fall.

Right along with these new models, we're expanding our capacity for fuel-efficient engines and drivetrains. We're completing a $300 million program to convert our Trenton, Mich., engine plant to production of a new four-cylinder engine. We expect to produce about 400,000 of these new engines in the first model year. At our Kokomo transmission plant, we're expanding production of automatic transaxles to 675,000 units in 1981—more than double what we produced in 1979. And we are converting our new process gear plant for production of an all-new manual transaxle.

The changes don't stop there. By 1981, two-thirds of our cars will be four-cylinder and front-wheel-drive. By 1984, Chrysler will be a total front-wheel-drive car company, and the largest car we build will weigh less and get better fuel economy than the smallest car we built in 1975.

All these new products with their new engines and drivetrains will go to meet the continuing demand for better fuel economy. That demand is strong, and it will get stronger. The American market has been changed in a basic way by the events of the past few years. We have seen the price of gasoline go from 30 cents a gallon in 1974, to 60 cents in 1977, to more than $1.30 in some places today. We've seen spot gasoline shortages, long lines at service stations, and rising fears about the availability of gasoline in the future.

The rise in gasoline prices and the fear of gasoline shortages have changed our market for good. Today's buyer wants fuel economy, and he wants it now. Since October of 1978, the small car share of the market has jumped from 40 percent to an average of 57 percent in the first 3 months of 1980.

We expect this trend to continue. The age of cheap energy is over, and the demand for fuel efficiency will continue. We intend to produce cars and trucks that will meet that demand. In fact, given the market trend that we see building for the years ahead, we may well have a 35-miles-per-gallon fleet average by 1995.

What would that fleet look like? It would be dramatically smaller on the outside—a mixture of 4- and 5-passenger small cars and 2-passenger commuter vehicles.

Front-wheel-drive will provide a surprising amount of interior room in a small package.

The cars will be powered by 4-cylinder—or smaller—engines.

Miniature computers will control major systems like fuel delivery, spark timing, and valve timing.

Plastics, aluminum, and high-strength low-alloy steel will replace heavier conventional steel and cast-iron on many parts of the car.

The cars will have new tires and improved lubricants for reduced rolling resistance.

And they will be streamlined—designed from the ground up for aerodynamic efficiency.

None of this will come cheap. The Carnegie-Mellon Institute estimates that in the 10 years between 1985 and 1995, investments by the U.S. auto industry for fuel economy alone could peak over $10 billion a year for at least 5 years in a row. And that will come on top of the $80 billion the U.S. auto industry will spend on improving its products between 1978 and 1985.

The real question this hearing raises is what Government can do to help both the industry and the market handle these expenditures and move toward this kind of fleet as quickly and as effectively as possible.

There are three areas where Government can help—and I'd like to cover them quickly now.

First, technology. We need the support of both Government and the academic research community to develop new technology for the 1990's. We need to study basics, like combustion processes, aerodynamics, and materials technology. However, right now, the industry has tied up virtually all of its resources in applying known technology to our products as quickly as possible. We have very little left over the time-consuming research needed for breakthroughs in the basic sciences.

For that reason, we support the cooperative automotive research program proposed by President Carter. It's a good step toward the kind of joint research that will be needed to produce long-range improvements in motor vehicle efficiency.

Second, regulations. We need a coordinated approach to automotive regulation. Too often now, we are whipsawed by regulations that work against each other. Even as one law requires improved fuel economy, another sets needlessly stringent emissions standards that waste fuel. The same agency that sets mileage standards requires equipment like 5-mile-per-hour bumpers that do little but add weight and waste more fuel.

We need to take a hard look at regulations like this, and get rid of the ones that take away more from the consumer in costs than they deliver in benefits. We estimate that eliminating the requirements for passive restraints, head restraints, 5-miles-per-hour bumpers, and current and proposed side-door strength would take 100 pounds off the cars of the future. That translates into over one-half a mile per gallon in fuel savings.

We've got a special problem with diesels. Until the Government finishes its studies on diesel particulates, we can't make long-range plans for diesels in our fleet. This is an issue that has to be resolved quickly. We need diesels to come anywhere near the levels of fuel economy we are discussing today. And we need a standard that we can count on for the long term—not one that will change from year to year. We can no longer keep shooting at a moving target.

Third, a national energy policy. We recognize that the automobile will have an important role to play in that policy. But we cannot continue to give 90 percent of the attention to a product which uses only 13 percent of the country's energy. Regulating the automobile will not do the job alone. We need to look at the automobile in the context of a comprehensive, long-term national policy.

The real question is not how small we can make a car in the next 15 years. We will continue to improve fuel economy, with or without standards, because that is what our market will demand.

The question is how we can reduce our dependence on foreign oil as quickly and efficiently as possible. We need to step back and look at the whole energy picture, instead of concentrating on regulation of the automobile alone. Each incremental improvement in automobile fuel economy will be more difficult and more expensive in the future. Eventually, we will pass the point of diminishing returns. There may well be ways of reaching our national goals more efficiently, and with less cost to the consumer. We need to take a hard look at every possible alternative.

There is one step we can take right now. We can set realistic prices for the oil we use. The most important thing Government can do to reduce consumption and stimulate production of petroleum is to take the controls off the price of gasoline, and keep them off. That single action will do more to solve our energy problems than any merchandising plan we write in Detroit or law we write in Washington.

Beyond this essential first step, we need to find new ways to encourage conservation. We need to investigate the long-term potential of new energy sources like synthetic fuels, geothermal power, and even hydrogen. We have to decide whether to concentrate on using coal for power plants, industrial plants, and other stationary sources, and save petroleum for transportation and petrochemical products like fertilizer and plastics. We need to look at all these alternatives before we can decide which of them will do the job at the least cost to the country.

Senator STEVENSON. Thank you, sir. Mr. Stewart.

STATEMENT OF FREDERICK A. STEWART, VICE PRESIDENT, GOVERNMENT AFFAIRS, AMERICAN MOTORS CORP.

Mr. STEWART. Thank you, Mr. Chairman.

My name is Frederick A. Stewart. I am vice president Government affairs, American Motors Corp.

American Motors is pleased to have the opportunity to offer comments on the proposed amendments to S. 2015, the Transportation Energy Efficiency Act of 1979.

These comments are made against a backrop of the most turbulent times experienced by the domestic auto industry in recent years. Due to the rapidly increasing costs of motor fuel and the sudden, strong shift of the market to smaller cars, plants are closing, production dropping, thousands of U.S. auto workers have lost their jobs, and profits of the auto companies have dropped sharply or vanished altogether.

While the difficulties the industry is experiencing today are very serious, there is every reason to be very optimistic about the long-

term outlook if we can weather the stormy period just ahead. The fact is that the majority of the U.S. vehicle fleet must be replaced in the near future with more fuel-efficient products. This, coupled with the potential world markets, particularly in developing countries, presents unparalleled opportunities for those who plan carefully and well. American Motors has a plan for coping with future challenges and opportunities. A good example of our long-range strategic plan is our affiliation with Renault of France. Under this agreement, we will begin production of highly energy-efficient, advanced technology cars in our Wisconsin plants starting with the 1983 model year. From this development we expect future products to flow which will meet both the national goals as well as the needs and desires of the consumer.

In order to make this transition possible, we will need modification of some Government mandates. Generally, Government mandates are most effective when they are directed at short-term problems. But long-range mandates are another matter. Sometimes they create new problems because of new circumstances that can't be foreseen when they are first adopted.

For this reason, we question the wisdom of setting forth precise fuel economy standards 15 years into the future as proposed.

But a more important reason for not extending the fuel economy standards beyond 1985 is that such an extension is not necessary.

A dramatic shift to smaller, fuel-efficient cars has already begun. In fact, the change in the market is so overwhelming that manufacturers are finding it almost impossible to sell big cars at any price. The market share of subcompacts more than doubled between 1977 and 1979. About two-thirds of this increase occurred between 1978 and 1979.

You may recall that a similar shift in the market occurred during the 1974–75 fuel crisis, but that the large-car market recovered quickly as soon as gasoline came plentiful once more. We are convinced this will not happen again. All of the evidence and all of our research indicates that the change in car-buying habits is irreversible. This time, consumers believe high fuel prices are here to stay.

The bottom line is that consumers are demanding better mileage than the Government standard currently requires. The shift to smaller, fuel-efficient vehicles, coupled with a reduction in miles driven, reduced gasoline consumption approximately 5 percent from 1978 to 1979. Gasoline consumption in February 1980 was reportedly down approximately 9 percent from a year earlier.

So by letting the free market operate, we can bring about a significant reduction in gasoline consumption. This approach promises to effect a greater reduction of fuel consumption than government mandates, with the least dislocation in the long run.

In the meantime, we must be careful that we don't compound the current plight of the U.S. automobile industry. In a recent speech, Secretary of Transporatation Goldschmidt talked about post-1985 fuel economy standards. He said the DOT is required by law to consider the financial health of American industry in setting regulations, and setting unrealistic requirements could have devastating impacts. He added that the DOT doesn't know enough yet to set realistic post-1985 standards.

Let us turn now to the subject of fuel economy tests. For many years automotive engineers have grappled with the problem of measuring fuel economy for a particular car model in a manner which would produce results similar to those that could be expected by the typical owner. Because of the many variables involved, no successful way of doing this has been found.

The present Federal test procedure produces technically sound results with a reasonable cost burden for both Government and industry. Careful thought should be given to any suggestion of change. Any proposals to super-impose another series of costly tests on top of those already required for emissions certification should be opposed.

Let me comment now on the development of test procedures and mandatory labeling of motor oils and tires for fuel economy purposes. We doubt seriously that such measures would be worth the cost and complexity. Both the nature of the situation and the general public apathy toward detailed consumer information give rise to these doubts. By the way of illustration, during the development of the first light truck fuel economy standards, DOT estimated that the contribution of so-called super-slippery oils was probably 0.5 mile per gallon. Other test data reported indicated values as low as 0.2. These small incremental differences are more than overshadowed by variations between drivers and between vehicles. It is doubtful that present Federal test procedures are sufficiently precise to discern these small differences.

The proposal which provides that automakers would be eligible for accelerated depreciation of facilities and equipment used to produce cars achieving at least 5 miles per gallon above applicable standards offers some interesting possibilities. This is one of the few, if not the only, proposal to offer an incentive for doing something rather than the usual disincentive or penalty for failure to do something. In principle, American Motors believes the "pull" effect of incentives is much preferred to the "push" effect of penalties. We further believe that this proposal, or something similar, deserves serious consideration and support.

Mr. Chairman, we believe the American public now understands the Nation's energy problem and is reacting very forcibly in the marketplace. The industry is getting the message loud and clear and is working very hard to respond as quickly as possible. This is as it should be. We believe the free market system which has served this country so well should be, not only permitted, but encouraged to function in the area of automotive fuel economy. If the necessary technological and economic bases are present to provide viable personal transportation to the public which will achieve a fleet average of 40 miles per gallon by 1995, you can rest assured that free competition will make it happen.

Thank you for inviting American Motors to participate in this hearing.

Senator STEVENSON. Thank you, Mr. Stewart.

I may have missed it, but I didn't hear in any of your statements any reference to taxes or quotas on imports and there were references to the marketplace.

Do I take from that that you do not support any of the current proposals for imports, quotas, voluntary or otherwise, tariffs, in-

cluding tariffs on light trucks, and also tax incentives that would encourage consumers to opt for domestically produced vehicles over foreign produced?

I don't think there was any reference to any of those subjects. Is my inference correct that you don't support those proposals?

Mr. STEWART. How do you wish to proceed?

Senator STEVENSON. Mr. Stewart.

Mr. STEWART. Well, let's see. I believe one of the questions you asked had to do with tariffs on small trucks. We have made representations to the Treasury Department and the Department of Customs with respect to the small truck tariffs as related to the controversy over the so-called chicken war. We firmly believe that the current law should be enforced and upheld, specifically that the cab chassis light truck should be reclassified as a truck, which in our view it truly is, and avoid the subterfuge of taking the box off and pushing it through the fence and saying, well, it only is eligible for a 4.5 percent tax rather than the statutory 25 percent.

Your overriding question I think had to do with tariff barriers and quotas and that sort of thing.

Senator STEVENSON. Any other tariffs and quotas that you support.

Mr. STEWART. We at American Motors do not believe that there should be tariff barriers thrown up to keep the foreign products out of this country. We think the foreign manufacturers should be encouraged to participate in this market to the extent that they can build plants here or whatever. If they are going to profit and reap benefits from this market, then we think they ought to contribute something to it to support it.

We also have suggested on various occasions that during this transitory time we have at the moment, which is particularly difficult for the industry and our employees in particular with so many people out of work, thought should be given perhaps to taxing over to the foreign manufacturers some of the cost of the Trade Adjustment Act benefits that are made available, for instance. These are just ideas that have been discussed.

Senator STEVENSON. Are there any additions or disagreements from the other witnesses?

Mr. STEWART. I will yield.

Senator STEVENSON. If not, I assume you all agree.

Mr. SCOTT. Mr. Chairman, speaking for Ford, we clearly agree with the 25-percent tariff position on light trucks. We have so indicated to Treasury.

With regard to the Japanese situation in general, you used the term quotas and tariffs. It is our view that something must be done and must be done soon and we were pleased frankly to see that the UAW has filed a 201 that would call for examination of Japanese import quotas in this country. We will cooperate with them in furnishing pertinent data that may be required. We feel the situation is very serious. We really were thinking about a 201 ourselves but we were quite frankly very surprised by the administration's view that it would not consider any action in this area at all and therefore we have not been vocal on the matter. We have cited that the problem is serious.

The Japanese import levels now are where they are taking away the jobs of the people in this country. They are taking away our markets. They are taking away our profits as we are trying to retool and change our plants and systems to make the kinds of cars that the public wants in this country now, and we are fearful that without some arrangement hopefully of voluntary restraint on the part of the Japanese that when we get there with the right kinds of products we may find that our customers have been taken away.

Senator STEVENSON. Anything further, Mr. Kennedy?

Mr. KENNEDY. You also asked about the incentive approach or tax relief or other monetary incentives to purchase more fuel efficient cars. That surely is a very attractive way to help the short-term problem while the industry makes a transition to products which are in demand and which we are bringing on.

The quickest way to improve the fleet average of all the vehicles in use is surely to get rid of the older cars which use a great deal more fuel than newer ones and encourage the replacing them with new ones.

With current high interest rates acting as an enormous deterrent to the purchase of those cars, this may be a way to encourage sales of those vehicles. You would obviously help employment in this country during the transition period and we think it is well worthy of consideration.

Senator STEVENSON. Mr. Potter.

Mr. POTTER. Let me just confirm that our position on the trucks is as indicated by the other people; that we are free traders, fair traders, and believe that there should be free access to markets all over the world. We would like to have that reciprocity conferred on us. We choose not to turn it off in this country.

Senator STEVENSON. Everybody is for free trade but voluntary restraints. Do you suggest that the Japanese are dumping or is the basis for this complaint to the ITC just damage to the industry?

Mr. SCOTT. Well, speaking for Ford, we make no allegations that we think they are dumping. We believe the Japanese are very efficient producers and have a very substantial cost advantage.

Senator STEVENSON. Any disagreement with that statement?

Mr. STEWART. I think we share that view. In past considerations of that particular question, I think that it's been established that it's virtually impossible to prove dumping one way or the other because of all the financial thicket you have to go through.

Senator STEVENSON. With respect to the light trucks, when will the industry have available for sale comparable light trucks?

Mr. POTTER. We are redoing our truck line. It is not our practice to announce the dates of introduction this early, this much in advance, but let me assure you that it is going along very rapidly and we have advanced the time frame. It will certainly be within the next couple years.

Mr. STEWART. American Motors expects to have a vehicle which will be a derivative of one of our current Jeep vehicles available in the 1981 model which will more nearly be competitive with that type vehicle.

Mr. KENNEDY. We expect to be more than competitive inside of 3 years.

Mr. SCOTT. Ford expects to be there in 2 years.

Senator STEVENSON. Thank you. Now we have all talked about uncertainties in the marketplace and the long leadtimes involved in the development and production of vehicles. Granted, there are uncertainties and large investment, and large economic stakes. So there must be some assumptions made by the industry about the marketplace in the course of its planning for the development and production of vehicles many years downstream.

What assumptions does the industry make about the price and availability of gasoline and diesel fuel in the 1980's or the late 1980's in the North American market, and about the condition of the economy? That is to say, the purchasing power of the consumer in that time frame. I grant it's a difficult question to answer, but can you give us a response?

Mr. POTTER. It's a fairly long question because it involves several things. One, the energy situation, as we see it; then the economic consequences; and then some of the Federal policies, national policies, which will modify these results.

Let me say that geologically and technically I must agree with Senator Schmitt. There is no reason for having a scarcity of petroleum products on a geological basis. Certainly within our lifetime that is not necessary. The cost of those products may increase, but not significantly above the present costs. Whether they are available depends an awful lot on national policy. That is one of the externals that we must wrestle with. We have been looking at various fuel costs from the present rate extended out to factors of two and three higher. There is a considerable elasticity not only in the driving but we are now beginning to find an elasticity in the demand, the long-term elasticity being a function of the kind of cars people will choose to buy in view of the fuel prices. That's a number that's not well known yet.

Our economists are struggling with that and the coefficients are perhaps higher than we thought at first, but if I couple this together I'm looking at what Senator Jackson talked about, the externalities that affect our business so mightily.

It would appear that there are policies that the country can follow that will give us a reasonable assurance of reasonable amounts of fuel over the long term, but if I look at the three things he talked to, the question of total availability, the reliability of the supply, and finally price, all being determined by these externals; and the strategies that you choose depend upon each of these three, but in different ways.

If it is only an issue of price, not of reliability or ultimate availability, then the consumer makes a cost-benefit statement for himself. He will certainly not choose to buy a vehicle whose cost exceeds any payback that he would ever get in the fuel saving. For instance, there's an upper bound to the technology one would buy under that condition.

Further, those people with limited incomes might choose to sacrifice some of the luggage capability or versatility that save money. Those are price decisions and that's where we are today.

I think our customers are driven by that consideration and that has shaped our market.

The other two, though, are very much more difficult to look into. The question of availability, that is, must there be a national

restriction via deliberation. This would force one into a decision that is no longer economic but simply that you be able to discharge whatever your day's duties are. You may be able to drive to work or whatever it is. You then take a car with sufficient fuel efficiency, bearing in mind the amount of fuel you're supposed to use in a day to get you back and forth.

The third situation, the reliability of supply, is an even more tenuous one. That is, if you literally cut off supplies, as occurred in this country first in the west coast in April and May of last year and then moving to the east coast during the summertime, then the customer might decide electric vehicles are the way to go.

Until those externalities can be pinned down, I think it's very difficult to decide what kind of fleet the American public will choose to own.

We are trying to position ourselves so that we can build in any of the three categories. We can build in any of the three categories and have the technology and know what to do. What we then talk about is the volume and those volume decisions are things that are made in the nearer term; that is, over 1, 2, or 3 years while you bring in transmission or axle plants or whatever has to be modified.

I think one of the points that one should examine is the argument that we were having about a year and a half ago about the front-loaded standards. At that time we were very concerned because all the market projections said the big cars were back. DOT had a very fine study that indicated that the share of full and intermediate size cars or large size would be 60 percent, 40 percent for the small. Today it's actually reversed. So we were all trying to look into that market and we had decided what technology we had to pursue in order to meet that customer demand and still meet the fuel economy standards. We were persuaded that certain technological advances that were not cost effective would have to be put in place. NHTSA concurred and in fact less than a year ago was urging on us a course of action that today, had we pursued it and had we obligated all that money, would have cost us on the order of $3 billion in useless investment.

Let me just tell you what those were. First of all a module of rear-wheel-drive four-speed transmissions. We won't even have that car by 1984. Two modules of V-6 engines, the 90-degree configuration chopped down from our V-8's, too large to fit in the transverse front-wheel-drive car.

As I have explained, by 1984, by the model year 1984, by the end of 1983, 4.8 million units of ours will not be able to take that engine they were urging on us for two modules, and similarly I can go on down the list.

Material substitution: We would have created the aluminum foundries to put in enough aluminum to make the material substitutions that were suggested. Now these expenditures, some of them, would have had a useful life of 1 or 2 years; some would not come into production for years to come, perhaps maybe never. That's the sort of thing one wants to avoid—the commitment to large capital expenditures when you're out ahead of the buying public.

Now I think we are coming on just as fast as we can to produce the things they want to buy and it doesn't happen to include these elements.

Senator STEVENSON. Does anybody care to add anything to that or disagree with anything that Dr. Potter said? There's not much to add to that.

Granted all the externalities and all of the uncertainties that you have very articulately described, what kind of a commitment is the industry willing to make? It may surprise you to hear this, but I think all of us want to help. All of us would prefer incentives to regulation and we are deeply concerned about the implications of the conditions in this industry not only for it but for the entire economy and indeed our national security.

I think it was Senator Jackson who said that the incentives, the assistance—the attitudes of the Congress toward regulation are going to depend on the willingness of this industry to make a commitment. I raised the question at that breakfast meeting and there was no response except to the consumer choice, the wide range of vehicles in the mid- to late-1980's. It was a pretty vague commitment and not what any of us wanted to hear. If you want us to abandon regulations and provide incentives, what then can we and the public expect from you in the way of fleet fuel efficiency standards in the mid- to late-1980's?

Dr. Potter, do you want to go first again?

Mr. POTTER. Our commitment is to be poised to build whatever the conditions of the times tell the people to buy.

Senator STEVENSON. But you have to do it now. You have to plan now.

Mr. POTTER. We are doing all the necessary technical things to have available the range of products that will most likely be wanted, and what we must commit to then is to maintain that versatility and to hope with the Congress that we do have the lead time of a year or two to anticipate whether gasoline prices will double or triple or stay the same over the next 10 years. We will be in a position to change the mix by really modifying the number of units that are sold in the various classes or the number of units that we are capable of manufacturing.

I think it's exactly true that to date we have very hot products. They are selling. We are simply in very short supply. We put onstream five plants to build those new cars. We put on five different plants to build Chevettes and our X-body cars. I think that was anticipated. We need another five plants. I'm not going to say we couldn't use five more today.

I think that given the externalities as they exist, that one would be foolish to position oneself way out ahead of them because if you miss you miss very, very badly. We don't like getting caught in the situation we are in and we will try to be better positioned for versatility, but I can't commit to a miles per gallon when perhaps what I should commit to is total production of electric cars. There are just too many unknowns when you're looking ahead to 1990 and 1995.

Mr. Chairman, if I were to ask you if you tried to answer this question in 1965, what should you be doing today, I think it would have been almost an impossible guess because just last year we

were faced with this exact question of how to do it, what to get poised for, and we would have made a mistake just a year ago.

Senator STEVENSON. You threw down that red flag in front of the wrong Senator. It wasn't 1965. It was in 1969 when I started predicting this crisis and started dealing with those economists that you're dealing with. I can remember in 1973 when I was chairman of this committee's Subcommittee on Oil and Gas Production, with the Secretary of the Treasury and a phalanx of economists, experts of the CIA, coming in to convince us that the oil price would clear at $7.34. We knew better. I don't know why this industry which is dependent on fuel as it is didn't know better, and I don't know why you can't do better now to give us some assurances. You heard Senator Jackson. It's the Government, as you have all recognized in one way or another, which to a very large extent determines those externalities, maybe in ways you don't like, but it determines them, and it's the Government right now and such Members of the Congress as Senator Jackson who are saying it's going to be $2 next year, if it's available for discretionary driving at all. In the mid- to late-1980's it's going to be several times the gas price of what it is today. That would indicate to most of us that instead of a range and a choice, you ought to be going all out to produce the most energy efficient automobiles you can and at prices an impoverished consumer can pay.

Do any of you have in development any vehicles such as the Volkswagen—two of them that Mrs. Claybrook described earlier?

Mr. POTTER. Mr. Chairman, we do.

Senator STEVENSON. That's good. The same time frame, as far along in development?

Mr. POTTER. About. They have an experimental vehicle. We have an experimental vehicle.

Senator STEVENSON. Similar efficiencies?

Mr. POTTER. Similar.

Mr. KENNEDY. All of us are looking at much the same technology. It's available to everyone. The turbocharged diesel engine is very economical. It's also very expensive. We are not sure that is something the customer would opt to buy unless gasoline prices—in this case diesel prices—go where Senator Jackson predicted. We can plan on the basis of $2 gasoline next year and $3 gasoline in 1985, but we don't know whether it will go that high. We will commit to plans responding to $3 gasoline, which could be a 40-miles-per-gallon fleet or greater in 1985. If those prices don't happen, we are terribly, terribly wrong. If Senator Jackson will commit to guarantee us $2 gasoline next year and $3 gasoline in 1985, we will react, but that's all we can do. Until we know what gas prices will be, it's very difficult to commit to anything.

Senator STEVENSON. Anything further?

Mr. SCOTT. I just wanted to add, Mr. Chairman, that the product planning process in the automobile industry is a very awesome and complex thing and one must make assumptions and live by them. One cannot plan for depressions. One shouldn't plan for a boom in the market and it's very risky to pick a number and say to ourselves fuel will be at x price at a certain date and wrap everything around it, just as it's very risky to say now what the mandated CAFE should be in 1995. What we do is try to take a trend line of

normal expectancies. We are working with very firm assumptions with regard to the price of gasoline. We have a rate of increase above the inflation rate through the years. We also work on the assumption that not every single person wants to buy the same kind of car because different people have different needs and we have been a full line manufacturer. All of us have been. Most of us still are. Some of us are still trying to be. We believe we must try to satisfy a reasonable range of driving requirements and that is the basis on which we are operating and if we are wrong in the future in underestimating or overestimating fuel price assumptions or willingness of consumers to yield convenience options or to give up on the family car or to say goodby to a station wagon, we take these risks at great peril and we pay a dreadful price, just as we are paying today—not so much, I think, because we misread but because we found ourselves in a market situation where the public was aiming at different kinds of products than we were making. It's very unfortunate.

We are trying to turn that around. I just want to emphasize it is an orderly process. You ask what are we willing to commit to. Mr. Potter said we commit to make the kind of products people need and want. That's the essence of what we do do, and we have to have the flexibility to make mid-course corrections, which we do. If a larger car was contemplated for a certain volume and certain years and it's fallen way off, we say goodby. The public puts it out of our system. We try to put in the flexibility we need.

Senator STEVENSON. The consumer is going to want the most energy efficient automobile he can afford. Does Ford have models comparable to those Volkswagen models in development in comparable stages of development?

Mr. SCOTT. We are doing work in our research area as well. I have been under the impression that IRSV—or whatever the higher one is—is strictly a research vehicle. We are working with research vehicles in the diesel area as well. We are also working with outside organizations, universities, and some other companies too.

Senator STEVENSON. Well, I understood the other vehicle—I mean, they are all development, but they could be put into production—at least the first could quite quickly, according to what we have been told. They are ready to go as soon as there's some competitive need for it.

What about American Motors? Does it have anything comparable?

Mr. STEWART. I think the simple answer is yes, we are working on those kind of developments. We prize very highly the affiliation with Renault and I won't go back through that, but this does give us access to advanced diesel technology which we haven't had in the past and we certainly intend to capitalize on that to the utmost.

I would also like to add, Senator, the point that maybe I didn't make too well in my statement that I feel very strongly about, and that is that the situation we find ourselves in now is I think a short-term situation and I think that the solution to the problem doesn't lie in whatever the fuel economy requirement is going to become in 1995. I think the real root of the problem is what are we

going to do to get turned around and get competitive with the kind of vehicles that are needed in the near term, in the middle and latter part of the 1980's or tomorrow if we can do it, and I think that the fuel economy standard is not necessarily the best way to go about it.

I think we should ask ourselves collectively how did the foreign competition we are so concerned about get to the position they are in with no fuel economy standards. We are the only industrialized country in the world to my knowledge that has had an artificially depressed price of gasoline and energy and at the same time a series of fuel economy standards imposed upon the industry. It seems to be kind of a dichotomy, if anything.

But even so, the foreign manufacturers, despite the research efforts that you're mentioning here, have not necessarily found an "Eureka" button that's going to make all the problems just go away.

For instance, I was rather surprised to find out if you take the Japanese manufactured vehicles sold in this country as a whole and look at them as a fleet and compute their CAFE standard for that group of vehicles, their performance level, I should say, it's something on the order of 28 or 28.5 miles per gallon. Now that's quite respectable, no question about it, but on the other hand, it's a far cry from 60 miles per gallon or the kind of numbers we have been discussing.

Likewise, the German fleet is about 30, and it's heavily sales weighted with the small Rabbit, particularly the diesel version.

The point is, I don't think we are that far off course and I think we have a relatively short-term situation to overcome here and then get back into the main foray.

I think we, as an industry, certainly speaking as American Motors, we are certainly capable of doing it.

Senator STEVENSON. I wish I could agree that it's short term or that the fundamental problem of competitiveness is confined to your industry. It's not. But I'm not going to press this except to suggest that the attitude of the Congress toward accelerated depreciation or other forms of assistance will I think depend on the attitude of the industry to the public and, if not a commitment, some form of assurance that with assistance it's going to do everything it can to produce the most cost efficient, energy efficient vehicles in the mid to late 1980's within, of course, the means of the consumer to pay for them, and that requires some prediction too.

One final question. How will the industry be helped by the efforts to persuade the Japanese to develop more highly efficient production capacity and locate it in the United States? Won't that simply displace more domestic production by the American producers? Does anybody care to take that one on? Mr. Scott?

Mr. SCOTT. Well, there's not unanimity in the industry on the wisdom of urging the Japanese to come to this country to manufacture their cars here. I think the genesis of this——

Senator STEVENSON. Excuse me, but they are not going to give up their manufacturing plants back there. They are not going to dismantle them. They are already topping off their production capacity as I understand it.

Mr. SCOTT. I was just making a general comment. I think it's generally understood that this is a rather costly market in which to manufacture cars. The Japanese market is a less costly one in which to operate and this leads to much of the advantage the Japanese have in bringing cars into this country. If the Japanese are going to participate in this market in the kind of volume, we have seen, it's sort of a natural development to say—shouldn't they be here to face the same kind of costs we face, for example, plant regulatory costs, OSHA matters, and so forth? Should they not be exposed to the same circumstances of the automobile business if they are going to participate in this market as strongly as they have been?

And, of course, the UAW quite understandably has urged this as well, and I believe that the difference between my view versus what you just said is that I would assume if the Japanese were to come here and make cars in reasonable volume, that there would be idle capacity in Japan rather than idle capacity in the United States.

Senator STEVENSON. Do you all agree with that conclusion?

Mr. POTTER. Mr. Chairman, I have no comment to make on the issue. I think that it is clear that any capacity that is brought into this country will take out some domestic capacity. We are in the process of rebuilding our capacity and adding new plants. They are certainly welcome to compete in this marketplace with anybody else.

Senator STEVENSON. No comments, Mr. Kennedy? Nothing to add? No opinion?

Mr. KENNEDY. Not at this time.

Mr. STEWART. I would like to say, sir, that certainly I think it would be much more competitive if they were placed on the same cost basis we are—labor cost, environmental costs as Mr. Scott said, which they are not today by operating from their home base. Don't you think this is one of the reasons why when Japanese manufacturers are approached on the subject of building plants in this country that we're "slow walked" to death with studies and intentions being voiced which never seem to be realized. Why should they be? There's no incentive.

Senator STEVENSON. I think some of their costs are higher. Raw material price in Japan is higher. Over here they will compensate for putting in increased labor cost by putting in advanced production procedures so they will not employ as many American workers and end up with a net decrease in employment and, of course, you've got some regulatory requirements placed on them, but you end up with an overall increase in capacity and no less capacity certainly in Japan. That's still coming onstream. There are lower fuel costs here. You're the experts. I just see that this looks to me like a very mixed bag with some lower cost to the Japanese as well as some higher cost, and overall the reasons for the Japanese reluctance has more to do with quality control, with Japanese employment, and perhaps most importantly of all at the moment, the relationship between the yen and the dollar. That's another externality that's tough to predict.

Thank you, gentlemen. I appreciate your testimony.

Our next witness is Howard Young, representing the UAW.

Mr. YOUNG. Mr. Chairman, I have a small chart.

Senator STEVENSON. Fine.

Mr. YOUNG. This is the same chart as on the second page of my prepared statement in case there's any difficulty in seeing it.

STATEMENT OF HOWARD YOUNG, SPECIAL CONSULTANT TO THE PRESIDENT, UAW SOLIDARITY HOUSE

Mr. YOUNG. My name is Howard Young. I am special consultant to the president of the UAW and I appreciate the opportunity to present our views. I have submitted a prepared statement and I will just summarize that or cover some of the points if that's acceptable.

The Energy Policy and Conservation Act mandates rising new passenger car fuel economy with new models to average 27.5 miles per gallon by 1985. EPCA, which the UAW supported over auto industry opposition, is doing its job. In fact, the U.S. Big Three producers are ahead of the required schedule, with their 1980 model cars projected to average more than 21 miles per gallon, a 35-percent improvement over 1975 models.

The UAW still believes that Government-mandated fleet average fuel economy targets will continue to be a desirable element of the Nation's energy policy. The essential questions are the level and timing of further increases in those targets, and their relative importance as compared with other means of reducing oil consumption.

In relation to the latter point, it is important to keep in mind a basic mathematical fact: As average fuel economy improves, further increases in the new car miles per gallon figure provide progressively smaller absolute savings in gasoline use. As the attached chart shows, the required average of 27.5 miles per gallon for 1985 models means that 364 gallons of gasoline are used for each 10,000 miles driven. It should be kept in mind that while we talk about miles per gallon, EPCA actually measures and then converts into miles per gallon, gallons per mile and that's really the fundamental variable that's of interest.

Although the fuel economy in miles per gallon goes from 14 to, for example, the suggested 27.5 by 1985 and using, for example, the 40 miles per gallon proposed by 1995, let's look at the fuel savings.

At 14 miles per gallon, to drive the typical 10,000 miles per year took 714 gallons of gasoline. By 1985, when we are up to 27.5 miles per gallon for new cars, it will take 364 gallons of gasoline. In other words, it will save 350 gallons in driving that same distance.

If we look at a fuel economy target of 40 miles per gallon, which means that you could drive 10,000 miles with 250 gallons of gasoline, the additional savings is only 114 gallons.

Now I don't say only in the sense of dismissing it, but I say it in terms of the relative marginal increase and in order to keep in mind how we compare with other alternatives available to us. Even at the 85-miles-per-gallon figure, which has been talked about as a conceivable target, it takes 117 gallons of gasoline to drive the 10,000 miles. As compared with the 1985 standard, the savings would be 247 gallons or only 70 percent of the saving that we achieve in going from the 1974 level of 14 miles per gallon to the 1985 level of 27.5 miles per gallon.

So that aside from any technological difficulties which may be involved in achieving additional miles per gallon increases, the improvements already achieved have drastically decreased the amount of gasoline that can be saved through such additional miles per gallon increases.

With that in mind, the following points are covered in the remainder of this statement.

The post-1985 period should be used initially to consolidate the progress that is now being made. The industry is focusing heavily on the legislated numerical CAFE requirements, and—as recent recall data indicate—could fruitfully use a period in which the production process is made more efficient and reliable. In addition, during the post-1985 period we should close the gap between fuel efficiency as measured under present law and the performance that the new car buyer is likely to achieve. That is important to saving fuel, and it would improve the credibility of fuel economy regulations.

Greater attention should be paid to the ongoing fuel efficiency performance of cars in use. This would involve manufacturing improvements aimed at long-term performance as well as provisions related to maintenance, traffic management, and so forth. At any given time, new model cars constitute no more than one-tenth of the cars in use. Therefore, each 1-percent fuel efficiency improvement for all cars saves as much gasoline as a 10-percent improvement for new cars.

In addition, most American families only buy in the used car market. They never buy a new car. Hence, long-term maintainability is important if they are to benefit from the improvement in new cars. As new car prices rise and incomes stagnate, older cars are becoming an increasing portion of the fleet. In July of 1970, the average car was a little over 5.5 years old, and only 30 percent were 7 or more years old. By July 1979, the average age was 6.6 years and 39 percent were 7 years or older.

We have suggested that consideration be given to a scrappage program. For example, the Government might offer to buy any car on the road for $300. We estimate that roughly 20-percent of the fleet is over 10 years old and that that's a competitive market price for such a car. Taking those cars off the road would significantly reduce fuel since those tend to be the cars with the least fuel efficiency, with the highest emissions, with the worst safety and presumably a significant piece of the $300 could be recovered simply from the scrap value of the steel and other items.

We have suggested that there be a tax credit for the replacement of existing cars with more fuel-efficient cars. The fuel savings—the kind of analysis that is indicated on this chart—in transferring from a 14-miles-per-gallon car to a 20-miles-per-gallon car, which is the current required average in this model year, is greater than the fuel savings in going from a 20-miles-per-gallon car to a 34-miles-per-gallon car. So that a great deal can be achieved by paying attention to the fleet on the road as well as the manner in which new cars are moved out.

We have suggested that if prices will continue to be the main mechanism for restraining the use of gasoline, then consideration should be given to a two-tier pricing system. If we are concerned

with restraining the marginal additional use of gasoline, there's no need to raise the price of every gallon of gasoline, and attached as an appendix to my statement is a submission we made to the Department of Energy outlining a program which we labeled "Gasoline," which is an adaptation of the "Lifeline" concept that has been used or referred to in the pricing of electricity and natural gas for home use.

Finally, along these lines in the spirit of a suggestion that could be investigated rather than a specific advocacy item, for businesses which use autos and light trucks as one of many alternatives—that is, I'm not talking about businesses in transportation services—we might look at the fact that gasoline is used as a tax deductible item and change the economics of their decisionmaking by making it nondeductible.

In another area, a more complete analysis needs to be made of the alternate ways of reducing U.S. oil use and dependence. As previously discussed, the opportunities for fuel saving through higher new car fuel economy requirements continually decrease; hence, other approaches are more and more likely to be lower cost targets for conservation.

We understand that American refineries can make only 45 percent of a barrel of crude oil into gasoline. The yield is even lower when started from heavier crudes and as the octane rises, and most small refineries are not equipped to make more than 20 percent of their crude into unleaded gas. Recently a new refining technology was announced that claims it can yield vastly improved yields of over 70 percent in gasoline. Another study indicates that a 4-year $18 billion investment in refinery upgrading could increase the per barrel yield enough to reduce the U.S. oil imports by 20 percent.

I understand the Office of Technology Assessment is undertaking a new study in this area of the relative importance of new car fuel economy versus other approaches.

Mr. Chairman, I see the red light is on. I do have a few comments that go directly to the research question and I'd like to cover those if I may.

We believe there are important initiatives needed in research procedure, including the establishment of a more objective basis for setting future auto standards, one which provides adequate lead-time for their implementation. At present, the discussion of post-1985 CAFE numbers is sadly reminiscent of the 1974–75 debate on the current standards: The numbers essentially plucked out of thin air, with supporting arguments often based on prejudices for or against automobiles rather than on objective analysis. The important fact is that too many technological and financial uncertainties exist in today's automotive sector for the Congress to reasonably set post-1985 standards now.

That is not to advocate that nothing be done. What we suggest is that a mechanism be put in place which would in fact permit that kind of information to be assembled on an ongoing basis and permit standards to be promulgated in advance but not so far in advance, not 15 years in advance, and not in an atmosphere of legislative debate but, rather, in the atmosphere of an objective debate. Mainly as a basis for discussion, we outline a procedure for periodically establishing standards to be met by demonstration

vehicles built by manufacturers in a specified time period after the standards are established. The legislation would not set the standards. It would give the authority to an administrative agency to set such standards for a demonstration vehicle, have an opportunity for interaction with the industry, and the key is we would not be talking about the kind of experimental vehicles that were discussed earlier such as Volkswagen, but vehicles that are in fact ready to be mass produced within a reasonable period of time. It seems to us it's that kind of a flexible mechanism that's needed to more readily adapt to ongoing circumstances and we believe that that kind of proposal could easily be incorporated into S. 2015 or H.R. 4707 which are under consideration by this committee.

As a final point, let me mention that we in the UAW have long advocated that there be joint or cooperative Government and industry research. In addition, we have long advocated that there be mechanisms by which there could be intraindustry research across several companies. We think that the requirement that all companies do all of the research independently is wasteful and it's interesting that just recently six European automakers announced plans to pool their technological know-how as a defense against the expected onslaught by the U.S. and Japanese producers.

As a final final point, it will not surprise you if I point out that EPCA properly recognized that high oil consumption is not the only problem that the Nation must solve. An additional goal when EPCA was enacted was to insure that fuel-efficient cars would be produced domestically. The fear in 1975 when EPCA was under debate was that the U.S.-based companies might import such cars from their foreign plants, thus a domestic content requirement was imposed to distinguish domestic and other production. That provision has had its effect.

Now, however, soaring fuel prices have resurrected the problem as foreign producers have made heavy inroads. Thus, provisions should be enacted in EPCA or other legislation to once again assure the fuel-efficient cars sold here in large volume contain adequate domestic content. Thank you very much.

Senator STEVENSON. Thank you very much, Mr. Young. That's an excellent and very comprehensive statement which I'm going to take home with me over the weekend.

Is 40 miles per gallon plucked from the air in 1995?

Mr. YOUNG. Yes, in the sense, Mr. Chairman, of whether it's an appropriate goal. I think that everyone has indicated that it is technologically feasible. I suspect a higher number is technologically feasible, but whether it's the appropriate goal for 1995, 15 years from now, in view of the circumstances that none of us can anticipate that this country will face, the precise circumstances, I have no way of knowing and I suspect no one else knows whether 40 is a better number than 35 or 32 or 50.

It's better in the sense that it's higher. More is always good conceivably. But there is no objective basis that says that's the right number for the circumstances that will prevail at that time.

Senator STEVENSON. Well, how about 1986? 40 miles per gallon isn't going to be enough to maintain a competitiveness of this industry in 6 years, is it?

Mr. YOUNG. I think as a fleet average it will not be required to maintain competitiveness. What this industry needs as far as we can see today is more ability to produce—that is, ability to produce more of the high-fuel-efficiency cars they already know how to produce. We would not be in precisely the circumstances we are in today—certainly not with respect to the relative role of the imports—if, say, General Motors had greater capacity to sell X-cars and Chrysler had greater capacity to sell Omnis and Horizons. We would be suffering from the impacts of the recession that we are in, but that doesn't have very much to do with the kinds of cars that are available.

Senator STEVENSON. That technology is available now. What's required from Government? Capital?

Mr. YOUNG. I don't believe that except in the specific case of Chrysler, which obviously had a special problem, I don't believe that the constraint on the companies tooling up to provide additional capacity for those particular cars was a capital constraint.

They made a market decision of what they expected. I would advocate that, contrary to what the companies have said, if anything, the Government play an even greater role in setting the direction and the target, but it do it in a way in which the Government is capable of being more responsive to changing circumstances than would be true if it simply locked a system in 15 years in advance.

So that while there will be capital problems down the road and the best way to meet them is something that has to be looked at, today's problem is not a result of that as far as I can see.

Senator STEVENSON. Chrysler's problem isn't so special any more, is it?

Mr. YOUNG. In terms of this year it is. Whether that will become a more widespread problem 5 or 6 years from now will I think depend to some extent on what is done short term with respect to, say, Japanese exports. I believe that if they continue to take the larger and larger share of the market, then that problem could become more widespread to other companies and that's why we're so concerned about it.

Senator STEVENSON. Would Chrysler be helped by more Japanese capacity in the United States?

Mr. YOUNG. I don't think they will be disadvantaged in any way. I don't see any reason to believe that if the Japanese build their cars here that they will sell more cars than they now sell and to the extent that the Japanese do under those circumstances have to meet similar regulations with regard to plants and OSHA and so forth, then I understand there will be some gap that will be closed in terms of cost.

Senator STEVENSON. And there may be some new gaps created. I don't think they're going to shut down any capacity in Japan, but have you compared the labor content of American vehicles with Japanese vehicles?

Mr. YOUNG. It's extremely difficult to do because the Japanese companies, as specific business organizations, tend to be less vertically integrated than the U.S. companies. We understand that the Japanese companies are in the process of expanding their capacity in Japan, or at least they were until very recently, so that it isn't a

question that there's a lot of capacity there that would suddenly be abandoned. We think they should shift some of those plans and as we have noted before the head of the Japanese auto union, who obviously has certain concerns in these areas, has supported that view. He has expressed the view that it will not cause significant dislocations among Japanese workers and that ultimately the growth of the industry there and here—because I think that the industry will grow in the long run—can absorb that.

Senator STEVENSON. Well, you may be right. I don't know. I was under the impression that those plans and plans for increased capacity in other parts of the world, including Italy, were pretty far along and unlikely to be reversed and, therefore, capacity here might be additional capacity. But the question I hoped you could answer was about the labor content of Japanese vehicles, regardless of where they are manufactured.

My impression is that they use the most advanced manufacturing procedures, including robotics, and that the labor cost associated with the production of Japanese vehicles are not so much because of labor wages but because there are fewer production workers involved and substantially fewer, and therefore the concern is that additional Japanese capacity over here will displace American production with a net decrease in the employment of autoworkers.

Mr. YOUNG. Well, I have to give a fairly long answer to that. It is my impression, but I'm certainly not an expert on Japanese manufacturing and not even for that matter on U.S. manufacturing processes, but if you look at comparable types of cars, the gap in terms of use of automation and other things is not quite as wide.

One of the reasons that the Japanese have gone more heavily into robotics and similar forms of automation is that they have had a narrower range of vehicles. I understand that the kind of techniques being used, for example, to produce Omnis and Horizons as an illustration, or Chevettes or other cars, where they are more comparable to the Japanese vehicles, have tended to come closer to the automation the Japanese have.

Whether that trend will continue or how fast it will continue—I'm sure it will continue—is something I don't know. As I'm sure you know, we in the UAW have not taken the position that that's an objectionable trend. We are obviously concerned that as it happens that the workers who are affected be protected, again to the extent that it's at all possible, against the adverse effects. But we have long understood that if the choice is fewer people building some cars or everybody building no cars, that it's the former that makes sense.

Senator STEVENSON. Well, if you could get us additional information about the labor content of the most advanced U.S. production facilities, like the one at Belvidere, Ill., and the Japanese in this sense, plants, for example, that produce the Datsuns, I think it would be of importance to us and it might be of importance to you too.

My impression is that they produce their new cars with far less labor and that therefore there's a risk such plants over here may end up displacing American workers overall.

Mr. YOUNG. We'll do our best to come up with something.

Senator STEVENSON. One final question. We are just running out of time.

The industry is suggesting relief from regulation. If you have addressed this in your statement, don't bother to repeat, but how does the UAW feel about relief from the passive restraint requirements, bumper requirements, emission standards, and so on?

Mr. YOUNG. That point was not addressed in the statement, but we are in general not in agreement with the industry's position that these regulations should be rolled back or lifted or otherwise changed. There are specific instances where we would look at regulations. We argued when the Clean Air Act was last under discussion that the CO level was tighter than it had to be. I'm sure there are a number of specific instances that ought to be examined on their merits, but as to the general premise that the problems are the safety regulations or the emission regulations or the bumper regulations, we are not in agreement with their position.

Senator STEVENSON. Thank you very much, Mr. Young.

[The statement follows:]

STATEMENT OF HOWARD YOUNG, SPECIAL CONSULTANT TO THE PRESIDENT, INTERNATIONAL UNION, UAW

The Energy Policy and Conservation Act of 1975 (EPCA) mandates rising new passenger car fuel economy, with new models to average 27.5 mpg by 1985. EPCA, which the UAW supported over auto industry opposition, is doing its job: in fact, the U.S. Big Three producers are ahead of the required schedule, with their 1980 model cars projected to average more than 21 mpg, a 35 percent improvement over 1975 models.

The UAW still believes that government-mandated fleet average fuel economy targets will continue to be a desirable element of the nation's energy policy: the essential questions are the level and timing of further increases in those targets, and their relative importance as compared with other means of reducing oil consumption.

In relation to the latter point, it is important to keep in mind a basic mathematical fact: as average fuel economy improves, further increases in the new car miles per gallon figure provide progressively smaller absolute savings in gasoline use. As the attached chart shows, the required average of 27.5 mpg for 1985 models means that 364 gallons of gasoline are used for each 10,000 miles drives. That is 350 fewer gallons than were required to drive the same distance at the pre-EPCA 1974 model year average of roughly 14 mpg. Now consider the additional savings that would result from some of the future targets under discussion:

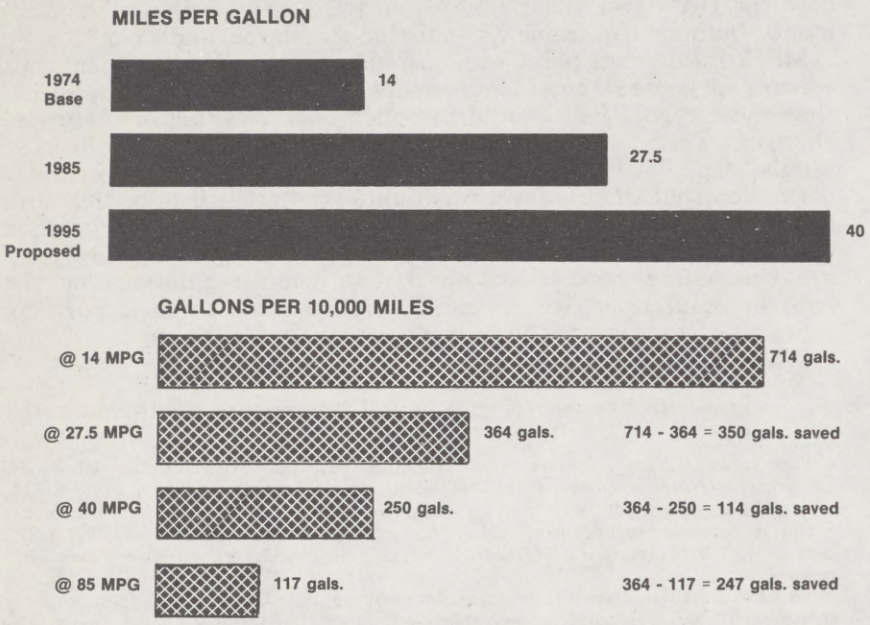
At 40 mpg, it takes 250 gallons to travel 10,000 miles; that is 114 fewer gallons than at 27.5 mpg.

Even at 85 mpg, it takes 117 gallons to go 10,000 miles; that is 247 fewer gallons than at 27.5 mpg.

In other words, the gasoline savings [1] that would result if we eventually were to move from 27.5 mpg to 85 mpg is only 70 percent of the savings realized in going from 14 mpg to 27.5 mpg.

[1] In fact, EPCA calculations basically reflect gallons-per-mile and are only converted to miles-per-gallon as a final step to jibe with the more commonly discussed concept.

THE DECLINING EFFICACY OF NEW CAR CAFE STANDARDS



Thus, aside from any technological difficulties which may be involved in achieving additional miles-per-gallon increases, the improvements already achieved have drastically decreased the amount of gasoline that can be saved through such additional mpg increases.

With that in mind, the following points are covered in the remainder of this statement:

The post-1985 period should be used initially to consolidate the progress that is now being made. The industry is focusing heavily on the legislated numerical CAFE requirements, and—as recent recall data indicate—could fruitfully use a period in which the production process is made more efficient and reliable. In addition, during the post-1985 period we should close the gap between fuel efficiency as measured under present law and the performance that the new car buyer is likely to achieve. That is important to saving fuel, and it would improve the credibility of fuel economy regulations.

Greater attention should be paid to the ongoing fuel-efficiency performance of cars in use. This would involve manufacturing improvements aimed at long-term performance as well as provisions related to maintenance, traffic management, etc. At any given time, new model cars constitute no more than one-tenth of the cars in use. Therefore, each one percent fuel-efficiency improvement for all cars saves as much gasoline as a 10 percent improvement for new cars.

A more complete analysis needs to be made of the alternative ways of reducing U.S. oil use and dependence. As previously discussed, the opportunities for fuel-saving through higher new car fuel economy requirements continually decrease; hence other approaches are more and more likely to be lower-cost targets for conservation.

Finally, there are important initiatives needed in research procedure, including the establishment of a more objective basis for setting future auto standards, one which provides adequate lead time for their implementation. At present, the discussion of post-1985 CAFE numbers is sadly reminiscent of the 1974–75 debate on the current standards: the numbers are essentially plucked out of thin air, with supporting arguments often based on prejudices for or against automobiles rather than on objective analysis. The important fact is that too many technological and financial uncertainties exist in today's automotive sector for the Congress to reasonably set post-1985 standards now.

Before elaborating on these points, I would like to emphasize one other matter. EPCA properly recognizes that high oil consumption is not the only problem that the nation must solve. An additional goal was to assure that fuel-efficient cars would be produced domestically. The fear in 1975, when EPCA was under debate, was that the U.S.-based companies might import such cars from their foreign plants; thus a domestic content requirement was imposed to distinguish domestic and other production. That provision has had its effect. Now, however, soaring fuel prices have resurrected the problem, as foreign-based producers have made heavy inroads. Thus provisions should be enacted, in EPCA or other legislation, to once again insure that fuel-efficient cars sold here in large volume contain adequate domestic content.

Let me now elaborate on the points I have raised by exploring four questions.

1. How much petroleum is conserved by rising new car fuel efficiency?

First, it should be obvious that each additional increase in mileage (actually, decrease in gallons per mile) yields progressively less conservation. An increase in CAFE requirements from 25 to 30 miles per gallon, other things equal, saves one-third less fuel than an increase from 20 to 25.

Second, other things are not equal: there is evidence that, absent huge fuel price increases and/or supply shortages, miles driven rise as gallons per mile decline. The 10 percent drop in average annual miles per car between 1976 and 1979, for example, occurred despite a slight increase in miles per new car.

Third, because mass automobilization has long since reached maturity in the U.S., each new model year contributes at most 9, and often as little as 7, percent to the on-road vehicle fleet. If, for example, 1979 model cars had averaged 20.6 instead of 19.6 miles per gallon, the U.S. would, as of today, have conserved about half of one day's U.S. oil use![2]

This leads to a second set of issues:

2. Might there not be a bigger payoff to approaches aimed at improving the fuel efficiency of the total on-road fleet than to a policy focused on new cars alone?

The 104 million passenger cars now registered in the U.S. include a substantial number of older, low-miles per gallon autos. Moreover, as new car prices rise and consumer incomes stagnate, these older cars are becoming an increasing proportion of the fleet. In July 1970, the average car was 5.55 years old, and only 30 percent were 7 or more years old. By July 1979, the average age was 6.6 years, and 39 percent were 7 years or older.

These older, fuel-wasting, air-polluting, unsafe cars are relatively untouched by public policy, except to the extent that allowing fuel prices to rise depresses their trade-in values and hence encourages their continued use. Emissions inspection/maintenance programs, for example, typically exempt cars eight or more years old, judging them to be prohibitively expensive to repair to compliance levels, despite the fact that they may be responsible for an absolute majority of mobile source pollutants.

Simple arithmetic makes it clear that to match the fuel savings of replacing a pre-EPCA 14 miles per gallon car with a 20 miles per gallon one, a 20 miles per gallon car would have to be replaced by one that achieves more than 34 miles per gallon.[3] Not even counting air quality and safety gains, it seems fair to say that society would be better off putting more of its resources into scrapping the oldest cars and less into improving the mileage of new ones.

Based on current used car prices, it is our estimate that, for each $1 billion in "bounty," the U.S. government could induce some three million Americans to turn in cars for scrappage.[4] Not only would the most fuel-thirsty cars be off the road, but a large part of the cost of such a scrappage program would be offset by the value of the steel scrap and other recyclable materials recovered from the cars turned in.

While there is beginning to be more interest in the scrappage approach, it continues to be neglected by most energy policy analysts. We in the UAW have been advocating accelerated scrappage since 1975, and we remain convinced that it would be foolish to set post-1985 new car CAFE standards without seriously comparing the resulting fuel-saving with the conservation impact of an accelerated vehicle scrappage program.

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[2] As of May 9, 1980 the average 1979 model car had been driven 17,300 miles. Fuel saving at 20.6 vs. 19.6 miles per gallon would be 42 gal. or 1/BBL/car. Times 8.3 million 1979 domestic cars, equals 8.3 mb.

[3] At 10,000 miles per year, a car uses 714 gallons at 14 miles per gallon, 500 at 20, and 294 at 34. The savings are 214 gallons and 206 gallons, respectively.

[4] To avoid a run on $100 "clunkers" by speculators seeking a windfall, a minimum registration period could be required.

Our point is simply that new car fuel economy is only one of a number of "marginal opportunities" to conserve scarce petroleum. It is only fair to ask:

3. Are there significant untapped opportunities for oil saving outside the auto industry, and might not those opportunities be exploited at a lower per barrel cost?

We don't know the answer to this question. The most common cost comparison, of course, is between new CAFE standards and the development of liquid fuels from coal and shale. In our view, this is probably the comparision that most favors new mileage standards, though recent work out of OTA suggests that lignite-based methanol may already be cost-competitive with unleaded gasoline.

Before proceeding further, let us calculate the oil saving likely to result from a 40-miles-per-gallon 1995 new car fleet. Assume that we are contrasting two overdrawn scenarios, one in which all 1985 and later models average 27.5 miles per gallon, and another in which CAFEs rise linearly from 27.5 in 1985 to 40 in 1995. Let us assume further that the period during which the two scenarios compete is 1985–2005. Under the assumption most favorable to the rising CAFE scenario—no increase in driving as mileage improves—the comparison is of 20 years at about 25 miles per gallon versus at about 31 miles per gallon.

Model year	New model CAFE		Nonnew model CAFE		On-road fleet CAFE [2]	
	No new standards	Proposed standards [1]	No new standards	Proposed standards	No new standards	Proposed standards
1985	27.5	27.5	20.1	20.1	21.0	21.0
1986	27.5	28.75	21.0	21.1	21.8	21.9
1987	27.5	30.0	21.8	22.2	22.5	23.1
1988	27.5	31.25	22.5	23.1	23.1	24.1
1989	27.5	32.5	23.1	24.1	23.6	25.1
1990	27.5	33.75	23.6	25.1	24.1	26.1
1991	27.5	35.0	24.1	26.1	24.5	27.2
1992	27.5	36.25	24.5	27.2	24.9	28.2
1993	27.5	37.5	24.9	28.2	25.2	29.3
1994	27.5	38.75	25.2	29.3	25.5	30.4
1995	27.5	40.0	25.5	30.4	25.8	31.5
2005			27.4	39.7	27.4	39.7
Average 1985–2005					25.0	31.0

[1] Assumes linear schedule.
[2] Assumes that new model cars account for 12 percent of total miles driven.

Assuming one trillion annual miles driven, the 20-year fuel consumption difference is:

$$20 \times \left[\frac{10^{12}}{25} - \frac{10^{12}}{31}\right] \text{gallons} = 3{,}681 \times 10^{6} \text{ barrels},$$

or 2.9 percent of U.S. 1985–2005 oil use at 17.5 mbd.

The question can now be posed as follows: What is the most efficient mix of ways to forego 2.9 percent of future oil consumption?

Again, we in the UAW don't have a satisfactory answer; but we do think that his way of asking the question demands careful study of the costs of oil-saving strategies composed of at least the following elements:

a. Conversion of electric utility and large industrial boilers to coal, coal/oil mixtures, peat, and low-Btu gas;

b. Stepped-up effots to enhance supplies of natural gas from deep fields and of synthetic gas from coal and biomass that could back out pertoleum products;

c. Development of methanol from lignite coal and of distillates (including diesel fuel) from shale, as consistent with environmental standards; and

d. As discussed above, a program to accelerate scrappage of older motor vehicles.

This list is, of course, not exhaustive. Moreover, it takes the existing state of technology as a given, thus omitting all strategies requiring further technical development. We therefore must also ask:

4. Are any of the technological constraints to more abundant motor fuel supplies removable at lower cost than future new car fuel economy standards?

This question is implicit in the debate between synfuel development and new auto mileage standards. Those who answer "yes" estimate a synfuel capital cost "cross-over," relative to new fuel economy mandates at or below a 30-mpg CAFE. Those answering "no" believe that technical obstacles hold off the cross-over to a 40-mpg-plus CAFE level.

But synfuels are hardly unique in their potential for reducing oil supply constraints. A much more immedite set of petroleum product contraints is embodied in the nation's stock of oil refineries. To put a complicated issue in its simplest form, American refineries (which average over 20 years' service) can make only 45 to 48 percent of a barrel of crude oil into motor gasoline. The gasoline yield is even lower when starting from more abundant heavy crudes; it falls as desired gasoline octane rises; and most refineries are not equipped to make more than 20 percent of their crude into unleaded gasoline.

At first glance, this seems to make reduced automotive fuel use all the more necessary—though, as we've pointed out, new car mileage standards may not be the best way to accomplish that. But it means at least two other things as well:

a. Beyond a certain point, efforts to reduce petroleum use must aim to conserve the entire line of refined products in relatively fixed proportions; and/or

b. Existing refineries must be updated and new ones constructed to be consistent with the mix of refined products required by the nation as it pursues a least cost energy policy.

As many of you are aware, the oil industry has held off building new refineries because it expected—correctly—that EPCA would result in reduced gasoline demand. Unfortunately, that halt has increased our vulnerability to cutoffs of imported light crudes, and has meant that shortages have tended to be centered on gasoline, conveniently creating price pressures on the only remaining price-controlled petroleum product, pressures that make it harder to have the real debate over how the windfall resulting from rising prices should be distributed and spent.

Recently, Ashland Oil has announced a new refining technology that it claims can achieve "a vastly improved yield of more than 70 percent gasoline" from a barrel of fuel oil feedstock. Using high-temperature catalytic conversion techniques, the Ashland process also appears to be able to handle heavy and high-sulfur feedstocks with no significant loss in motor fuel yields. The questions raised by Ashland's announcement are obvious: is sharply reduced gasoline consumption likely to be central to lower overall oil use in the post-1985 period? And, what would be the cost of making it less central?[5]

A study by Purvin and Gertz, Inc. for the American Gas Association estimates that a four-year $18 billion investment in refinery upgrading could increase the per barrel yield of light products enough to reduce U.S. oil imports by 20 percent or about 1.4 mbd. Achieving an oil consumption reduction of that magnitude through new car fuel economy standards would require a 1995 CAFE mandate of about 90 mpg!

At this point, we want to be clear that we are not arguing for "letting the market work" instead of setting new regulatory standards. While many of our points may parallel arguments made by business groups seeking to discredit the principle of government intervention in our otherwise anarchic economy, we dissociate ourselves from such arguments. Certainly, we plead no special brief for the U.S. auto industry which, despite its massive recent spending to downsize the domestic new car fleet, consistently ignored UAW demands that more and better-built small cars should be produced.

It is our view, however, that a great deal *has* been done in the automotive fuel economy area. If we are correct that there may be significant alternatives to a conservation policy focused primarily on new cars, then instead of rushing to set post-1985 standards we should use the next several years as a time for taking stock of what has been done, consolidating the gains that will have been made, and deciding how best to proceed.

The remainder of this submission is therefore organized around three topics:

How to consolidate and maximize the gains from existing fuel economy mandates;

How to induce fuel-saving behavior through pricing and tax policy; and

How to develop an efficient, effective mechanism for promulgating reasonable future automotive regulations.

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[5] This is not a wholly new set of questions. A number of insiders—notably Saudi oil minister Yamani—have long insisted that U.S. oil companies are systematically underinvesting in high-gasoline-yield refineries to help slow the conversion of utility and industrial boilers off of fuel oil, much of which is not imported.

1. LIVING UP TO EPCA

The bill passed by the Congress in December 1975 did more than establish 1978–1985 model year CAFE requirements. EPCA also mandated conversion of major oil-burning installations to coal; authorized the President to mandate full-tilt production during supply shortages; required a rationing plan; called for a program to recycle used oil products; and created a one billion barrel Strategic Petroleum Reserve (SPR), of which 150 million barrels were to be in recoverable stock by December 1978. Of these, only new car fuel economy requirements have been met.

Even there, however, technical and definitional problems in test procedures have meant that new car's official EPCA mileage figures seldom accurately reflect drivers' actual consumption experience. In recent years, this has led to the public reporting of only the "city" mpg figure as more representative of the mileage drivers can actually expect. More important, it has led to estimate that predictions of future gasoline demand that are unrealistically optimistic. There is, in fact, a developing consensus that EPCA figures are between 2.4 and 4.0 mpg above real experience. Instead of using 364 gallons to travel 10,000 miles, therefore, a car rated at 27.5 mpg for EPCA purposes may really require, say 417 gallons,[6] some 15 percent more. That additional fuel use creates a credibility problem, and that in turn increases cynicism about the effectiveness of public policy.

The UAW sees this shortfall as a proper target for public policy. We supported EPCA believing that 27.5 was 27.5, and we therefore have no objection to using the post-1985 period to close the measurement error gap. That, by the way, would mean about the same thing as leaving the existing measurement methodology alone and setting a new CAFE requirement of 31 mpg. Contrasting that with the 40 mpg mandate proposed for 1995, one finds that the difference in 1985–2005 oil consumption in only 1.8 percent.

2. PLUGGING HOLES IN CONSERVATION POLICY

As we have argued, there are many ways to conserve petroleum; new car mileage requirements are only one. In this section, the UAW would like to call attention to two major and two minor untried policies that make sense to us.

a. Conservationist pricing of motor fuels

The UAW has proposed a two-tier fuel pricing structure called "gasoline" (a lifeline for gasoline), which is included as Attachment I to this statement. It seems to us ridiculous to mandate huge expenditures to improve new cars' mileage from, say, 27.5 to 30 mpg and then sit back and watch much of that 9 percent improvement eaten up by increased driving. If we really want to conserve that last 9 percent of our fuel, why do we sell it for the same price per gallon as the first 9 percent?

This is not, we would note, simply a call for higher gasoline prices on *all* gasoline. That would be conservationist, but also cruelly inequitable. Rather, "gasoline" amounts to a stiff tax on marginal volumes of fuel, with essential—and hence price-inelastic—consumption protected.

b. Conservationist tax treatment of business spending on fuels

Very few Americans know who buys new cars. First, most American families never buy a new car—they can't afford one. (This underlines our earlier point about the need to emphasize maintaining the fuel economy performance of cars as they age.)

Second, over half (57 percent in 1978, the latest year for which we have hard data) of all new U.S.-built cars are purchased in fleets of 4 or more, about half of those in fleets of 10 or more. While these numbers include some cars ordered by retail dealers for lease to individuals, it is still the case that something like half of new American cars are, at least for tax purposes, owned and operated by businesses.

Examination of what cars businesses buy turns up the following startling fact: while fleet buyers are part of the general trend toward smaller cars, they are still much more likely than the market as a whole to buy large cars. Where in 1979 only 54 percent of the new U.S. cars were standards or intermediates, those two segments made up nearly 87 percent of the cars bought by purchasers of fleets of 10 or more.

One big reason for this business/individual split may be that fuel costs are treated differently by the IRS for businesses than for individuals. To wit, as long as spending on fuels can be treated as a business expense like any other, it implicitly is being given a 46 percent subsidy. While it may be argued that fuels compete against

[6] That is, it may only achieve 24 mpg.

similarly-subsidized alternatives, the fact remains that the cost difference between a full-size car and a subcompact is much smaller for a business owner than for an individual owner. A change in the tax treatment of fuels is therefore worthy of serious study by anyone seriously committed to conserving petroleum.

c. Explicit linking of optional features and fuel use

New car buyers should be provided with detailed information regarding the fuel economy penalty—and the resulting cost at a variety of fuel prices—of such auto options as automatic transmission, automatic overdrive, four-wheel drive, limited slip differential, and air conditioning.

d. Subsidization of fuel-related onboard computer capability

The technology now exist to inform drivers of fuel-wasting performance, reanging from the effect of unnecessary racing of the engine to the datum that tire pressure is suboptimal. It would be determined whether or not access to this level of information stimulates significant changes in driving habits and if so the government should consider a subsidy to accelerate the penetration rate on onboard computers on new cars.

This last point raises the more general question of the relationship between technology and fuel conservation. If NHTSA were to announce today its intention to promulgate a 30, or 35, or 40 mpg rule, we would hear tomorrow outcries ranging from "Not stringent enough!" to "It can't be done!" To those of us familiar with both the auto industry's "Official pessimism" and the modern technocrats' antipolitical faith in technical fixes, these responses are simply predictable replies to a thoroughly arbitrary proposals. The task that shoud dominate auto regulators in the next decade is to remove the arbitrariness from standard-setting. Some ideas on how to do that make up the balance of the UAW's submission.

3. TOWARD A RATIONAL PROCEDURE FOR NEW AUTOMOTIVE REGULATION

Since the late 1940s, the UAW has called on the government and the auto makers to work jointly on automotive research and development in both basic and applied research programs.We continue to call for that. We reject outdated laissez-faire objections to inter-company technology-sharing.[7]

More to the point, since 1975 we have called for joint government-industry R, D, & D aimed at providing the public and its representative with better knowledge of production capabilities, in order to provide a basis for more informed and intelligent standard-setting. In the absence of such a procedure, we argued, long lead times were essential to give the industry time to solve— as well as to implement mass-producible solutions to—basic technical problems.

It is quite apparent that our suggestions were not heeded, as rulemaking has continued to be characterized by short lead times, arbitary standards, and interminable debate—all sustained by the apparently endless argument over whether to emphasize "maximum feasible progress" or "economic practicability." We are today little closer to knowing what kind of cars the U.S. auto industry can credibly build by 1990, or 1995, or 2000, than we were in 1975. In the interests of not being able to say that again in 1985, the UAW offers the following proposal.

The U.S. needs a procedure for periodically establishing standards to be met by "demonstration vehicles" (DVs) built by the manufacturers within a specified time period after such standards are established; legislation would not itself set standards for DVs. Such an approach would give the government greater flexibility to respond to new developments, which could be reflected in demonstraion standards rather than requiring hasty enactment of new legislation.

A draft proposal outlinging a specific mechanism for setting demonstration standards is appended to this statement as Attachment II. In general terms, our concept is that regulatory agencies woudl publish standareds for DVs—relating to emissions, fuel economy, safety, etc.—on a known time schedule. Comments would be solicited, again on a set timetable, resulting in final agency proposals.

At that point, a new body—a "Board" composed of auto regulators and scientists/engineers—would, within a fixed period, evaluate agency proposals. Having done so, it would forward to the Congress its recommendations for new demonstration standards, which would take effect unless specifically disapproved.

The key to this proposal, of course, is the concept of a DV. To be a useful proxy for a future mass market car, it has to be mass-producible in a way that a "prototype" need not be. If the DV concept is valid, as we believe it is, our proposal could be built into either Title III of S. 2015 or Sec. 102 of H.R. 4707. In either case, a

[7] Six European auto makers have recently announced plans to pool technological know-how as a defense against the expected onslaught by U.S. and Japanese producers.

special group (or "Board," "Research Center") would be charged with some or all of the duties of the "Board" as outlined above.

It is our hope that automotive standard-setting can be made a more rational process. The record to date is impressive in many respects—large improvements in fuel economy, big declines in mobile-source emissions, and some progress in occupant safety—but it is also long on dislocation and capital absorption. In the rush to comply with ad hoc standards, the industry has often introduced new technologies as mere add-ons to existing engines and other major components, with basic component research and design suffering relative stagnation.

In addition, the "bank starts" for new models resulting from short lead times may also be carrying quality costs, as recent recall data—which show a strong link between newness of nameplate and frequency of recall—suggest.

As always, the UAW stands ready to work with any individual or group committed to the development of a more rational automobile sector and a more rational economy. We urge this committee to use the coming period to move toward greater regulatory rationality, rather than charging blindly ahead in the hope that more of the same will save the day.

Appendix I.—UAW Statement in Response to U.S. DOE Request for Comment on Changes in Retail Gasoline Price Regulations (Docket No. ERA-R-7932)

To: Office of Public Hearings Management, U.S. Department of Energy, 2000 M Street, N.W., Room 2313, Washington, DC 20461.

The United Auto Workers Union urges that the DOE reevaluation of the current system of retail-level gasoline price controls avoid an exclusive emphasis on the size and form of gasoline retailers' profit margins. Rather, policy-making must begin from the basic question of how retail prices should be set. The answer must, of course, speak to the needs of retailers; but it must also take into account such issues as affordability, the price-availability connection, and the impact of gasoline prices on the distribution of income and mobility.

In this brief statement, the UAW will set out what we believe is an effective, equitable approach to gasoline retail pricing. We will not treat every detail of our approach at this time, but if the Department is interested, we will be pleased to provide further elaboration. Note particularly that this proposal is (as indicated in point 4 below) compatible with a variety of methods of determining retail dealer profit margins.

We want to emphasize at the outset, that, while this proposal uses a mechanism similar in some ways to "white market rationing," it is not a rationing proposal.

We call our proposal "gasline," a combination of the words "gasline" and—from the field of electric and natural gas utility rate structure—"lifeline." Gasline consists of a two-tiered retail pricing system for gasoline, with a volume-regulated lower tier price and a higher upper tier price. The volume to which the lower tier price would apply is a political decision, albeit one informed by estimates of the share of demand needed for essential—and hence price-inelastic—uses. The remaining volume would be priced at a level which reflects overall goals of conservation, fair return to retailers and producers, etc. A general outline of our proposal composes the remainder of our submission.

1. Each individual over age 16, or alternatively each licensed driver, would be entitled to buy gasoline stamps. Issuance could be through banks or post offices.

2. Stamps would permit the purchase of the specified volume at a predetermined lower tier price per gallon. (That price might be increased over time. Other details and refinements might include setting the price pre-tax to allow for state and local tax differentials; maintaining leaded-unleaded differentials to discourage owner tampering; etc.)

3. There would not be any limit on how much gasoline people could buy; again, this not rationing. The stamps simply allow a certain amount to be purchased at a reasonable price; any additional amount could be purchased at the upper tier price. Thus, while sale of unneeded stamps on a white market could be permitted, there is less need for that (and less incentive for buyers to go to the trouble of finding sellers) than under a rationing program.

4. The gasoline retailer would use the stamps to pay the wholesaler a specified price for the corresponding number of gallons. Of course, that wholesale price would be somewhat less than the consumer paid with the stamps, so that the retailer would have some markup (for expenses and profit) on gas sold with stamps, just as on other gas.

5. There would be a "clearinghouse" operation, so that any wholesaler that collects a disproportionate number of stamps (too many or too few)—and hence a

disproportionate share of sales at the lower tier gasline price—would receive (pay) an equitable adjustment.

Obviously, this proposal would not be simple to administer. However, there is no running away from the real issue in retail gasoline pricing: whether to achieve conservation by having everyone pay a high price for all of their gas, or whether to protect people's access to essential amounts of fuel while achieving the same (or a higher) level of conservation.

Since the underlying problem dealt with here is inextricably related to the price of oil, a similar two-tiered pricing mechanism should be established for heating oil.

As stated above, we would be pleased to elaborate on our proposal.

Sincerely,

HOWARD YOUNG,
Special Consultant to the President,
International Union, UAW.

APPENDIX II.—UAW DRAFT PROPOSAL: DEMONSTRATION STANDARDS

1. As of June 30 of each calendar year, a regulatory agency (referred to as "the Agency") would publish its proposed demonstration standards (as noted below, the intent is to have such standards demonstrated within 30 months of such initial publication). Such standards might deal with emissions, fuel efficiency, safety, or other auto-related matters. The standards might vary by weight class or be innovative in other ways.

2. Simultaneously with such publication, the Agency would furnish background material indicating the basis for the proposed DV standards.

3. During a specified period (e.g., two months, i.e., by August 31), the Agency would accept formal comments regarding the proposed standards. Such comments could support or oppose the standards, and could suggest any modification of the standards (to be more or less restrictive). Obviously, during some calendar years, the Agency may choose not to suggest any new standards; if so, that fact is to be published, and comments (which might still recommend some standards) would be accepted.

4. During a subsequent period (e.g., two months, i.e., October 31), the Agency would evaluate the comments and publish its final proposal (which might or might not modify its initial proposal; it is possible that at this point the Agency might decide to propose that no new demonstration be required).

5. A new super-agency, such as the one that would be created by H.R. 4707, would function as a "Board of Directors" for auto regulations (hereafter, "the Board"), staffed by equal numbers of representatives of auto-related regulatory bodies (such as NHTSA and EPA) and of scientific-technical bodies (such as NSF, OTA, and OST). The Board would have a fixed period (e.g., two months, i.e., by December 31) to make its evaluation of the final proposal by the Agency. During that period, it could—but would not be required to—hold hearings or follow other appropriate procedures to obtain any additional desired input.

6. At the expiration of the above porocedures (i.e., by January 1 of the next calendar year), the Board would forward to the appropriate House and Senate Committees (if more than one standing committee in a House is involved, an ad hoc committee made up of members of each standing committee would be set up) the Agency proposal, along with its own recommendation. The Board's recommendation could endorse the Agency proposal, propose modified standards, or propose that no new DV standards be required.

7. During a subsequent specified period (e.g., three months, i.e., by March 31), the committee in each House could react to the Board report in any of the following ways:

(a) it could take no action in which case the Board's proposal would go into effect; or

(b) it could disapprove the Board's recommendation (no further action could be taken if it does not disapprove at this point).

If either committee disapproves the Board recommendation, then it would not go into effect (alternatively, the Board recommendation would go into effect unless both committees disapprove it).

The intent is to have a procedure that uniquely determines what standards, if any, are to go into effect whether or not the committees act by their deadline (e.g., March 31). No other Congressional, or Presidential, action is contemplated. Of course, such action could be taken and would be appropriate if it was felt that standards other than those suggested by the Board or the Agency should be demonstrated.

By the second following year-end (i.e., 30 months after the initial Agency proposal and 21 months after the deadline for Congressional reaction), each auto manufactur-

er would have to build a limited number of demonstration vehicles that meet the standards. These DVs would become the basis for standards covering mass-produced vehicles.

Senator STEVENSON. That concludes the hearing. We will reconvene on Wednesday morning at 9:30. The subcommittee is adjourned until then.

[Whereupon, at 12:40 p.m., the hearing was adjourned.]

AUTOMOTIVE TECHNOLOGY AND FUEL ECONOMY STANDARDS

WEDNESDAY, MAY 14, 1980

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D. C.

The subcommittee met at 9:37 a.m. in room 235, Russell Senate Office Building, Hon. Adlai Stevenson (chairman of the subcommittee) presiding.

Senator STEVENSON. This morning the subcommittee continues its hearing on automotive fuel economy standards.

Our first witness is Mr. Richard Shackson, assistant director of transportation, Energy Productivity Center of the Mellon Institute.

I will invite him and all our witnesses, if they can, to summarize their statements, in which case the full statements will be entered in the record.

STATEMENT OF RICHARD H. SHACKSON, DIRECTOR OF TRANSPORTATION, ENERGY PRODUCTIVITY CENTER, MELLON INSTITUTE; ACCOMPANIED BY JAMES LEACH, SENIOR TRANSPORTATION ANALYST

Mr. SHACKSON. Mr. Chairman, I am Richard Shackson, director of transportation programs for the Energy Productivity Center of the Mellon Institute. I am accompanied by James Leach, senior transportation analyst.

My testimony today is based on the findings of a study which we are conducting at Mellon to estimate the costs and benefits of two strategies for maintaining the viability of the Nation's automotive transportation system: The production of synthetic fuels and the continued improvement of automobile and light truck fuel economy.

I'd like to first summarize several relevant findings, and then speak to the direct questions which you asked in your invitation.

From the outset it should be noted that a number of things will influence future average fuel economy: One, technological feasibility; two, economic feasibility; three, the cost to the consumer—not only in terms of cost-effectiveness but in terms of needed price increases which can reduce volume and profitability; and finally, four, the willingness of the consumer to accept performance and utility compromises which are essential for substantially higher CAFE's.

Turning first to the question of technical feasibility, we have limited our study to known technologies, and we have assumed that these technologies would be implemented as rapidly as they

become available, constrained only by the ability of the supply and construction industries to provide the necessary facilities and tooling.

Based on these assumptions, we estimate that a CAFE of 40 to 45 miles per gallon is technologically feasible by the midnineties and, if technologies such as the ceramic gas turbine are brought to commercialization, the CAFE could exceed 50 miles per gallon by the end of the century. This improvement would be accompanied by a decrease in utility. For example, the four-passenger subcompact share would double, and the average weight of this class of car would decrease from 2,500 to 1,700 pounds.

This fuel economy improvement, when accompanied by a proportionate program for light trucks, could yield a reduction in fuel consumption of 3.5 million barrels per day in 1995 and over 4 million in 2000. We estimate synfuel production, similarly constrained by technological availability and construction capacity, at 1.5 million barrels per day in 1995 and 2.4 million barrels per day in 2000.

Each of these two strategies would require a cumulative capital investment of about $100 billion, 1980 dollars, over the next 20 years, but the investment streams are quite different. In the case of synfuels, the annual investment increases smoothly from zero to about $5 billion and remains at this level throughout most of the period. Fuel economy improvement, however, would require major investments on the order of $10 billion per year—for the next several years, in addition to the investment normally required by the auto industry for other than fuel economy related programs.

From the consumer's standpoint, both strategies appear cost-effective over the next 15 years if we assume that petroleum-based gasoline will approach $2.50 per gallon. We estimate that the weighted average price of the most likely mix of synfuels will be $1.50 to $2 per gallon—that is 1980 dollars, excluding tax—depending on the method used for financing the production facilities. The price of specific fuels ranges from $1 to $4.

On a comparable basis—cost per gallon saved—the marginal consumer cost of fuel economy improvement is estimated at about $0.50 per gallon this year, at 20 miles per gallon, increasing to nearly $4 per gallon by the year 2000, at about 50 miles per gallon.[1]

When discussing cost-effectiveness it is important not to lose sight of the significance of absolute increases in car price due to fuel economy improvement, which we estimate at $100 to $250 per car per year, again in 1980 dollars. While our study makes the simplifying assumption that the more efficient cars can be sold at this higher price, any negative impact on sales will reduce revenues and inhibit the ability of the manufacturer to continue future product improvement

Turning now to the first of your specific questions: the optimal fuel economy for the decade of the nineties. From the standpoint of technological feasibility, consumer cost, and consumer utility, a fleet average of 40 miles per gallon could be justified. Above 40

[1] This cost is computed by dividing the incremental consumer cost of fuel economy improvement in a given model year by the discounted lifetime fuel savings of that model year versus the prior model year.

miles per gallon the cost of fuel economy improvement is no longer competitive with synfuels or with the expected price of petroleum. The critical issue, however, is capital. Without a change in the capital formation climate, it is doubtful that 40 miles per gallon can be achieved at this time schedule—standards or no standards.

With regard to your second question: the role of electric vehicles; such vehicles were excluded from the first phase of our study. For the current phase we have added a "city car" class which includes electrics, hybrids, and small, high-miles-per-gallon vehicles propelled by internal combustion engines. This class will be permitted to compete with the other classes for market share on the basis of price and specific characteristics, but we don't yet have an estimate of the success of this competition.

Your next question concerns the level of capital investment necessary to achieve 40 miles per gallon. We estimate that $60 to $65 billion in 1980 dollars would be required for passenger cars alone, and $70 to $75 billion if a proportionate effort is included for light trucks. If this investment is added to that required for purposes other than fuel economy improvement, the total auto industry investment would increase to $100 to $110 billion, 1980 dollars, more than one-half of which would be required in the next 5 years.

Question 4 asks whether 40 miles per gallon will be achieved as a result of market forces in the absence of standards. Our cost estimates suggest that if gasoline price is permitted to rise to the $2 to $2.50 level, rational consumers will be demanding 40-mile-per-gallon cars in the midnineties, and I am certain that the auto industry will attempt to meet this demand. Their ability to do so will not be enhanced by the presence of a standard—indeed, it may be hindered. It can be argued that if relieved of the necessity of meeting an average standard, the domestic manufacturers could concentrate their capital resources on small cars—improving the Nation's international competitive position and better meeting the demands of the market of the 1990's.

Your final question was whether a federally supported program of basic research such as that proposed in S. 2015 would be necessary and sufficient to achieve these results. I believe in federally supported basic research. It is one of the things which Government does well, and is vital to the continued health of our scientific and technological enterprises. It is not, however, particularly relevant to 1995 fuel economy—which will be achieved through applied research and development of technologies already well known today. A program of basic research in thermodynamics, materials, lubrication, and related sciences could be expected to lead to new technological options for commercial applications 20 years from now, but such a program is neither necessary nor sufficient to achieve increased fuel economy in the early 1990's.

What is necessary, and what would be sufficient if fuel price is permitted to rise, is a major change in the climate for capital formation and capital recovery for the auto manufacturers and their supporting industries. Tax incentives such as those proposed in S. 2015 are a step in the right direction, but what is needed is an integrated look at the overall system of fuel supply and fuel economy, with the objective of rationalizing Federal policy on the basis of costs and benefits of both. There is great potential in the auto

industry, and with the right incentives it could attract, from the private sector, the capital it needs.

That concludes my prepared statement, Mr. Chairman. I'd be happy to respond to questions.

Senator STEVENSON. Thank you, Mr. Shackson.

Are you suggesting that a 40-mile-per-gallon standard by 1995, as Senator Jackson proposes, is not necessary, or is undesirable or, to be realistic, requires something more, like some incentives to capital formation?

Mr. SHACKSON. My conclusion is that, absent some change in the ability of the producing industries to acquire capital, the presence of a standard will not enable the accomplishment of the 40-mile-per-gallon average, and that the probable expected price of petroleum should lead to a demand for fuel economy in the 40-mile-per-gallon range so that a standard is not necessary.

I believe, though, that without some change in capital formation climate, a standard would be counterproductive.

Senator STEVENSON. What was the last thing?

Mr. SHACKSON. Let me restate the last point.

My view is that the consumers will be demanding 40-miles-per-gallon cars in large numbers in the midnineties, given the probable price of fuel, and therefore a standard is unnecessary. The attempt to accomplish the 40-miles-per-gallon level by promulgating the standard would not accomplish the objective and probably would result in continued failures within the auto industry.

Senator STEVENSON. Why would it hinder the industry?

Mr. SHACKSON. By 1985, the fleet will have gone through one and in some cases two down-sizing steps, and the so-called large cars will be achieving on the order of 20 miles per gallon.

In the presence of a standard, because of the effect of the harmonic averaging, the industry would be required to invest substantial capital in further improvement of that large segment of the fleet or abandon it. Absent a standard, the capital could be invested in the small cars, and the 20 miles per gallon, or thereabouts, large cars prevalent in 1985 could continue to be offered for those who chose to purchase them and drive fewer miles under the influence of higher fuel prices.

So the major portion of capital investment could be applied to the small car, which would improve the competitive position of the industry vis-a-vis imports.

Senator STEVENSON. Even with some optimistic assumptions, namely, that the world's financial system will not have collapsed or the fuel supply be interdicted and the world be suffering a depression well before 1995, won't the consumer be looking for something that produces better than 40 miles per gallon by 1995? He can get that now from Volkswagen.

Mr. SHACKSON. Mr. Chairman, I think it depends a lot on what it costs. I think we tend to stress cost-effectiveness as a consumer decision criterion, and it certainly is important, but particularly in depressed economic conditions, if that improved fuel economy results in a substantial premium in car price, there is going to be some consumer resistance to purchase, or consumer inability to purchase.

We estimate, as I have pointed out, I believe, in the testimony, an increment of about $100 to $250 a year of added consumer cost in order to maintain the pace of fuel economy improvement which we believe is technologically feasible. I don't think any of us is able to estimate the extent to which that increased cost, when it is pervasive throughout the fleet, is going to cause consumers to delay or forego purchase.

One consequence could be an increase in the prevalence of leasing as a way of overcoming the initial capital investment, and I would consider that highly desirable. But I believe that the unknown is the extent to which this price increment in terms of initial price is going to be a deterrent in terms of purchase. The option to hold onto the old car is still there.

Senator STEVENSON. It won't be a deterrent for the cars which already achieve 40 miles per gallon, will it?

Mr. SHACKSON. No; that is correct, it won't. But given the existence of a standard, that price will clearly be reflected in all of the other cars which have been improved in order to maintain the average required.

Senator STEVENSON. What I am suggesting is that you are, I think, speaking about a price increment for the American manufacturers of cars, and I am trying to suggest that if that estimate is accurate, the United States would be at a growing disadvantage, assuming no trade barriers, against the foreign manufacturers of cars which either come close to or already achieve 40 miles per gallon like the Volkswagen.

Mr. SHACKSON. Except that the Volkswagen Rabbit already carries a premium price which is comparable to the price premium that we are talking about for achieving the same mileage. And I think that what one has to recognize is that the Volkswagen diesel Rabbit is not being purchased by every consumer. It is appealing to a group of consumers who have the extra capital to make that initial payment.

Senator STEVENSON. But if I understood you, though, you said the price increments would be greater for the American manufacturers than, in this case, Volkswagen.

Mr. SHACKSON. No; the price increment per mile per gallon is going to be the same for everybody. Obviously, if you are already at 40 miles per gallon with a vehicle you have zero increment required to get there. But that increment is already, in most cases, seen in the premium price which is paid for that car today.

Senator STEVENSON. Well, is that the explanation? With respect to Volkswagen imports, you are paying a premium because of the current exchange rates, the dollar against the deutsche mark. For domestic manufacture of Volkswagens, what is the explanation? Are you suggesting they charge whatever the market will bear, demanding a premium for an energy-efficient automobile?

Mr. SHACKSON. It is obviously partly market-motivated pricing. You see similar premiums on domestically produced diesels. But it also reflects an inherent cost content in the more expensive technology.

Senator STEVENSON. Are you familiar with the new European cooperative effort to develop basic automotive technology, a cooper-

ative for basic research for the development of automotive technology?

Mr. SHACKSON. Yes, sir.

Senator STEVENSON. Will you tell me a little about that.

Mr. SHACKSON. Well, it is a program which, first of all, involves a level of cooperation between the manufacturers and Government which we haven't yet achieved here.

It is significant that, therefore, it is not constrained by any concerns of antitrust or other prohibitions against sharing of research results by competing manufacturers, which tends to be a problem here once research goes beyond the basic stage.

Senator STEVENSON. I thought they were not going—I don't know quite where you draw the line here, but on paper, at least, it stops at basic research, doesn't it? It stops short of product development, at least.

Mr. SHACKSON. It stops short of product development. A number of the programs that I have heard discussed as part of the operation tend to be verging on the applied research. In other words, one can identify clear product applications. And it is a hazy line. I think it is an excellent program.

Senator STEVENSON. How much money are they putting into it?

Mr. SHACKSON. I am not certain, Mr. Chairman.

Senator STEVENSON. I think we are going to have to take a closer look at that.

Do you have any suggestions as to how the Congress could help overcome the capital formation problems in this industry? So far the Congress has jumped in to divert $3 billion out of the marketplace to Chrysler, which is not likely to be very helpful to Ford, and no thought has been given on how we should respond to the particular critical problems of this large industry. Do you have any suggestions?

Mr. SHACKSON. We haven't reached the stage of detailed proposals, but I have some ideas I could offer.

In the first place, I think it would be a mistake to try to do it with Government money. I think there is the ability to attract private capital. And perhaps a key would be to look at the things that have been done to attract private capital to risky ventures in energy development, in energy exploration.

I think, for example, if I could invest in tooling for fuel-efficient cars and achieve the same tax treatment that I receive for investments in an oil limited partnership, I might find investment in automotive tooling to be attractive to me.

Certainly an energy tax credit for the purchasers of fuel-efficient cars seems to make sense. There are the obvious problems of how one treats an import under those conditions, but it is still worth study.

Perhaps a little further out, but still along the lines of the concept of regarding fuel economy improvement and fuel production as parallel and interchangeable paths, would be one which stems from the recognition that an oil company which is looking for increased capacity has the option to invest $40,000 or $50,000 to get one barrel per day of capacity in synfuels. By investing half that, $20,000 or $30,000, it can achieve a barrel per day of capacity

through auto fuel economy improvement. The only catch is how does the oil company participate in the revenues which accrue?

One possibility would be a leasing program in which I could go to my local gasoline station and lease cars on a cost-per-mile basis, in which the oil company would have the incentive to reduce both fuel consumption and fuel cost and could apply its capital resources proportionately to reduce its cost and therefore maximize its profits.

I feel that concepts of that nature are certainly worth investigating, and they are only recognized if one looks at supply and fuel economy improvement in a similar light.

Senator STEVENSON. Thank you very much.

Our next witness is Dr. Merton C. Flemings, director, Materials Processing Center, Massachusetts Institute of Technology.

STATEMENT OF DR. MERTON C. FLEMINGS, DIRECTOR, MATERIALS PROCESSING CENTER, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. FLEMINGS. Thank you. My abbreviated remarks this morning will be on the relation between materials and fuel economy and on materials research and development needed to achieve the potential fuel economies, and on the important question of materials availability.

In 1985 we will achieve a 27.5-miles-per-gallon fleet fuel economy average through a combination of factors, including weight reduction from downsizing, light weight substitution, engine design, and reduction of friction. Weight reduction between now and 1985 will be on the order of 600 pounds, to be achieved in large part by substitution of aluminum, plastics, and high-strength steel for cast irons and carbon steel. A recent GAO report, dated February 5, summarizes and details these weight reductions.

Further weight reduction is a major potential means of achieving significant additional improvements in fuel economy in the time period beyond 1985, with or without additional downsizing. Weight reductions are possible from substitutions of new or improved materials. One example shows substitution of 100 additional pounds of aluminum in a car would result in an overall weight savings of 55 pounds. An equivalent amount of magnesium would result in a savings of 75 pounds in weight.

The question is sometimes asked: Can substitution of materials such as aluminum, magnesium, and composites result in life-cycle energy savings even though they require much more energy to produce than does, for example, cast iron? The answer is, yes. Many different calculations have been made which demonstrate this. The bottom line is that energy savings from increased gas mileage far outweigh the increased energy cost of producing the primary material.

So why are these newer, high-strength, lightweight materials not used to a greater extent today than they now are? And what will limit their utilization in the future?

The answers are—some of them:

First, material availability and availability of adequate and economic production capacity.

Second, the existence of processes to produce, fabricate, and recycle materials economically and reliably.

Third, the state of technological development of the material.

Fourth, the availability of technological information on design and fabrication of the material.

And, last, experience in design, use, and repair of the materials.

These factors reflect themselves directly in the marketplace as excessive cost, inadequate reliability, or uncertain availability of the material or finished part.

A coherent national materials policy would do much to focus the Nation's attention and resources on critical stumbling blocks in the above list. In the context of this bill and its amendments, I will focus my remarks on two important aspects—research recommendations and the question of materials availability.

Materials research in this country has for years emphasized new and exotic materials for the aerospace, electronics, and other industries, with little orientation to the needs of basic industries such as ground transportation. The part of the materials field which it is now critical to fund is that part we now call materials processing. It is the engineering field that is concerned with control of structure, shape, and properties of materials, and with doing so in a cost-effective way with acceptable social costs. This is a field which has been underfunded and underemphasized for decades. It is through advances in this field that the economic lightweight automobile must come.

Basic directed research and development in this area in universities and industry is essential, and a major effort should be undertaken to increase the number of skilled technologists in the field. As the National Research Council's 5-year outlook for science and technology has stated, there is a near absence in our universities of research in materials processing and manufacturing technology.

My more extended report lists a number of potential specific areas of payoff in the materials processing area.

But the point for this meeting is that the Planned Basic Automotive Research program of title III of S. 2015 can be an enormously potent positive force in helping promote research of the type needed to achieve an economic, lighter weight automobile, in addition, of course, to promoting the education and training once again of young men and women with the tools and ability and interest in working in the basic production industries such as the automotive industry.

On the question of materials availability, material availability, as an issue, is fundamentally as critical to the United States as energy availability. The changing mix of materials required to construct the lightweight energy-efficient vehicles of the future will severely test the ability of this country, and its materials industries, to accommodate radical change in materials consumption patterns. While we are all well aware of the problems facing the steel industry, with respect to foreign competition and reduced automotive demand for ferrous products, existing problems in other materials sectors are less well understood. The recent GAO report dated February 5 discusses some of the materials supply and economic disruptions that could result from these changing consumption patterns.

The energy, natural resources, environmental, and economic consequences of the expanded use of particular lightweight materials

are not well understood. Planning and public policy at the national level is needed to establish the tradeoffs between the social objectives of energy conservation, environmental protection, and optimal domestic resource utilization, on the one hand, and the automotive industry's cost, weight, and performance criteria on the other.

Two very brief examples. One is the case of magnesium, the lightest commercially available structural material. This metal represents a unique opportunity to simultaneously use a domestically available alternative resource and to minimize imports of competing raw materials, and energy. However, at this time magnesium is used only sparingly in automobiles and is only marginally competitive with the other materials on a price basis. Current studies indicate that magnesium could and will find a major niche in the automotive industry, provided appropriate technical development is carried out and appropriate plant investment undertaken.

Another example of this problem of materials availability is that of the shift of the aluminum industry to offshore capacity. Currently the trend in the price and availability of domestic energy, a major cost factor in aluminum production, is forcing U.S. producers to expand offshore.

If, for example, all future primary aluminum production capacity is also shifted offshore, the annual cost of imported aluminum could exceed $10 billion by the end of this century. And the possibility, therefore, exists, as pointed out in the recent GAO report, that the energy savings which result from enhanced utilization of aluminum in the automobile could be negated by a very large balance in payment deficit.

The foregoing few examples serve to illustrate that a national materials policy is needed which would consider the critical materials needs of the Nation in our evolving industrial economy. We should, through policies based on quantitative materials and energy systems analysis, focus our resources, both human and natural, on solving primary materials production, supply, and productivity problems.

The Materials Policy Research and Development Act of 1979 recently passed by the House, H.R. 2743, and now under consideration by this committee constitutes a significant step toward meeting this need.

And finally, in connection with this bill, materials policy studies should be viewed as a vital concomitant, and perhaps predecessor to, any major legislation likely to result in perturbations or further perturbations to materials utilization, such as the proposed mandated CAFE standards contained in amendment No. 1664 to the bill under consideration.

Thank you.

Senator STEVENSON. Thank you, sir.

We have had about as many materials policies studies as we have had administrations since Herbert Hoover. We have been holding hearings on materials policy for as long as I have been chairman of this subcommittee, perhaps longer than that, and nothing ever happens. It is like energy. That is the real crisis, the real shortage—leadership.

You imply some support for title III, but you also imply or recognize that a sensible materials policy is critical for many purposes, of which the automobile or automotive fuel efficiency is just one.

How would a basic research effort on materials, including materials processing, supported by the Government, be optimally structured? Do we push it into automotive research and stick it in the Department of Transportation? Or would it be wiser to create a new agency or to use the innovation centers that we are proposing—I don't know if you are familiar with that measure—or NASA which has some history in research and development, unlike the Department of Transportation.

What would be the optimal way of structuring such research?

Dr. FLEMINGS. I can, of course, only give a personal view on this matter. My own preference is to have primary funding through an agency such as DOT, with heavy emphasis on university research as opposed, for example, to funding through a mechanism such as these innovative centers being proposed in a separate bill.

I think that research in universities has a twofold function. One is to do the research, and the second is to train the people. I think one of the great problems in industry—as you see here, my ideas go beyond the automotive industry. I think one of the basic problems with several of our industries, including the metal working industries, is that the exotic industries and Government activities over the last 20 years have drained away much of our best engineering talent and raised the salaries of those left so that the basic industries either were unable to attract many of these people or felt unwilling to compete for them.

And I see this bill being pointed directly toward automotive applications coming through an agency such as DOT to universities. I see it being an excellent training ground for young people to prepare them for work in basic industry.

Second, we do not have in this country a history of successful, independent, innovative centers as some foreign countries do. At the same time, our universities in this country have a much more successful track record in performing not only basic research but what we might call basic directed research, if you will, than do the universities in many foreign countries. And I, therefore, see them as a resource that many foreign countries do not have of performing useful and successful research across the spectrum from basic to approaching applied research.

Senator STEVENSON. But we expect the innovation centers to be located at and managed by universities—they have to be—by universities or other not-for-profit organizations. Why wouldn't that formula lend itself to precisely what you envisage?

Dr. FLEMINGS. Are we talking about innovative centers emanating from Jordan Baruch's activities?

Senator STEVENSON. No, from this committee's——

Dr. FLEMINGS. If you have centers arising from this committee that are to be managed by universities, I was not aware of that, and I think it is marvelous. I think some of the innovative centers that I have heard about in other areas to be formed by what would seem to be more or less ad hoc grouping are less likely to succeed than the type you seem to be considering.

Senator STEVENSON. Well, we will give you a copy of the report which gets filed tomorrow, I think, and maybe if you have had a chance to look at it, if you have any further thoughts as to how the kind of innovation centers contemplated by it would lend themselves to this effort on materials we'd be glad to do that.

Dr. FLEMINGS. Very good; I would appreciate that.

Senator STEVENSON. There is a model there that I think should be considered in this context.

Now, there is another model which has been suggested for basic research, and that would make NASA the Government agency for the lead in this effort, with, of course, much of the research contracted out. NASA has had good industry relations. It has also in some instances had, I think, good university relations. That agency, unlike DOT, also has a long, strong track record in basic research. It already is conducting a substantial amount of work on automotive technology, and its mission is research as opposed to the regulation of transportation. In other words, research might be less likely to be influenced or guided by a variety of ulterior policy considerations or responsibilities of that agency.

How would you feel about putting responsibility for automotive technology, including materials policy, in NASA?

Dr. FLEMINGS. Well, those are two different questions, the materials policy being much more broad.

Senator STEVENSON. That is the problem I am having in my mind. These are hearings on automotive technology, and I am not quite sure where you do draw the line. Title III, which you supported as a means of getting into materials policy, is on automotive technology. I don't know which comes first. I guess materials policy is a little more basic than automotive-type technology. But if I understood you correctly, you are supporting title III, which is automotive technology as a means of supporting materials policy.

Dr. FLEMINGS. I meant to express support for two separate things. I meant to support title III, which I understand to be the basic automotive technological research program. I meant to express in both my written and oral version strong support for that.

I further meant beyond that to indicate that certainly as a concomitant to any such major thing as extension of fuel standards, I felt that this was one example of the need to undertake broader materials policy studies.

Or to put that a different way, I felt as a separate item that materials policy studies, such as are contained in a separate bill and not the subject of today's discussion—but that broad materials policy studies should be taken certainly before any further automobile or CAFE standards are imposed.

Senator STEVENSON. Are you familiar with efforts in Europe or Japan to conduct research on materials? The Japanese strategy for the 1980's has some emphasis on materials research, does it not?

Dr. FLEMINGS. I am not familiar with that.

Senator STEVENSON. How long would it take, and to what level of magnitude, for the comprehensive assessment of alternative materials, which I think you contemplate to come before standards.

Dr. FLEMINGS. I think some 3 to 4 years would provide us with much of the information we need. I think there should be an ongoing continuing effort, but I think some 3 to 4 years of exten-

sive policy studies would provide us with much information we do not have now.

In the dollar level I have not thought a great deal, but in the $10 to $20 million range perhaps for that narrow focus. I think for the broader materials policy questions we are talking something larger and certainly longer than that. But I pointed my answer there to the specific automobile issues, such as aluminum, magnesium, and so forth.

Senator STEVENSON. Why is there a near absence of research on materials processing in the universities? It is appalling.

Dr. FLEMINGS. It is appalling. And as I say, it was a major topic in that recent science study.

The answer, most simply, is that in the 1960's, with the arrival of *Sputnik* and with the emphasis on science in American universities, the work in fields such as materials, and specifically including materials, become much broader and much, much more fundamental, much more scientific. Not all of that was bad; much of it was good. But what it meant was that places like MIT and engineering institutions all over the country, and including not only teaching and laboratory work but basic research work as well in important areas, such as steelmaking or foundry or casting or polymerics—these things went by the board for more exciting, more apparently sophisticated work on atomic structure, for example, to pick a simple example.

We are now, I might say, swinging back toward important work in areas such as materials processing, but we have much further to go.

Senator STEVENSON. Thank you very much.

Dr. FLEMINGS. Thank you.

[The statement follows:]

STATEMENT OF DR. MERTON C. FLEMINGS, FORD PROFESSOR OF ENGINEERING, DIRECTOR, MATERIALS PROCESSING CENTER, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

My remarks will provide some background for the proposed Title IV of S. 2015 and amendments thereto extending provisions of the automotive fuel economy program to the decade beyond 1985. They particularly relate to: (1) The relation between materials and fuel economy, (2) materials research and development needed to achieve the potential fuel economies, and (3) the vitally important question of materials availability.

MATERIALS AND FUEL ECONOMY

In 1985 we will achieve a 27.5 mpg fleet fuel economy average through a combination of factors including weight reduction from downsizing, light weight substitution, engine design, and reduction of friction. Weight reduction between now an 1985 will be on the order of 600 pounds, to be achieved in large part by substitution of aluminum, plastics, and high strength steel for cast irons and carbon steel. A recent GAO report dated February 5[1] summarizes and details these weight reductions.

Further weight reduction is a major potential means of achieving significant additional improvements in fuel economy in the time period beyond 1985, with or without additional downsizing. If consumer preference permits additional downsizing, and materials and processes are available, economy of manufacture for a given mpg can be signficantly improved. It is cheaper in the long run to build small cars of a given weight and fuel economy than to build larger cars of the same weight and fuel economy.

[1] Policy Conflict—Energy, Environmental, and Materials: Automotive Fuel-Economy Standards' Implications for Materials, Report to the Congress of the United States, prepared by the U.S. General Accounting Office, EMD-80-22, Feb. 5, 1980.

How will weight reductions in the time period beyond 1985 be achieved? Primarily by substitution of new or improved materials. One calculation shows, for example, that substitution of 100 additional pounds of aluminum in a car would result in an overall weight savings of 55 pounds. An equivalent amount of magnesium would result in a savings of 75 pounds in weight.

The question is sometimes asked: Can substitution of materials such a aluminum, magnesium, and composites results in life cycle energy savings even through they require much more energy to produce than does, for example, cast iron? The answer is "yes". Many different calculations have been made which demonstrate this. The "bottom line" is that energy savings from increased gas mileage far outweigh the increased energy cost of producing the primary material.

For example, one calculation has shown that, over the lifetime of a car, substitution of one pound of magnesium from cast iron could result in a net energy saving of as much as 7 gallons of gasoline—assuming appropriate redesign. Thus, if 100 pounds of magnesium were to replace an equivalent weight of ferrous components in each of 112 million automobiles currently in use, approximately 8.2 billion gallons of gasoline would be conserved annually. This is equivalent to 7.0 percent of total annual U.S. gasoline consumption, 2.8 percent of total U.S. oil consumption, and 5.8 percent of total annual U.S. petroleum imports.

The resulting overall savings in energy consumption to be obtained by achieving sufficient weight reduction to attain a 40 mpg automobile are readly calculated. They are enormous. For example, assuming 112 million cars are in operation, driving an annual 12,500 miles per vehicle, the saving (as compared with a 27.5 mpg fleet) is 13 billion gallons of gasoline per year, 12 percent of current total oil consumption, and 37 percent of total U.S. petroleum imports (in 1977).

WHAT IS NEEDED

Why, are these newer, high strength light weight materials not used to greater extent today than they now are? What will limit their utilizaiton in the future? The answers are:

Material availability, and availability of adequate and economic production capacity;

Existence of processes to produce, fabricate, and recycle materials economically and reliably;

State of technological development of the material;

Availability of technological information on design, and fabrication of the material; and

Experience in design, use and repair of the materials.

These factors reflect themselves directly in the marketplace as excessive cost, inadequate reliability, or uncertain availability of the material or finished part.

A coherent National Materials Policy would do much to focus the nation's attention and resources on critical stumbling blocks in the above list. In the context of this bill and its amendments, I will focus my remarks on two important aspects—research recommendtions and the question of materials availability.

RESEARCH RECOMMENDATION

Material research in this country has for years emphasized new and exotic materials for the aerospace, electronics, and other industries, with little orientation to the needs of basic industries such as ground transportation. The part of the material held which it is now critical to fund, is that part we people have come to call "Materials Processing". It is the engineering field that is concerned with control of structure, shape, and properties of materials, and with doing so in a cost effective way with acceptable social costs. This is a field which has been underfunded and underemphasized for decades. It is through advances in this field and the economic light weight automobile must come. Basic directed research and development in this area in universities and industry is essential, and a major effort should be undertaken to increase the number of skilled technologists in the field. As the National Research Council's five year outlook for science and technology has stated, there is a "near absence in our universities of research in materials processing and manufacturing technology".[2] Some examples of areas of great potential payoff in materials processing technology are:

Development of new processes to increase availability, and improve the economy of production and utilization of light weight materials;

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[2] "Science Academy Head Sees U.S. Technology Lag", American Metal Market/Metal Working News, Dec. 31, 1979.

Process improvement through robotization, etc., to lower costs of energy efficient materials;
Improving strength and reliability of current materials;
Improving non-destructive inspection; and
Improving recyclability.

Related research and development work is also needed on materials structure, reliability, performance, and durability.

The planned Basic Automotive Research Program of Title III of S. 2015 can be an enormously potent positive force in helping promote research of the type needed to achieve an economic, lighter weight automobile.

MATERIALS AVAILABILITY

Materials availability, as an issue, is fundamentally as critical to the United States as energy availability. The changing mix of materials required to construct the light weight energy efficient vehicles of the future will severely test the ability of this country, and its materials industries, to accommodate radical change in materials consumption patterns. While we are all well aware of the problems facing the steel industry, with respect to foreign competition and reduced automotive demand for ferrous products, existing problems in other materials sectors are less well understood. The recent GAO report dated February 5 discusses some of the materials supply and economic disruptions that could result from these changing consumption patterns.

While the manufacturers have already expanded the use of light-weight materials, the changes after 1985 could be even more dramatic. The energy, natural resources, environmental, and economic consequences of the expanded use of particular light-weight materials are not well understood. Planning and public policy at the national level is needed to establish the trade-offs between the social objectives of energy conservation, environmental protection, and optimal domestic resource utilization on the one hand, and the automotive industry's cost, weight, and performance criteria on the other.

The four major competing light-weight materials are high-strength low-alloy (HSLA) steels, aluminum, plastics, and magnesium. Of these, only HSLA steels are based on coal, which is the most abundant domestic energy source. The primary feedstock for plastics is natural gas, whose alternative use is as fuel. Several long term problems, including disposability and recyclability are certain to develop from increased use of plastics.

Magnesium, the lightest commercially available structural material, represents a unique opportunity to simultaneously use a domestically available alternative resource and minimize imports of competing raw materials, and energy. However, at this time magnesium is only marginally competitive with the other materials on a price basis. Current studies indicate that significant improvements in both the overall cost and energy consumption of magnesium production are possible.

A prime example of the domestic materials availability problem is the shift of the aluminum industry to offshore capacity. Currently, the trend in the price and availability of domestic energy, a major cost factor in aluminum production, is forcing U.S. producers to expand offshore. The long-term trend would appear to be a leveling off or decline in the level of production capacity of the U.S. aluminum industry because of the loss of capacity to offshore sites due to the lack of available domestic energy.

At the present time, 90 percent of the primary aluminum produced in the United States is based on imported bauxite or alumina. Although international bauxite reserves are adequate to supply the world's needs for the next 200 years at current rates of consumption, doubts remain concerning the continued availability of adequate bauxite supplies to the United States at current price levels. This is partly due to increased competition with other industrialized nations for available resources and to the actions of the International Bauxite Association (IBA). Since 1970, IBA countries—principally Jamaica—have increased the price of U.S. bauxite imports by raising the levies on bauxite exports by nearly 700 percent. The tax levies imposed by this cartel, in its attempt to increase revenues from and control over worldwide bauxite operations, have become the largest single element in the cost of domestic bauxite.

Increasing bauxite prices add to the balance of payments deficit, and potentially adversely affect the competitive position of U.S. primary aluminum producers in the international marketplace. They also create a threat of supply interruption which has national defense-related implications.

Assuming aluminum production continues by the bauxite/alumina route, the future cost of the required alumina, Al_2O_3, production capacity has been estimated, based on a forecast of 5 percent annual growth in domestic aluminum demand to

the year 2000. According to this forecast, construction of nearly 20 million annual tons of alumina capacity will be required. In 1977 dollars, this is equivalent to an investment of roughly $13 billion and will create 10's of thousands of jobs, both permanent and construction. Because of the limited domestic supply of bauxite and the increasing costs of shipping the bulk material, the installation of new alumina capacity has shifted strictly to the country of origin of bauxite since 1959, when the last new domestic alumina facility was built. By the year 2000, additional foreign payments for imported bauxite/alumina are estimated to increase to billions of dollars annually.

If all future primary aluminum production capacity is also shifted offshore, the annual cost of imported aluminum could exceed $10 billion by the year 2000. If this foreign primary production capacity represents foreign investments by U.S. aluminum producers, the cost will exceed 10's of billions of (1980) dollars. Of course, whether aluminum production capacity will actually be shifted offshore will be determined by future capital and production cost trends plus technological change and government policy. However, the possibility exists, as pointed out in the recent GAO report that the energy savings which result from enhanced utilization of aluminum in the automobile could be negated by a large balance in payment deficit.

The foregoing few examples serve to illustrate that a national materials policy is needed which would consider the critical materials needs of the nation in our evolving industrial economy. We should, through policies based on quantitative materials and energy systems analysis, focus our resources, both human and natural, on solving primary materials production, supply, and productivity problems. The "Materials Policy Research and Development Act of 1979" recently passed by the House (H.R. 2743) and now under consideration by this committee constitutes a significant step toward meeting this need.

In connection with this bill, materials policy studies should be viewed as a vital concomitant, and perhaps predecessor to, any major legislation likely to result in perturbations to materials utilization—such as the proposed mandated CAFE standards contained in Amendment No. 1664 to S. 2015.

Senator STEVENSON. Our next witness is Dr. Frank N. von Hippel, chairman, Federation of American Scientists.

Wait a minute, Dr. Hippel. I beg your pardon. I am going to have to call Dr. Rivlin first. Excuse me, Dr. von Hippel. I didn't see her. She is so retiring.

Thank you for joining us, Dr. Rivlin.

Our next witness will be the Director of the Congressional Budget Office.

STATEMENT OF DR. ALICE M. RIVLIN, DIRECTOR, CONGRESSIONAL BUDGET OFFICE; ACCOMPANIED BY RAYMOND SCHEPPACH, ASSISTANT DIRECTOR FOR NATURAL RESOURCES; AND SALLY FERRIS

Dr. RIVLIN. Mr. Chairman, I have with me this morning Dr. Ray Scheppach, on my right, who is our Assistant Director for Natural Resources and related concerns, and Sally Ferris, on my left, who has done much of the work on this morning's testimony and the study related to it.

Mr. Chairman, I am happy to appear before the subcommittee to discuss the feasibility and possible impacts of increasing the fuel economy standards for cars produced after 1985. In my comments, I would like to discuss four questions raised by the adoption of such standards:

What level of average fuel economy is technologically feasible for new cars between 1985 and 1995?

Would increased standards after 1985 be of benefit to consumers, bearing in mind the additional costs of producing vehicles that are more fuel efficient?

How significant a contribution might increased standards for automotive fuel economy make to the Nation's efforts to conserve petroleum?

What would be the capital costs necessary to produce more fuel-efficient automobiles?

TECHNOLOGICAL FEASIBILITY

In the 15 years between now and 1995, many improvements in automotive fuel efficiency are likely. Only several years ago, fuel economy of at least 27.5 miles per gallon by 1985, as required by current legislation, appeared to be very difficult to attain. Technological progress, together with increasing fuel prices and consumer acceptance of smaller cars, now makes it likely that this standard will be achieved.

Since the Energy Policy and Conservation Act of 1975, a variety of fuel-saving technologies have already been incorporated into new cars. Others are planned for production in the next few years. Even so, most of these improvements will generally apply to less than one-half of all cars manufactured in 1985. Significant further gains in fuel economy are possible after 1985 by incorporating these same technological improvements in a greater proportion of new cars.

At the request of this subcommittee and the Senate Committee on Energy and Natural Resources, the Congressional Budget Office has reviewed existing studies of fuel-saving technological changes to automobiles. This review is the basis of both my testimony this morning and a report on this subject which we expect to issue in June. This review did not develop original estimates of the cost and performance of technological options—we don't have the kind of staff that can do that. Rather, it reviewed a variety of estimates developed by the automobile industry, research institutions, and government agencies.

These studies show considerable consensus regarding the technologies which are likely to be utilized to produce more fuel-efficient vehicles. They are also fairly consistent in their predictions of the effects each of these technologies will have on fuel economy. Their estimates of the associated costs tend to be somewhat more varied, but they are close enough to permit some rough approximations.

On the basis of these analyses, it appears that the technologies that will yield the greatest improvements in fuel economy during the post-1985 period are reductions in vehicle weight, front-wheel-drive design configurations, turbocharged diesels, and improved lubricants. These various approaches are listed in appendix table 1.

Weight reductions and front-wheel-drive design configurations together account for over one-third—2.7 miles per gallon—of the projected fuel economy gains. The fuel-saving advantages of front-wheel drive stem from the reductions in weight that this design makes possible through the elimination of the drive shaft and the substitution of smaller engines and lighter components.

Turbocharged diesel engines would increase the average fuel economy of new cars by about 7 miles per gallon. Under our projection, turbocharged diesels could be mounted on 25 percent of all new cars by 1995, resulting in an increase in average new car fuel economy of 1.4 miles per gallon. This projection assumes the relatively strict—1 gram per mile—standard for emissions of oxides

of nitrogen; even greater fuel economy benefits could be realized if these strict environmental standards continue to be waived.

A fourth technological advance, that of improved lubricants, would bring fuel economy benefits ranging from 0.5 to 2.8 miles per gallon. These lubricants are also relatively inexpensive, particularly with respect to the amount of capital investment required. The balance of the estimated fuel economy benefits will be derived from improvements in aerodynamics, accessories, tires and brakes, transmissions, and electronic controls.

In coming years, as gasoline prices continue to rise, sales of small cars will probably increase relative to sales of intermediate and large cars. Such market shifts promise to add about 2 miles per gallon to the average fuel economy of new cars in 1995, on top of the 35 miles per gallon that appears technologically feasible. Thus, new cars in 1995 could achieve an average performance of around 37 miles per gallon. While this is less than the 40 miles per gallon required by the Jackson-Magnuson proposal, it represents the low end of what will be technologically feasible, since it excludes any new technologies that might be developed during the next 15 years. So we use a conservative estimate.

EFFECT ON CONSUMERS

The additional price of a car achieving 37 miles per gallon has been estimated at approximately $567 per car—less than 10 percent of the cost of a new car in 1978 dollars. This additional cost appears small relative to the implied fuel savings.

For example, a car rated at 27.5 miles per gallon would consume 5,673 gallons of gasoline throughout its life, assuming an average vehicle life of 125,000 miles. On the same basis, a car rated at 37 miles per gallon would consume 4,216 gallons—a lifetime savings of 1,457 gallons.

The value of these savings in 1995 is obviously uncertain—it depends on the price of gasoline. Nevertheless, assuming that the gasoline tax recently proposed by the President is enacted—which seems a little less certain this morning—and that the price of crude oil grows at 2 percent a year above the rate of inflation, gasoline would cost around $1.75 per gallon in 1995, in constant 1978 dollars. At this price, the fuel savings would be worth $1,262 when discounted over the life of the vehicle. This means that consumers would experience a saving of more than twice the cost of the improvements.

While there is considerable uncertainty about the exact size of the benefit to consumers, it is clear that consumers would experience some net benefits from these fuel-saving technologies under almost any combination of factors.

For example, if we construct a worst case by selecting, for each technology, the lowest estimate of fuel economy and the highest estimate of cost from the studies reviewed, the sum of the discounted fuel savings still outweighs the additional cost of the new cars. A similar exercise shows that the fuel savings estimated earlier exceed the associated increment in vehicle cost as long as gasoline prices are above $1 per gallon.

PETROLEUM CONSERVATION

Improved automotive fuel economy can yield significant reductions in national petroleum consumption. Adoption of the technologies described above would yield savings of 167,000 barrels per day during the first year. After 10 years, when cars averaging 37 miles per gallon were fully phased in, the Nation's automobile fleet would consume more than a million barrels per day less than if cars continued to average 27.5 miles per gallon. This represents a 25-percent reduction in the Nation's consumption of petroleum products by automobiles, or savings equivalent to 5 percent of the Nation's total consumption of petroleum.

AUTOMOBILE INDUSTRY

The improvements in automotive fuel economy discussed here would require substantial capital investment. Several of the studies that we reviewed included estimates of capital expenditure. These indicated that the costs of the special tooling needed to produce vehicles getting 37 miles per gallon would be around $20 billion; additional investment would also be required for related plant and equipment. In sum, about $40 billion in capital expenditures would be required to increase average new-car fuel economy from 27.5 to 37 miles per gallon. On an annual basis, this would be about $4 billion a year from 1985 to 1995, which is roughly equal to the profits of the domestic automobile industry in recent years. See Appendix, table 2.

The extent to which such capital requirements may impose a financial burden on the industry has not, as yet, been fully analyzed by CBO.

If the domestic auto industry does not make additional fuel economy improvements between 1985 and 1995, it is likely to lose sales to foreign manufacturers. The decline of domestic new-car sales relative to imported new-car sales during recent months is at least partially attributable to the generally superior fuel economy of imported autos. If the decline were to continue after 1985, the industry's gross sales receipts in 1995 from new cars without further improvements in fuel economy could be substantially less than the corresponding revenues it would have received if further fuel economy improvements had been made. In short, past investment practices in the domestic automobile industry are unlikely to persist in any case, since the threat of increased competition from imports may force domestic manufacturers to make large investments merely to hold their market share.

In conclusion, the 1995 fuel economy standard contained in the legislation introduced by Senator Jackson and Senator Magnuson appears to be technologically achievable during the next 15 years. Increased use of fuel-saving technologies that are currently in production or that are slated for production within the next 5 years could increase the average fuel economy of new autos to about 35 miles per gallon by 1995. Additional fuel economy increases of about 2 miles per gallon are also likely to occur as buyers shift toward smaller, more fuel-efficient autos in response to continued increases in gasoline prices. This means that, even without further innovations that may occur during the post-1985 period, an average

fuel economy of about 37 miles per gallon appears clearly technologically feasible for new cars in 1995. Given that further innovations are likely during the next decade, an average fuel economy of 40 miles per gallon is probably technologically within reach by 1995. Such fuel economy standards would also significantly reduce petroleum consumption after 1985 and would be cost effective to consumers—that is, the additional cost to consumers for more fuel-efficient automobiles would be more than offset by savings in gasoline.

The capital investment required to produce such vehicles is estimated at $4 billion annually over the 10-year period from 1985 to 1995. Although this represents only 4 percent of the current gross sales revenue of the industry, it is equal to the profits of this industry over the last several years. The ability of the Nation's auto industry to sustain this level of capital investment is unclear at this time.

Thank you, Mr. Chairman.

[The tables referred to follow:]

APPENDIX TABLE 1.—CBO ESTIMATES OF FUTURE FUEL ECONOMY IMPROVEMENTS AND ASSOCIATED COSTS

Technology	Market penetration			Fuel economy improvement				Consumer cost		
	1985 (percent)	1995 (percent)	Change in percent market penetration between 1985 and 1995	Per car (percent)	Increment over 27.5 mpg per car (mpg)	New-car fleet (percent)	Increment over 27.5 mpg for new-car fleet (mpg)	Base cost per unit (dollars)	Escalated cost per unit [1] (dollars)	Average increase per car (dollars)
4-Speed automatic transmission	23	50	+27	6	1.7	1.6	0.4	180	261	70
Weight reduction [2]	0	100	+100	5	1.4	5.0	1.4	86	129	129
Turbocharger	10	30	+20	10	2.8	2.0	0.6	175	184	55
Electronic controls	75	100	+25	4	1.1	1.0	9.3	100	115	29
Diesel	5	25	+20	15	4.1	3.0	0.8	550	605	121
Proco	0	10	+10	12	3.3	1.2	0.3	350	403	40
Front-wheel drive	50	90	+40	12	3.3	4.8	1.3	150	225	90
Aerodynamics	50	100	+50	5	1.4	2.5	0.7	14	15	8
Lubricants	0	80	+80	5	1.4	4.0	1.1	15	15	12
Improved accessories	50	100	+50	2	0.6	1.0	0.3	14	15	8
Reduced rolling resistance	10	30	+20	4	1.1	0.8	0.2	25	25	5
Total							7.4			567

[1] The escalated cost per unit takes account of the recent increase in interest rates and the associated increase in the cost of capital. See Congressional Budget Office, "Preliminary Assessment of Post-1985 Automotive Fuel Economy Standards," draft report, Apr. 29, 1980.

[2] Assumes second round of weight reduction.

APPENDIX TABLE 2.—FINANCIAL STATISTICS FOR THE U.S. AUTO INDUSTRY

[In billions of constant 1978 dollars]

	1975	1976	1977	1978	1979 [1]
Total sales	88.8	102.0	115.6	122.2	115.1
Capital spending	4.4	4.3	6.7	7.8	8.8
Net income	1.6	4.9	5.6	4.9	2.8

[1] Does not include data for American Motors.

Source: U.S. Department of Transportation, based on corporation annual reports.

Note.—Total sales income was deflated using the implicit price deflator for auto output, final sales. Capital spending was deflated using the implicit price deflator for nonresidential fixed investment. Net income was deflated using the GNP deflator.

Senator STEVENSON. Thank you, Dr. Rivlin.

Is that $4 billion a year in addition to the $7 or $8 billion per year in capital expenditures by the industry now?

Dr. RIVLIN. It is a little hard to tell. Let's see if Dr. Scheppach has a comment on that.

Dr. SCHEPPACH. We are beginning to look at that question. It is unclear at this time, however, how much of the $4 billion would be in addition to the $7 to $8 billion correct level. New York financial people seem to indicate that the total is going to be in the neighborhood of $80 billion.

Senator STEVENSON. $80 billion over how many years?

Dr. SCHEPPACH. Over 10 years. So they are talking about an estimate that is double what we are talking about.

Senator STEVENSON. That is about what it is now?

Dr. SCHEPPACH. That has been the last couple of years.

Senator STEVENSON. So it might have to continue at that abnormally high rate?

Dr. SCHEPPACH. We have not looked at that, but New York financial people indicate that the capital expenditure requirement of the auto industry over the next 10 years will be about equivalent to the rate in the last couple of years.

Senator STEVENSON. You are saying that is excessive?

Dr. SCHEPPACH. It is a lot higher than it's been historically.

Senator STEVENSON. And higher than you are projecting?

Dr. SCHEPPACH. Our projection of $40 billion is just to meet fuel efficiency standards. That does not include the retooling costs associated with other design changes.

Senator STEVENSON. But you think the fuel economy, retooling and everything else, could be financed at about a level of $8 billion over 10 years?

Dr. SCHEPPACH. We have not looked at it, but other people indicate that the requirements will be about $8 billion a year over the next 10 years.

Senator STEVENSON. Will this be looked into in your final report when this comes out in June?

Dr. RIVLIN. To the extent possible.

Senator STEVENSON. Well, that level of effort, you say, will produce fleets which average 37 miles per gallon, though you say that is a conservative estimate and it may be higher.

Dr. RIVLIN. That is an estimate of what is technologically feasible with the introduction into a larger proportion of the fleet the

technologies already available. And we will assume there will be some technological progress in the next 15 years.

Senator STEVENSON. Well, that is a safe assumption in Japan and in Europe.

Where will we be at the end of that period? We will have just achieved what Volkswagen has already achieved. Where will Volkswagen be in 1995? Where will Datsun be? They have already organized their basic research effort in the European community. The Japanese have their strategy for the 1980's. And we are projecting levels that in 1995, 15 years from now, will only put us where Volkswagen is today. We don't have to speculate about the availability of capital in Europe or Japan either, do we? They will make sure they have the capital. They have mechanisms by which the government can assure it's available and at lower rates of interest than we have now. All we have is the bailout for Chrysler.

So what good does all this do us? Are we going to rely on trade barriers? Have you made projections for the Europeans and Japanese? And how about the Russians and how about the Swedes?

Dr. RIVLIN. No; that goes beyond what we were asked to do or what we have the competence to do.

Senator STEVENSON. Well, what good is it going to do us or any industry to invest billions of dollars a year not only in the retooling for the industry but also in basic research effort if all we can do 15 years from now is what Volkswagen does today?

Dr. RIVLIN. We don't know what the rate of technological progress beyond a certain point will be. But clearly the alternative is worse. It may be to close down our domestic automobile industry.

Senator STEVENSON. Well, I don't think that's the only alternative. With respect to the industry, what I am trying to suggest is we need to do some leapfrogging with respect to capital and technology and have in place something far more ambitious than you or anybody else has suggested and move beyond the automobile, which by 1995 may be obsolete. It may be like the dinosaurs. Some of these resources might be going into efficient rail equipment production. We don't have any. We've got one German-owned manufacturer of passenger rail equipment in the United States. These articulated buses are imported. We are down to two bus manufacturers in the United States.

Have you looked at the condition of those industries, the market penetration? The foreign penetration is far greater in this industry. And one thing you can conceivably be pretty confident about is high-priced energy in the future if it's available for discretionary driving at all.

The most unrealistic assumption I have seen is—what was it? $1.75 for gasoline in 1995? We will hit that in 1983.

Dr. RIVLIN. But that was just to demonstrate——

Senator STEVENSON. Without the tax.

Dr. RIVLIN. Right.

Senator STEVENSON. You would agree, Dr. Rivlin, wouldn't you, that we will have that soon without the tax?

Dr. RIVLIN. That price is in 1978 dollars. It is not a predicting of the price of gasoline in 1995 dollars. It was to show that, even at what seemed a relatively low price of gasoline, it is still to the benefit of the consumer to make these changes.

Senator STEVENSON. And you have done that very, very effectively. Even with such an optimistic assumption, the fuel efficiency pays off for the consumer. What I am questioning is whether it can save this industry.

Dr. RIVLIN. I think you should be questioning that. It is a real problem. My own guess would be that, while rail and bus and other modes of transportation are terribly important, they are not going to supplant the automobile in this period.

Senator STEVENSON. Particularly if we have to import them. Well, it is a very cheery hearing so far.

I don't know. We'll break out these capital investment figures but it will be very helpful to take a look at what foreign competitors are doing and where they are going to be at their projected levels of capital investment and investment also in research and technology, and then figure out what we have to do, not just to produce 37 miles per gallon which Volkswagen produces already but to survive with the most fuel-efficient vehicles that will be competitive in a very competitive world market—competitive not just because of the foreign producers but also because of the financial difficulties likely to be encountered by the potential buyers of automobiles in this time frame.

Is that within your ambit?

Dr. RIVLIN. We can see what is available in the future in foreign countries. We do not really have the staff that could take on projections of technological improvements in Japan, Germany, and elsewhere.

Senator STEVENSON. They are always here watching what we are doing. Usually these hearings are filled with representatives of the Japanese industry and the Russian industry. They can project what we are going to do. Why can't we project what they are going to do?

Dr. RIVLIN. As you point out, they are ahead of us on fuel efficiency.

Senator STEVENSON. I understand Volkswagen has a 60-mile-per-gallon vehicle it can put into production in months. All it has to do is supercharge the diesel for its Rabbit. They just don't need to because there is no competitive pressure from the United States. As soon as there is, that is the next step. And then they have another prototype beyond that that gets them up to 85 miles per gallon when it is ready to go into production downstream.

It seems if they can anticipate what we are going to do and be ready at every stage along the way to beat us with a relatively small incremental investment, we ought to be able to do the same. We are starting from far behind, but the least we could do is to monitor their plans so we can factor that in and try to figure out what it is going to take for the United States to beat them. Otherwise we will race like crazy to stay in the same relative position, which has already required a massive bailout for one company.

Dr. RIVLIN. Part of our problem is that we have a very short history of paying any attention to fuel efficiency because we had very cheap fuel for a long time, and fuel efficiency wasn't something the American consumer needed to be concerned about, nor the automobile companies.

Senator STEVENSON. But that is an excuse, not a prescription for the future.

Dr. RIVLIN. That's right.

Senator STEVENSON. We are not going to live on excuses. And why? They were looking into the future and we weren't. The industry was taking market surveys. I don't think we are looking into the future today.

Well, can we do anything to help CBO so it can help monitor the activities of our competitors so we can beat them? We obviously can't rely on this industry.

Dr. RIVLIN. We'll do the best we can to be helpful, Mr. Chairman, but I don't think we can take on the problems of monitoring the technology of the automobile industry.

Senator STEVENSON. Should we get the CIA to help you? Would that be necessary?

Dr. RIVLIN. It could be. Maybe you should get Stan Turner up here to see what he would say.

Senator STEVENSON. Maybe I'll take that up with the intelligence community. As a matter of fact, I did several years ago without success.

We look forward to your June report and thank you all for joining us and helping us this morning.

Dr. RIVLIN. Thank you.

Senator STEVENSON. Now we return to Dr. von Hippel, the chairman of the Federation of American Scientists. And I apologize again to him for getting him up and interrupting him before, but I did promise Dr. Rivlin we'd get her on when she came in.

STATEMENT OF DR. FRANK N. VON HIPPEL, CHAIRMAN, FEDERATION OF AMERICAN SCIENTISTS

Dr. VON HIPPEL. Thank you, Mr. Chairman.

Mr. Chairman, I am here today for two reasons:

First, as an energy policy analyst I have spent most of the past year studying the technical possibilities for increasing the efficiency of petroleum use in U.S. automobiles and have concluded that the possibilities are very much greater than our automobile manufacturers are currently planning on realizing. I have written up my conclusions in a Princeton report titled, "Forty Miles a Gallon by 1995 at the Very Least," which I would like to submit for the record.

Senator STEVENSON. It will be entered in the record.

Dr. VON HIPPEL. Second, I am the current elected chairman of the Federation of American Scientists, a group of 5,000 natural and social scientists and engineers, including approximately one-half of the living U.S. Nobel Prize winners. The FAS has been working for the past 35 years to prevent nuclear war, and we are becoming increasingly concerned that the current level of U.S. dependence on petroleum imports is beginning to contribute significantly to the chances for such a war. Our organization has therefore launched a major new effort to obtain a rapid reduction of U.S. petroleum consumption.

In the next part of my prepared testimony, Mr. Chairman, I discuss the prospects for fuel efficiency improvements in transportation and conclude that with our current plans, our petroleum

consumption can be only expected to decline a small amount, 1 or 2 million barrels a day.

This gives us a projected petroleum demand for 1990 of 16 million barrels a day which is lower by 2 million barrels a day than our current petroleum consumption, and is also lower than the lowest projection made in the most recent, 1978, Energy Information Administration report to Congress.

The shock comes when we turn to the question of how this petroleum demand is to be met. Exxon and other U.S. oil companies are now projecting a big drop in domestic production—from 10 million barrels a day in 1980 to 6 million barrels a day in 1990. This decline will not be offset by the availability of liquid synthetic fuels whose production rate is currently expected to be at most about 1 million barrels per day in 1990.

We are also faced with the likelihood of a declining availability of imported oil. President Carter's proposal that the United States reduce its petroleum imports by one-half, down to 4 million barrels a day by 1990, probably reflects a prudent assessment of the availability of foreign petroleum to the United States 10 years from now. If we attempt to maintain or even increase our current level of imports, the result will probably only be to increase our vulnerability and that of our friends to every new twist of events in the unstable Middle East.

With a domestic production level of 7 million barrels a day including synthetics plus imports of 4 million barrels a day, U.S. petroleum supply in 1990 would be only 11 million barrels a day or 5 million barrels a day less than the low 16 million barrels a day projection that I discussed previously. Something has to give: In my view it must be either our economy, what remains of international stability or, I would hope, our petroleum-wasting systems.

In the area of personal transportation there is an emerging consensus that it is technically possible to drastically improve the efficiency of the U.S. automobile. In the hearings before this subcommittee last week and before the Senate Committee on Energy and Natural Resources the week before, no one from either Government or the auto industry argued against the feasibility of fuel economy standards of 40 miles per gallon by 1995.

That would, of course, have been hard to do since, as you have pointed out, VW has been marketing since model year 1978 the four-passenger Rabbit diesel which gets better than 40 miles per gallon. In case you haven't driven a VW Rabbit, it is not a small car—even though it appears so. Because of efficient packaging, it has more than 80 percent of the interior space of the average car sold in the United States in 1978—yet it is 40 percent lighter and has 2½ times the fuel economy. With the ongoing shift of the U.S. market toward smaller cars, the VW Rabbit will look more and more like an average U.S. car in the future—as far as size is concerned, at least.

So why shouldn't we expect a corresponding average efficiency? On the average, however, today U.S.-produced cars in the same subcompact size class as the VW Rabbit diesel get only half that car's fuel economy. In fact, they only get 4 miles per gallon better than the average domestic large car. Henry Ford is supposed to have said something like, "Give them any color car they want as

long as it's black." Today, Detroit seems to be willing to give us any size car we want—as long as it gets less than 25 miles per gallon.

It is important to realize that the diesel Rabbit is far from the technological limit for fuel efficiency. Recently, as you have pointed out, VW has made another four-passenger vehicle which gets 70 to 80 miles per gallon. Considering the obviously enormous technological opportunities and the gravity of the world oil situation, one is moved to ask whether we would be a little too relaxed if we waited until 1995 to achieve a fleet average fuel economy of 40 miles per gallon. Indeed, one of the witnesses before the Senate Committee on Energy and Natural Resources 2 weeks ago argued for an average fuel economy for automobiles and light trucks of 50 miles per gallon by 1990 and 80 miles per gallon in 1995.

To get a feeling for what is at stake, I have calculated how much U.S. petroleum consumption would be reduced if the Jackson-Magnuson proposal were adopted and the onroad fuel economy of the new U.S. automobile fleet rose linearly from 20 miles per gallon in 1985 to 40 miles per gallon in 1995 and then stayed constant. Comparing with a DOE scenario in which the EPA fuel economy of 27.5 miles per gallon mandated for 1985 corresponds to an onroad fuel economy of 22 miles per gallon and stays constant in the post-1985 period, the savings are: 0.5 million barrels per day of petroleum in 1990, 1.5 in 1995, and 2.2 in the year 2000. If with a more ambitious program in which the average onroad fuel economy of automobiles and light trucks were raised linearly from 20 miles per gallon in 1985 to 40 miles per gallon in 1990, and 60 miles per gallon in 1995 and held constant thereafter, the savings would be 1.6 million barrels a day in 1990, 3.4 in 1995, and 4.7 in 2000, that is, the savings would be more than doubled.

To put these savings into perspective, it might be helpful to note that 5 million barrels a day equals the petroleum consumption in 1976 of Japan and it exceeds the petroleum consumption of all of Latin America, including Mexico and Brazil. Obviously, a savings of this magnitude would have a significant impact on the world oil situation. On the basis of the technology which has already been demonstrated by VW, it appears that 40 miles per gallon 10 years from now and 60 miles per gallon 15 years from now are achievable targets. In the light of the probably seriousness of our liquid fuel shortage by the 1990's, I think that such targets must be seriously considered.

As Senator Jackson pointed out last week, while spokesmen for the automobile companies in his hearings were willing to agree that 40 miles per gallon is technologically achievable, none of them were willing to indicate that they had any plans to make such cars in the foreseeable future. Their reasons for holding back were summarized by the spokesman for Ford. He said:

> By 1985, we will have a fleet much like that of the rest of the world * * * there is no longer a need to play catch up. New car fleet averages even in countries with a long history of higher gasoline prices and total dependence on imported oil do not begin to approach 40 miles per gallon. In these circumstances, it would be most difficult to predict market, volume, and employment consequences for levels like 40 miles per gallon.

The problem seems to be, as you have indicated in your comments, that Detroit is treating the imports as a stationary target.

The auto companies are unwilling to prepare to build 15 years from now cars which on average are more efficient than foreign car manufacturers are building today. The fuel economy of the imports is not a stationary target, however. Between model years 1979 and 1980, while U.S. manufacturers improved their fleet average fuel economies by an average of 2.5 miles per gallon, the foreign manufacturers did also and the gap stayed constant. It appears likely, therefore, that unless U.S. automakers aim toward a target fuel economy which is higher than the imports are getting today, they will always be playing catch up.

So in my view, what is required is a three-pronged policy:

One, we need fuel economy standards at least as high as have been proposed in the Jackson-Magnuson amendment—preferably higher. This would protect auto manufacturers who produce fuel-efficient vehicles from competitors who might otherwise try to undercut them with heavy promotions of less fuel-efficient vehicles which could be made cheaper—in first cost at least—because they wouldn't require new investments in tooling. With ambitious fuel economy standards I would hope that we would never again have to witness the shameful spectacle of U.S. auto manufacturers trying to convince the public that buying fuel-efficient cars is not in their interest.

Ten to fifteen years advance notice would reduce the extra cost of retooling for increased fuel economy enormously because most of the automobile industry's tooling will have to be replaced during that length of time anyway. In contrast, the approach which the manufacturers are following today: tooling up to build 25-miles-per-gallon cars, is potentially disastrous. It is quite likely that, after this investment has been made, Detroit will find that new car buyers want 40-plus-miles-per-gallon cars and that foreign manufacturers are ready to supply them.

In fact, I think we heard in these hearings last week the spokesman from Ford saying higher fuel economy standards would make obsolete production lines which are being built today. I would add to that: If it is not higher fuel economy standards which made these production lines obsolete, it is likely to be the next wave in demand for yet more fuel efficient cars.

Two, In order to motivate new car buyers to purchase vehicles as efficient as the national security demands we need a big gasoline tax such as the Europeans and Japanese have.

In the fuel economy hearings over the past 2 weeks, the auto manufacturers have repeatedly complained that it is Government policies maintaining the level of U.S. gasoline prices at artificially low levels that have created the U.S. market for gas guzzlers. Even with oil price decontrol, U.S. gasoline prices will still be up to $2 per gallon lower than the prices in Europe and Japan, because of the difference in our gasoline taxes. As a result, the foreign market for fuel-efficient vehicles will continue to be ahead of ours, which is, of course, an advantage to foreign manufacturers in world competition.

It is not necessarily true that a gas tax will be harder on lower income people than on the rich. Many schemes have been developed by now for rebating gas tax revenues which would return

more money to lower income groups than the gas tax would take away, but which would still encourage everyone to save gasoline.

Three, finally, Detroit may need some help from the Government if it is to raise all the $100 billion or so that it now needs to retool to make more efficient cars. The Government should condition this help, however, on Detroit making a commitment to build really efficient cars, not just 25-miles-per-gallon cars which will soon be as obsolete as today's gas guzzlers.

In my view, such help to the industry will bring much larger returns in national security per dollar invested than the tens of billions of dollars which have already been committed to subsidized the production of synthetic fuels and to building up a military force that can be rapidly deployed to the Middle East. Our problem is that we have built into the current fleet of American automobiles a petroleum-consuming monster whose thirst we can no longer satisfy without getting deeper and deeper into trouble internationally, environmentally, and economically. The solution is to replace this fleet as far as we can with vehicles which are gas sippers, not gas guzzlers.

In summary, then, what we need is:

One. Ambitious fuel economy goals.

Two. A gas tax as big as other auto manufacturing countries have.

Three. A financial assistance package which will make it possible for Detroit to retool to produce vehicles as fuel efficient as our national security demands.

Thank you, Mr. Chairman.

Senator STEVENSON. Thank you, Dr. von Hippel.

I am going to have to apologize again because we have a vote. So we will have to recess briefly.

The subcommittee is recessed.

[Whereupon, a short recess was taken.]

Senator STEVENSON. The subcommittee will come to order.

Dr. von Hippel, I agree with what you said. I am not sure there is anybody else around here who does—at least I don't know any other supporters of big gas tax increases.

Yesterday the leadership in the House and the Senate met and they might very well deprive the President of authority to impose the fee on oil imports if the courts don't do so. So that part, at least, of your suggestion doesn't look very likely.

Dr. VON HIPPEL. It may be that, if we don't pass the gas tax, OPEC will. I think we need both fuel efficency standards and a gas tax.

Senator STEVENSON. Yes; and it might be wiser to pay ourselves the tax than the OPEC producers, but it will come.

Now, I asked for the standard. You suggest as high as 60 miles per gallon by 1995. One of the complaints about such a program is that it would simply force greater reliance on foreign sources of materials for the production of such automobiles. How do you react to that?

Dr. VON HIPPEL. Well, I looked at the GAO report on that and made a quick check of the numbers. I thought that their numbers were high, quite high.

But in any case, I don't think there is anything exotic about what VW has done with this four-passenger car which has already gotten 70 to 80 miles a gallon. I don't think there is anything very exotic as far as materials is concerned. All that has been done there is work on the engine, making the engine more efficient.

So I think whatever one might do in terms of material substitution would, in fact, be on top of that.

I would like to add in this connection that we really should be grateful to VW for showing us how far we are from the limits of what automobile technology can give us. Originally I wondered whether 40 miles per gallon might not be pushing too hard. As I have learned more about the technological possibilities over the past few months, however, 15 years seems an awfully long time in the future to get to what VW has already been doing for some years—especially in view of the additional opportunities.

Senator STEVENSON. Could you tell us more about the Volkswagen vehicles? I had understood that there were two models.

Dr. VON HIPPEL. Yes.

Senator STEVENSON. One is just the Rabbit, I think, with a turbocharged diesel engine. And then there is another that you have described which gets even more miles per gallon?

Dr. VON HIPPEL. First, we have today's commercial VW Rabbit diesel which gets in the 40's. Then in a Department of Transportation funded program, in their safety research program, a VW was modified—I think it's called Integrated Research VW—a turbocharger was added along with some safety improvements, and the fuel economy was raised to 60 miles per gallon.

Then VW, in collaboration with the Federal Government, in Germany has been conducting a program where they have been going quite a bit further in both the engine technology and also in very much improved aerodynamics. Their target there—what they focused on is a vehicle which would be larger than the Rabbit, someplace between a subcompact and the compact car, which would get over 65 miles per gallon.

What they have already I just know about by word of mouth. I have been trying to get something in writing. I think that they have put the engine that they were going to put in the 65-mile-per-gallon-plus car into a smaller vehicle—something like the Rabbit. That engine has a supercharger instead of a turbocharger; it is a direct-injection diesel instead of the prechamber injection diesel which today's Rabbit has, which gives some improvement in fuel economy; and the fuel is cut off during idle and coast. These improvements in the engine technology puts them in the 70- to 80-miles-per-gallon ballpark. It is my understanding that they will deliver this to the EPA for testing this fall so we might hopefully know a lot more about it at that point.

Senator STEVENSON. Do you know any obstacles to Volkswagen's production of such vehicles?

Dr. VON HIPPEL. Well, I was at a meeting with a VW representative where I learned about this, and he said that the idle is somewhat rough.

Senator STEVENSON. What's that?

Dr. VON HIPPEL. The idle is somewhat rough, and also they had not fully tested it as far as emissions and durability are concerned.

Senator STEVENSON. What about the emissions standards? Does the diesel comply?

Dr. VON HIPPEL. I think so. I'll tell you as much as I know, and then maybe somebody else can go beyond that. The EPA proposed standards for 1985 for particulate emissions are about 0.2 grams per mile, which is down by about a factor of 5 from what a large diesel car puts out today. But small diesels like these already have an advantage because, roughly speaking, the particulates are put out in proportion to the fuel consumption. So today's VW Rabbit diesel is already down to around 0.3 grams per mile. With turbocharging I think it would be pushed down to about 0.2.

And then beyond that, the EPA has tested exhaust clear up devices—essentially filters in which the particulates would be burned periodically—which has been tested to reduce particulates by another factor of three. That would being a small diesel such as we are talking about well below the standards, and probably to an acceptably low level.

Senator STEVENSON. Can you tell us anything about the efforts of the Japanese or the other European manufacturers, the Russians or Swedes, and so on?

Dr. VON HIPPEL. I think there are other efforts on small diesels.

Another thing that has been interesting to me also is the presence in Japanese fleets, for example, of cars much smaller than anything we've got. I remember some years ago driving a 500 CC Fiat. Such cars are still being sold and driven in Europe and Japan. When you're talking about small vehicles like that, I think you could, with technology such as we are discussing, go much further still in the direction of higher fuel economy.

But I don't know anything in terms of technology that goes beyond what VW is doing.

Senator STEVENSON. I think the EEC cooperative basic research effort does not include Volkswagen. I may be wrong about that. I don't know the explanation unless others are trying to catch up with Volkswagen in Europe.

Well, maybe instead of starting another Government effort to develop automotive technology, and with no effort to develop automotive technology, and with no assurance that it will come on stream in time and be utilized by the manufacturers and end up in competitive automobiles, we'd be wiser just to import technology. That is happening increasingly. It is happening in the steel industry. We have technology being imported now to modernize American steel plants. Volkwagen engines are already being imported for use in Chrysler vehicles.

Dr. VON HIPPEL. I don't think there is anything that challenging about the technology. It is just being able to convince Detroit that the people will be willing to buy it if they invest in producing it. And they really seem to want to be convinced the market is there before they produce it. But that builds in a delay which I consider unacceptably long.

Senator STEVENSON. Are any of the American manufacturers planning production of the small turbocharged diesels or even the nonturbocharged diesels or the direct-injection diesels of the kind you have just described?

Dr. VON HIPPEL. I think there are some programs on the small diesels, but I'm not really familiar with the details on it. I have been listening to the hearings here last week and Senator Jackson's hearings and the spokesmen for the domestic manufacturers weren't very forthcoming.

Senator STEVENSON. They got very secretive.

Dr. VON HIPPEL. Yes.

Senator STEVENSON. Volkswagen is more forthcoming?

Dr. VON HIPPEL. Yes.

Senator STEVENSON. They don't hesitate to tell us about their plans, or at least they tell us a lot more.

Thank you very much.

Dr. VON HIPPEL. Thank you.

[The statement and material referred to follow:]

STATEMENT OF FRANK VON HIPPEL, CHAIRMAN, FEDERATION OF AMERICAN SCIENTISTS AND SENIOR RESEARCH PHYSICIST, CENTER FOR ENERGY AND ENVIRONMENTAL STUDIES, PRINCETON UNIVERSITY

Mr. Chairman, I am here today for two reasons:

First as an energy policy analyst I have spent most of the past year studying the technical possibilities for increasing the efficiency of petroleum use in U.S. automobiles and have concluded that the possibilities are very much greater than our automobile manufacturers are currently planning on realizing. I have written up my conclusions in a Princeton report titled "Forty Miles a Gallon by 1995 At the Very Least!" which I would like to submit for the record.

Secondly, I am the current elected Chairman of the Federation of American Scientists, a group of 5,000 natural and social scientists and engineers including approximately one-half of the living U.S. Nobel Prize winners. The FAS has been working for the past 35 years to prevent nuclear war and we are becoming increasingly concerned that the current level of U.S. dependence on petroleum imports is beginning to contribute significantly to the chances for such a war. Our organization has therefore launched a major new effort to obtain a rapid reduction of U.S. petroleum consumption.

Let me start by briefly explaining why, in the absence of such a rapid reduction in our petroleum consumption, our economy is likely to get into more and more serious trouble over the next decade. I will do this by dividing our petroleum consumption by three end use categories: automobiles and light trucks, other transportation, and everything else.

Automobiles and light trucks (pickups, vans, etc.) currently account for more than one-third of U.S. petroleum consumption—about 6.5 million barrels a day. According to the Department of Energy, the current fuel economy standards will probably result in a 30-percent reduction in the average amount of fuel consumed by this fleet per mile by 1990. The effects of economic growth and the growth of the driving age population are expected, however, to result in an increase in total miles driven over this period large enough to almost exactly offset these savings, leaving the consumption of petroleum by automobiles and light trucks approximately constant.

The current level of petroleum consumption by other forms of transport—freight trucks, passenger aircraft, ships, railroads, etc.—is approximately half that of passenger cars and light trucks. Unless we have a sudden stop in the growth of air travel and intercity freight transport by trucks, a decline in petroleum consumption by these sectors appears unlikely. From our current perspective therefore the total petroleum demand in 1990 for transportation will be about the same as today—about 10 million barrels per day.

The remaining uses of petroleum—currently about 8 million barrels a day—are in the residential, commercial and industrial sectors for such purposes as space and water heating, plastics, industrial process heat, peaking electric power plants etc. Growth in the number of families, the work force, and in goods production will tend to drive up these demands but efficiency improvements and the substitution of other fuels for petroleum will hopefully force them down even faster so that we can hope for some reduction in petroleum use in this area. I don't have a good estimate so I will assume for the sake of argument a 25-percent reduction or 2 million barrels a day.

This gives us a projected petroleum demand for 1990 of 16 million barrels a day which is lower by two million barrels a day than our current petroleum consump-

tion and is also lower than the lowest projection made in the most recent (1978) Energy Information Administration Report to Congress.

The shock comes when we turn to the question of how this petroleum demand is to be met. It is beginning to appear that it will not be possible in 1990 to meet even this seemingly low level of demand. The Department of Energy has been assuming that, as a result of deregulation, domestic production will rise or at least stay constant. Exxon and other U.S. oil companies are now projecting, however, a big drop in domestic production—from 10 million barrels a day (MMBD) in 1980 to 6 MMBD in 1990. This decline will not be offset by the availability of liquid synthetic fuels whose production rate is currently expected to be at most about one million barrels per day in 1990.

We are also faced with the likelihood of a declining availability of imported oil. President Carter's proposal that the U.S. reduce its petroleum imports by one-half, down to 4 million barrels a day by 1990, probably reflects a prudent assessment of the availability of foreign petroleum to the U.S. ten years from now. If we attempt to maintain or even increase our current level of imports, the result will probably only be to increase our vulnerability and that of our friends to every new twist of events in the unstable Middle East.

With a domestic production level of 7 million barrels a day including synthetics and imports of 4 million barrels a day, U.S. petroleum supply in 1990 would be only 11 MMBD or 5 MMBD less than the "low" 16 MMBD projection that I discussed above. Something has to give: in my view it must be either our economy, what remains of international stability, or our petroleum-wasting systems.

In the area of personal transportation there is an emerging consensus that it is technically possible to drastically improve the efficiency of the U.S. automobile. In the hearings before this subcommittee last week and before the Senate Committee on Energy and Natural Resources the week before no one from either government or the auto industry argued against the feasibility of fuel economy standards of 40 mpg by 1995.

That would of course, have been hard to do since VW has been marketing since model year 1978 the four passenger Rabbit diesel which gets better than 40 mpg. In case you haven't driven a VW Rabbit, it is not a small car—even though it appears so. Because of efficient packaging, it has more than 80 percent of the interior space of the average car sold in the U.S. in 1978—yet it is 40 percent lighter and has two and one-half times the fuel economy. With the ongoing shift of the U.S. market toward smaller cars, the VW Rabbit will look more and more like an average U.S. car in the future. So why shouldn't we expect a corresponding average efficiency? On the average, however, today U.S. produced cars in the same subcompact size class as the VW Rabbit diesel get only half the fuel economy—in fact they only get 4 mpg better than the average domestic large car. Henry Ford is supposed to have said something like: "Give them any color car they want as long as it's black." Today Detroit seems to be willing to give us any size car we want—as long as it gets less than 25 mpg ["estimated" (city) EPA mpg].

It is important to realize that the diesel Rabbit is far from the technological limit for fuel efficiency. Recently VW has made another 4 passenger vehicle which gets "70 to 80 mpg." Considering the obviously enormous technological opportunities and the gravity of the world oil situation, one is moved to ask whether we would be a little too relaxed if we waited till 1995 to achieve a fleet average fuel economy of 40 mpg. Indeed one of the witnesses before the Senate Committee on Energy and Natural Resources two weeks ago argued for an average fuel economy for automobiles and light trucks of 50 mpg by 1990 and 80 mpg in 1995.

To get a feeling for what is at stake, I have calculated how much U.S. petroleum consumption would be reduced if the Jackson-Magnuson proposal were adopted and the on-road fuel economy of the new U.S. automobile fleet rose linearly from 20 mpg in 1985 to 40 mpg in 1995 and then stayed constant. Comparing with a DOE scenario in which the EPA fuel ecomony of 27.5 mpg mandated for 1985 corresponds to an on-road fuel economy of 22 mpg and stays constant in the post-1985 period, the savings are: 0.5 million barrels per day of petroleum in 1990, 1.5 in 1995, and 2.2 in the year 2000. With a more ambitious program in which the average on-road fuel economy of automobiles and light trucks were raised linearly from 20 mpg in 1985 to 40 mpg in 1990 and 60 mpg in 1995 and held constant thereafter, the savings would be 1.6 MMBD in 1990, 3.4 in 1995 and 4.7 in 2000, i.e., the savings would be more than doubled.

To put these savings into perspective it might be helpful to note that 5 million barrels a day equals the petroleum consumption in 1976 of Japan and it exceeds the

petroleum consumption of all of Latin America including Mexico and Brazil.[1] Obviously a savings of this magnitude would have a significant impact on the world oil situation. On the basis of the technology which has already been demonstrated by VW, it appears that 40 mpg 10 years from now and 60 mpg 15 years from now are technologically achievable targets. In the light of the probable seriousness of our liquid fuel shortage by the 1990's, I think that such targets must be seriously considered.

As Senator Jackson pointed out last week, while spokesmen for the automobile companies in his hearings were willing to agree that 40 mpg is technologically achievable, none of them were willing to indicate that they had any plans to make such cars in the foreseeable future. Their reasons for holding back were summarized by the spokesman for Ford. He said:

"By 1985, we will have a fleet much like that of the rest of the world . . . there is no longer a need to play "catch up." New car fleet averages even in countries with a long history of higher gasoline prices and total dependence on imported oil do not begin to approach 40 mpg. In these circumstances, it would be most difficult to predict market, volume and employment consequences for levels like 40 mpg . . ."

Here we see the problem: Detroit is treating the imports as a stationary target. The auto companies are unwilling to plan to build fifteen years from now cars which on average are more efficient than foreign car manufacturers are building today. The fuel economy of the imports is not a stationary target, however. Between model years 1979 and 1980, while US manufacturers improved their fleet average fuel economies by an average of 2.5 mpg, the foreign manufacturers did also and the gap stayed constant. It appears likely therefore that, unless US automakers aim toward a target fuel economy which is higher than the imports are getting today, they will always be playing "catch up."

This is where Congress comes in. Congress, to the extent that it can, must make it safe for US automobile manufacturers to work systematically toward ambitious fuel economy goals with 10 and 15 year lead times.

In my view, what is required is a three pronged policy:

(1) We need fuel economy standards at least as high as have been proposed in the Jackson-Magnuson amendment—preferably higher. This would protect auto manufacturers who produce fuel efficient vehicles from competitors who might otherwise try to undercut them with heavy promotions of less fuel-efficient vehicles which could be made cheaper (in first cost at least) because they wouldn't require new investments in tooling. With ambitious fuel economy standards I would hope that we would never again have to witness the shameful spectacle of US auto manufacturers trying to convince the public that buying fuel efficient cars is not in their interest.

Ten to fifteen years advance notice would reduce the extra cost of retooling for increased fuel economy enormously because most of the automobile industry's tooling will have to be replaced during that length of time anyway. In contrast, the approach which the manufacturers are following today: tooling up to build 25 mpg cars, is potentially disastrous. It is quite likely that, after this investment has been made, Detroit will find that new car buyers want 40+ mpg cars and that foreign manufacturers are ready to supply them.

(2) We need a big gasoline tax such as the Europeans and Japanese have to motivate new car buyers to purchase vehicles as efficient as the national security demands. In the fuel economy hearings over the past two weeks the auto manufacturers have repeatedly complained that it is government policies maintaining the level of US gasoline prices at artificially low levels that have created the US market for gas guzzlers.

Even with oil price decontrol, US gasoline prices will still be up to two dollars lower than the prices in Europe and Japan, because of the difference in our gasoline taxes. As a result, the foreign market for fuel efficient vehicles will continue to be ahead of ours—which is of course an advantage to foreign manufacturers in world competition.

It is not necessarily true that a gas tax will be harder on lower income people than on the rich. Many schemes have been developed by now for rebating gas tax revenues which would return more money to lower income groups than the gas tax would take away, but which would still encourage everyone to save gasoline.

(3) Finally, Detroit may need some help from the government if it is to raise all the 100 billion dollars or so that it now needs to retool to make more efficient cars. The government should condition this help, however, on Detroit making a commit-

[1] The savings of 5 million barrels a day in the year 2000 also equals the potential shortfall for 1990 which I described. Unfortunately it would come 10 years later. This means that we must push equally aggressively to save oil in buildings and in industry over the next ten years.

ment to build really efficient cars, not just 25 mpg cars which will soon be as obsolete as today's gas guzzlers.

In my view such help to the industry will bring much larger returns in national security per dollar invested than the tens of billions of dollars which have already been committed to subsidize the production of synthetic fuels and to building up a military force that can be rapidly deployed to the Middle East. Our problem is that we have built into the current fleet of American automobiles a petroleum-consuming monster whose thirst we can no longer satisfy without getting deeper and deeper into trouble both internationally and environmentally. The solution is to replace this fleet as fast as we can with vehicles which are gas sippers, not gas guzzlers.

In summary then what we need is:

(1) ambitious fuel economy goals;

(2) a gas tax as big as other auto manufacturing countries have, and

(3) a financial assistance package which will make it possible for Detroit to retool to produce vehicles as fuel efficient as our national security demands.

Forty Miles a Gallon by 1995 at the Very Least—Why the United States Needs a New Automotive Fuel Economy Goal

BACKGROUND

Until recently, virtually all of our nation's energy planning has been built on the expectation that petroleum prices and the availability of petroleum will change only slowly. Thus, the most recent (1978) Annual Report to Congress[1] by the Department of Energy projected that gasoline prices would rise at a rate of only a few percent per year with a doubling occurring at the earliest by the year 1995. Such a projection must have seemed reasonably conservative in 1978 when gasoline prices had been declining for four straight years at an average rate of 2 percent a year (in constant dollars) since their "anomalous" 25 percent increase during the winter 1973–1974 Arab oil embargo (See Figure 1[2]).

During the last year, however, we have become aware of the many other ways in which petroleum exports form the Middle East could be disrupted, requiring our allies and ourselves to cut back consumption by millions of barrels per day. And we have had the experience of seeing even a relatively minor reduction in world supplies precipitate in our own country half mile long gasoline lines and gasoline prices which, are now expected to be at twice their 1978 levels in constant dollars by 1981.

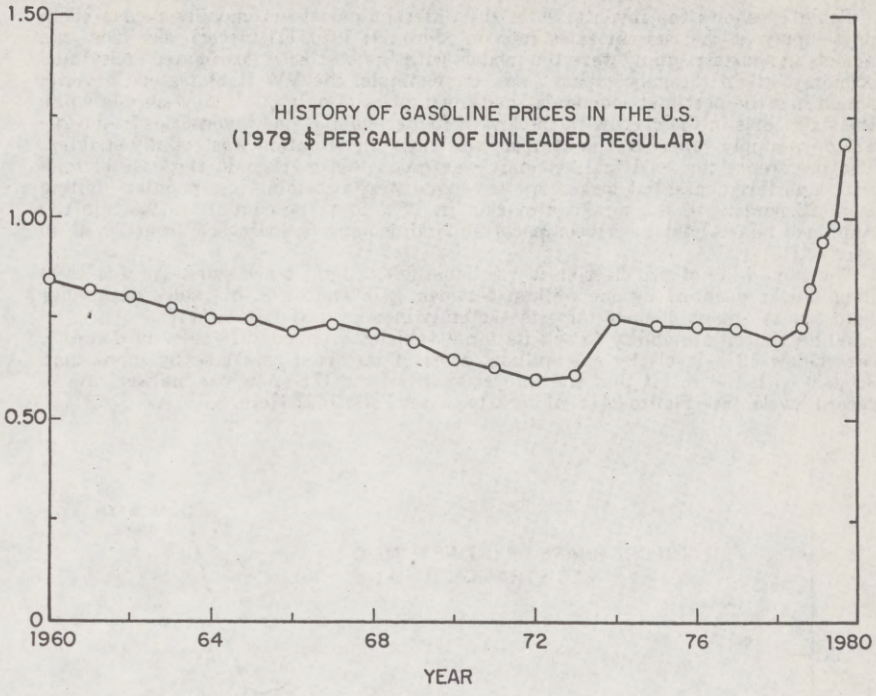

Figure 1

The United States consumes 30 percent of the total world production of petroleum.[3] Obviously, to the extent that we can cut our thirst for this liquid, the less disruptive any sudden supply cut-off will be and the less serious the international crisis which will result.

These perceptions are not new. The Arab oil embargo six years ago also focused national attention on the vulnerability which had come with our increasing dependence on imported petroleum. As a result, Congress in 1975 targeted the single largest cause of our enormous consumption of petroleum: America's 100 million gas-guzzling automobiles. A law was passed which mandated a doubling of the average fuel economy of new U.S. automobiles by 1985—to a minimum Corporate Average Fuel Economy (CAFE) of 27.5 miles per gallon for each auto manufacturer. Intermediate minimum standards were set by Congress for the years 1978–1980 and by the Secretary of Transportation for the years 1981–1984.[4]

Prior to the gasoline price rises of 1979, the US automobile manufacturers tried to slow the Department of Transportation's implementation of the fuel economy law.[5,6] They were reluctant to spend more than the absolute minimum required for retooling—perhaps because they were convince that they were being forced to make smaller less powerful passenger cars than the American public really wanted. And Congress forgot the urgency that it had felt in 1975 about the need for fuel economy improvements. Some key Congressional committees even began to listen sypathetically to complaints form the auto manufactureres that the EPA and DOT were being too aggressive in implementing the fuel economy law.[7]

Early in 1979, however, as a result of the gasoline price increases and uncertainties about future gasoline supplies, new car buyers began demanding an average fuel economy which was both higher than Congress had mandated and higher than Detroit could supply. A year later, despite the lay-offs of one quarter of a million auto workers,[8] despite heavy promotion of their big cars and trucks,[9] and despite steep price increases on their fast selling fuel efficient vehicles,[10] the domestic auto manufacturers had still not succeeded in getting their inventories back in balance.

Table 1[1] shows the inventories of the different model automobiles measured in days-supply at the current sales rate on March 1, 1980.[11] In each size class the models in shortest supply were the models with the best EPA "estimated" (city) fuel economy.[12] In the subcompact class, for example, the VW Rabbit and Chevette, which had the best fuel economies, had inventories of only 30–40 days-supply while the six models in the class with the lowest fuel economies had inventories in the 70–120 days-supply range. In the compact size class the situation was equally striking. The preference for good fuel economy was much less marked in the case of mid-sized and large cars, but large cars as a class were becoming less popular—falling from 22 percent of the new car market in 1978 to 18 percent in 1979 while the combined share held by subcompacts and minicompacts increased from 30 to 40 percent.[13]

The same kind of size class shift was being felt in light truck sales. Total sales of light trucks declined by one million between 1978 and 1979, but sales of smaller light trucks—many of them imports—actually increased by 100,000.[14]

While Detroit's inability to sell its large vehicles dropped 1979 sales of domestic cars below 1978 levels by one million, sales of imported cars rose by more than 300,000 with the result that the import share of the U.S. new car market rose to record levels. (See Figure 2.[15])aI35 Strip Offset Folio 1592 Here

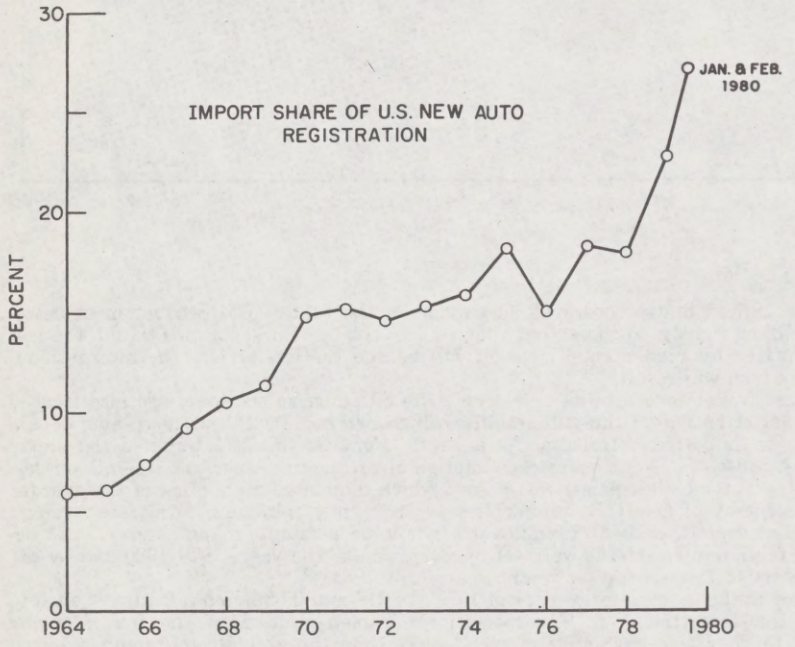

Figure 2

It is generally agreed that, without the pressure of the federal fuel economy standards, Detroit would have been caught even more unprepared for the sudden market demand for energy efficient vehicles. Thus, for example, Douglas A. Fraser, President of the United Auto Workers, recently stated that, without the standards:[16]

"We might have all Chryslers. We would not have [G.M.'s] 'X' cars or the [Chrysler] Omni. Without the standards, the industry would be devastated."

It is now only five years til 1985—not a long time in comparison to Detroit's planning horizon[17]—and it would appear timely for the Congress to address the question of post-1985 automotive fuel economy standards. In the absence of new initiatives, the federal minimum standard would remain at 27.5 mpg as measured

[1] Table 1 may be found at the end of the report.

by the EPA test. Data for 1974–1978 model automobiles indicate that this may correspond to only approximately 20 mpg on the road (see alos Figure 30.)[18]

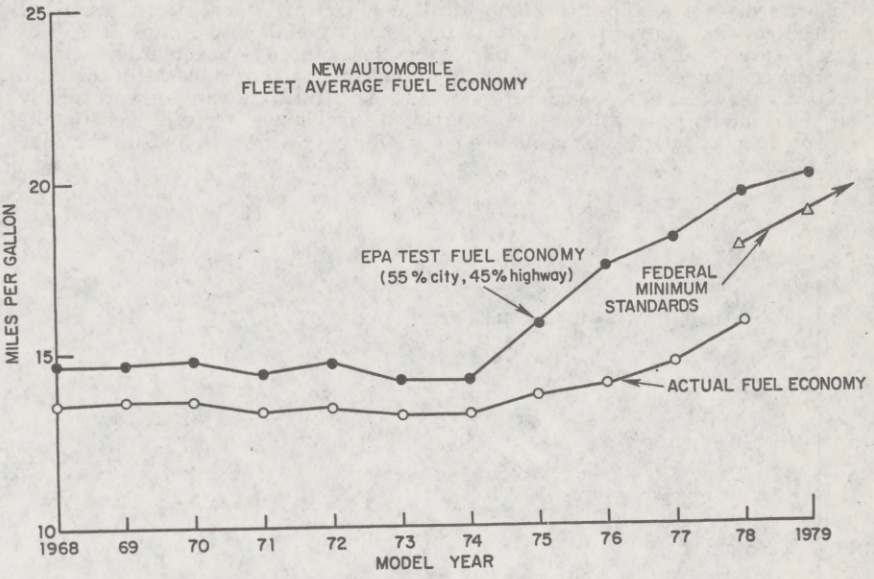

Figure 3

THE JACKSON-MAGNUSON PROPOSAL

Recently, twelve Senators led by Senators Jackson and Magnuson have taken the first initiatives to propose post-1985 automotive fuel economy standards. The Senators propose that by 1995 the minimum average automotive fuel economy of new cars should rise to 40 miles per gallon on the road.[19]

Such a fuel economy target is obviously achievable. VW has been selling since 1977 the diesel Rabbit which has a fuel economy af about 42 mpg on the road—almost three times the current US average. Although the Rabbit's exterior dimensions may be smaller than what we became accustomed to in the era when endless hoods and endless trunks made American cars look more like aircraft carriers than passenger vehicles, the hatchback version in only 20 percent smaller than the average US car when measured in terms of interior space.[20]

National and international security and economic interests require that we make as rapid a reduction of our petroleum consumption as possible. It may well turn out, therefore, as the proposed standards are considered further and the major technology opportunities for going well beyond the VW Rabbit technology become clearer, that the Senators have chosen a 1995 target that is too low.

Recently Charles Gray, the Chairman of the Transportation Task Force of the Solar Energy Research Institute Solar/Conservation Study, presented an analysis which indicated that a combined fuel economy standard for automobiles and light trucks of 80 mpg should be technically feasible with technology which exists in prototype today assuming an automobile and light truck size mix in which the vehicle with "average" fuel economy would be a four passenger car.[21] VW has already tested a 4 passenger car with an advanced small diesel engine and obtained an EPA composite fuel economy in excess of 70 mpg (see below). The company is also developing, in a four-year program funded in part by the West German government, a light weight low drag automobile larger than the Rabbit which is expected to get a fuel economy "in excess of 65 mpg" and to satisfy "all other requirements with respect to pollution and to vehicle safety."[22]

THE PROBLEM OF GAS GUZZLING LIGHT TRUCKS

Thus far no new legislation has been proposed which addresses the question of post-1985 fuel economy standards for light trucks (pickups, vans, etc.). During the past few years, for every ten new automobiles sold, three new light trucks have also

been sold. (See Figure 4).[23] These vehicles loom even larger in the Nation's gasoline consumption picture than their numbers indicate because they use more fuel per mile on average than cars. Because light trucks have such diverse uses, Congress did not establish any numerical fuel economy standards for them but instead gave the authority to do so to the Secretary of Transportation. The DOT has, however, been indecisive in implementing this authority—to date it has delayed its decisions on each model year until it was so late that it could do little to influence the plans of the manufacturers.[24]. Since light trucks are used principally for the same purposes as passenger cars,[25] the result is a major loophole in the fuel economy standards that should be more effectively addressed by both the DOT and Congress.

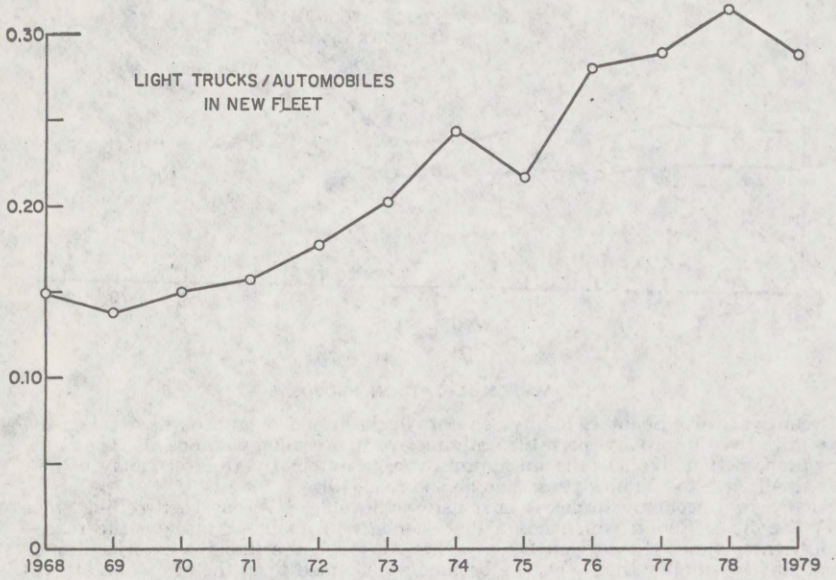

Figure 4

Below I discuss in more detail why post-1985 automotive and light truck fuel economy standards are both necessary and practical and also some of the issues which they raise.

THE POTENTIAL SAVINGS

If our current fleet of 100 million automobiles were getting an average of 40 mpg instead of about 15 mpg on the road, U.S. petroleum imports would be reduced by almost 3 million barrels a day. If the fuel economy of our current fleet of 30 million light trucks were improved by a corresponding factor to 30 mpg from about 12 mpg on the road, we would be able to forgo the import of another one million barrels a day (see Figure 5).[26] The 4 million barrels a day total reduction would correspond to about one-half of our current level of imports—or alternatively the total petroleum consumption of Latin America—or alternatively three times the total petroleum consumption of China. If, as is usually assumed, population growth and increasing affluence drive up the level of light vehicle miles traveled in the future, the savings would increase correspondingly.

RATE OF PETROLEUM CONSUMPTION BY TWO LIGHT VEHICLE FLEETS

(10^8 AUTOS, 0.3×10^8 LIGHT TRUCKS, 10^4 MILES PER VEHICLE)

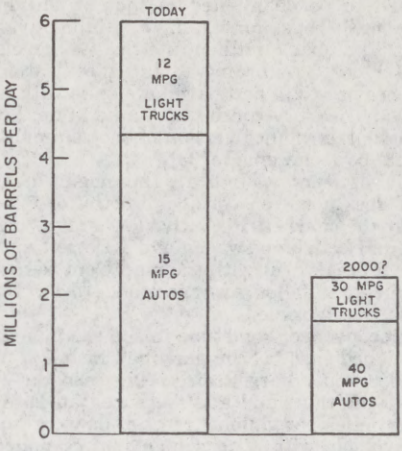

Figure 5

THE MARKET FOR FUEL ECONOMY

Some analysts oppose higher post-1985 fuel economy standards. They object, on principle, to a regulatory approach to the gas guzzler problem. "Let the market do it," they say, pointing to the fact that the recent increase in the price of gasoline has created a market demand for increased fuel economy.

What about the market? In 1976 it cost an estimated 20 cents per mile (1979$) to operate a "standard" size automobile. At an average on-road fuel economy of 13.5 mpg, only about 5 cents per mile went to the purchase of gasoline costing about 70 cents per gallon (1979$).[27] Assuming gasoline climbs in the next year or so to twice the 1976 price in constant dollars, the cost of operating this same car (other things being equal) would climb to 25 cents per mile (1979$). This would create a market incentive for the average car owner to buy a more fuel efficient car next time—but how much more fuel efficient? If he or she were able to go out and buy a new car which was identical to the old car except that it got twice the on-road fuel economy (27 mpg), then the gasoline costs would be reduced back down to 5 cents per mile and presumably the car owner would be as happy as before. But a doubling of fuel economy cannot ordinarily be obtained without cost. The new car would probably be either more expensive (in constant dollars) than the old one or smaller. As a consequence the new car buyer would probably end up "splitting the difference" and buy a new car with less than twice the fuel economy of the old one. (In the economist's jargon this would correspond to the "elasticity" of the demand for new car fuel economy as a function of gasoline price being less than unity.) And, indeed, when in the mid-1970's European gasoline prices were approximately at the current U.S. level,[28] the average fuel economy of European automobiles was only about 21 miles per gallon as measured on the road.[29] This would correspond to an average EPA composite fuel economy probably slightly higher than the 1985 U.S. standards of 27.5 mpg.[18]

A spokesman for Ford Motor Company appeared to be basing his conclusions on this type of analysis when he recently testified against 40 mpg fuel economy standards.[30]

"By 1995 we will have a fleet much like that of the rest of the world—conditioned to high energy prices . . . there is no longer a need to play 'catch up.' New car fleet averages even in countries with a long history of higher gasoline prices and total dependence on imported oil do not begin to approach 40 mpg. In these circumstances, it would be most difficult to predict market, volume and employment consequences for levels like 40 mpg . . ."

Similarly a survey of the leadership of the automobile industry found that "[t]he panels, as a whole, forecast a 30 mpg CAFE by 1990."[31] It is probably not

coincidental that 30 mpg happens also to be almost exactly the average composite EPA fuel economy of the cars imported into the U.S. during the first half of model year 1980.[32]

As a result of this perception by the domestic automakers, it appears that there is little if any effort going on to tool up to produce 40+ mpg vehicles. Instead much development effort seems still to be channelled in more traditional directions—toward cars with "performance." Thus, for example, Automotive News recently reported that Pontiac had just "pumped 8 million into the . . . development budget" of a new two seat "commuter car." According to the specifications given in the story, this commuter will be heavier than and have an engine with almost twice the power of the VW Rabbit diesel. The story continues: "in addition, Pontiac engineers are working on a sportier, high-performance version of the commuter" which would be equipped with an even more powerful engine.[33]

The following anecdote may also serve to indicate the magnitude of the efficiency improvements which Detroit does not even consider worthy of investigation based on its current perspective on the market: Recently, I was at a meeting at which engineering representatives from both Volkswagen and a Detroit auto manufacturer were present. During the lunch break I sat with the man from Detroit and discussed with him the proposed 40 miles per gallon average standard for 1995 automobiles. He responded flatly that it was not feasible.

After the lunch the group reconvened. Sometime in the ensuing discussion, one of the engineers from VW mentioned that his company had installed in a four passenger car a small three cylinder supercharged direct injection diesel engine which shuts off under coast or idle conditions and had measured an EPA composite fuel economy of "seventy to eighty miles per gallon." Most of us were unaware that VW had actually put together a vehicle with such a high fuel economy.[34] This news therefore caused some excitement. The engineer from VW seeing this hastened to add that the vehicle was not ready for mass production—for one thing, he said, "the idle is unacceptably rough." He did agree, however, that VW could certainly market a vehicle with comparable fuel economy by the 1990's. At this point, the man from Detroit broke in and said: "Sure, so could we, but who would want to buy such a car?"

We simply don't know what percentage of Americans would be interested in a relatively low performance 70–80 mpg subcompact today. Each gasoline shortage and/or price hike in the future is likely to increase that percentage, however, and we can expect such repeated shocks in the future.

Despite the decontrol of U.S. petroleum prices, Exxon is currently projecting that U.S. petroleum production will decline by more than one-third by 1990.[35] And President Carter has set as a target a cut in U.S. petroleum imports to approximately one-half their current level by 1990[36]—a goal which appears to realistically reflect the likely availability to the U.S. of foreign petroleum in that time frame. At the same time the Department of Energy projects that population and economic growth during the 1980's will increase the miles traveled by automobiles and light trucks by forty percent. This would approximately offset the reduction in consumption per vehicle mile which is expected to result from the current standards.[37] It is hard to see how it will be possible for Americans to retain our accustomed level of mobility with the amount of transportation fuel that is likely to be available from our reduced petroleum budget without much more dramatic increases in automotive fuel economy.

As the prospect of chronic transportation fuel shortages becomes more widely understood by the public it is likely that more and more Americans will decide that their choice is between having a small fuel efficient car such as the VW research vehicle—at least as a second car[38] or not being able to get where they want to go. Based on past experience, however, when the demand materializes on a large scale, it will be precipitated by some sudden shock such as another gasoline line crisis and Detroit will once again be caught unprepared.

Here once again, I would therefore like to quote the engineer from Detroit. He said: "If by any chance you want us to be producing cars like that by 1995, you had better let us know soon!"

If the nation's security demands that the average on road fuel economy of U.S. automobiles be raised much higher than 20–30 miles per gallon during the next ten years therefore, it will be necessary for the federal government to put policies in place which will encourage automobile buyers to want more fuel efficient vehicles and which will also ensure that the automobile manufacturers start tooling up to produce these vehicles without undue delay.

MARKET FORCING

One obvious way to give new car buyers a stronger incentive to take into account the national interest in reducing gasoline consumption would be to introduce in the U.S. a stiff gasoline tax such as the Europeans have had for years.[39] New car buyers could largely escape the effect of this tax by moving to more fuel efficient vehicles than they would otherwise have bought. The problem is of course how to soften the blow to those who would have to wait until these fuel efficient vehicles became available in the used car market. This complex subject has been explored elsewhere.[40]

How far a gasoline tax would push new car buyers toward fuel economy in the absence of other policies is uncertain, however. Because of this uncertainty and the current shortage of investment capital Detroit would probably "play it safe" by following the market and make incremental investments in a series of relatively small fuel economy improvements. This would avoid the danger of overinvesting in fuel economy in the short term, but the resulting fuel economy improvements would be a much slower and cumulatively more expensive route to a 40+ mpg fleet in the 1990's than a 10–15 year program systematically directed toward the achievement of a specific fuel economy target.

The role of fuel economy standards would therefore be to supplement a gasoline tax by making a clear national commitment to a specific minimum target. The auto manufacturer who produced fuel efficient vehicles would then be protected from competitors who might otherwise lag behind and capture that diminishing but traditionally lucrative part of the market which is still interested in the "long look" or engines which are "loaded with power." (One witness from Detroit recently testified: "There were never any profits in small cars in our company."[30])

TECHNOLOGY FORCING

When new car buyers decided in the middle of model year 1979 (March) that they wanted to reduce their gasoline costs, one of their principal tactics was to buy a smaller car. As Table 1 shows, however—despite the technological opportunities which have been demonstrated in the VW Rabbit diesel—the differences between the fuel economies of the small and large cars made by US auto companies are surprisingly small. As a result, the chaos in the new car market caused by the shift to small cars had a surprisingly small payoff in increased energy efficiency: only one mile per gallon average composite EPA fuel economy improvement between the first and second halves of the model year 1979.[41]

Fortunately, however, at the same time that Detroit was under pressure from the market to produce more small cars, it was also under pressure from the federal fuel economy standards to improve the energy efficiency of all its cars in ways that would be undetectable to most new car buyers. The payoff from this "technology forcing" became visible in September 1979 when the model year 1980 cars came out. In order to meet the stiffer model year 1980 minimum Corporate Average Fuel Economy (CAFE) standards, the auto manufacturers had cut the weight and improved the aerodynamics of their cars. They had also installed smaller engines, better transmissions, better carburetors and lower rolling resistance tires.[42] As a result, the EPA fuel economy of each model year 1980 car was an average 2 miles per gallon higher than that of the model year 1979 car which it replaced. The fuel economy effects of these technology improvements and the market shift were additive and the average composite EPA fuel economy of the new car fleet sold during the first four months of model year 1980 was almost three miles per gallon higher than that of the model year 1979 fleet.[43]

This experience makes clear once again that even if there is a strong market demand for fuel economy, if the manufacturers drag their heels in making design improvements, new car buyers will get a lot less than they are asking for. Tough fuel enomomy standards help force the pace of technological improvement.

MAKING THE MARKET PREDICTABLE FOR DETROIT

In a situation of uncertainty concerning the future demand for fuel economy, it might be expected that an industry which has traditionally minimized its capital investments in new technology (as opposed to style changes) will not invest in the tooling required to make fuel efficient automobiles. For the nation, however, such a strategy of following the market is unacceptable. It takes approximately ten years to replace our fleet of automobiles. if we add a five year delay for Detroit to catch up with the new car buyers, the fuel economy of the automobile fleet on the road will always be fifteen years behind what new car buyers are demanding. Events over the next two decades will just move too rapidly for us to have the luxury of

such a long adjustment period without major disruptions in our economy and potentially serious international confrontations resulting from petroleum shortages.

We must therefore make sure that Detroit does not waste any more time waiting to make sure that a market really will exist for cars which get better than 40 mniles per gallon. This can only be done by setting a national fuel economy target such as that proposed by Senator Jackson and his colleagues. If this target is backed up by a stiff gasoline tax, then the market for fuel economy will have been made predictable for Detroit, and the auto manufacturers will be able to focus on building cars which are as energy efficient as the national security requires. (A potential additional benefit to US auto workers and auto manufacturers of such a strategy is that, if our national fuel economy standards push U.S. automobile technology beyond that of Europe and Japan, we might see a demand for U.S. cars develop in those countries.)

WHY NOT SYNTHETIC FUELS INSTEAD

It is often suggested that a more economical alternative to retooling the U.S. automobile industry to produce "gas sipping" cares would be to invest the money instead in building plants which would produce gasoline from coal and alcohol from corn as a substitute for imported oil.

As far as alcohol is concerned, any likely level of supply would not propel America's current fleet of gas guzzlers very far. Even if all the corn grown in the U.S. were fermented into ethanol, it would still supply less than one-fifth of the energy consumed in U.S. automibiles today.[44] If U.S. cars become much more fuel efficient, however, the potential significance of fuels derived from biomass will become correspondingly larger.

Synthetic fuels could eventually be produced from coal, oil shale etc. in sufficient quantities to fuel our gas guzzlers but probably only at a cost much greater than that which would be required to shift Detroit over to the production of energy efficient light cars and trucks. In fact, the proposed federal contribution of up to $88 billion to help start up a U.S. synthetic fuels industry which would by 1992 produce "the equivalent of at least 2 million barrels of oil per day of synthetic fuels"[45] would by itself be more than enough to pay the entire cost of retooling the U.S. automobile industry to produce fuel efficient automobiles and light trucks.

The DOT's Transportation Systems Center has estimated that the total cost for retooling the U.S. automotive industry "for a continued post-1985 increase in motor vehicle fuel economy to a mid-1990's level of 40–50 miles per gallon for passenger cars and 25–35 miles per gallon for light trucks with a resulting saving of 2–3 million barrels per day in the year 2000," would require capital investments of 67 billion (1979) dollars.[46]

Any requirement for government aid over this period would presumably be much less since, in the absence of rising federal fuel economy standards, the industry could be expected to invest on the order of $50 billion over the same ten year period (1985–1995) in routine repair and replacement of its production capacity.[47] (This, of course, is the principal retionale for giving Detroit a ten to fifteen year lead time to phase in the production capacity for fuel efficient light vehicles. Over this period Detroit would ordinarily go through major retooling programs to produce two new "generations" of vehicles[48] and much of the plant and equipment not affected by these design changes would become obsolete and have to be replaced. As a result, the incremental costs of introducing fuel economy improvements in the course of all this turnover of capital equipment would be much reduced.)

Without outside assistance, however, Detroit might have difficulty in raising the capital it will need to retool. It is important therefore to assess and to begin public discussions as to whether such assistance will be required and how it might be most effectively provided.

Even if it were no less expensive than the development of synthetic fuels, a strategy based on light vehicle fuel economy improvements would still be preferable—both because of the pollution associated with fossil fuel production and consumption and because of considerations of international equity.

Locally, pollution problems would be reduced because in most cases they are directly proportional to the amounts of fossil fuels being produced (at refineries, synfuel plants, coal mines, etc.) or being burned. Globally we know that the current level of global fossil fuel use is leading to a build-up of carbon dioxide in the atmosphere toward a level that climatologists fear will result in major changes in the global climate during the next century. [49] If we can cut our consumption of fossil fuels by increasing the efficiency of their use, therefore, we will be buying extra time for the world to make the necessary transition to other energy sources.

Considerations of international equity arise because it does not appear likely that with current technology the global environment could tolerate a level of energy use

by the other peoples of the world at the current U.S. per capita rate. To the extent therefore that we reduce our energy use by efficiency improvements, our society will be coming closer to being a model which the rest of the world can realistically emulate without precipitating an environmental catastrophe.

WHAT COULD GO WRONG

There are of course some potential hazards associated with stiff national fuel economy standards. These include: possible rejection by the market, the safety issues associated with small cars, and the air pollution problems associated with diesels.

Market Rejection: Prior to the 1979 market shift, Detroit was arguing that the government was forcing it to make smaller automobiles than the public wanted, that many new car buyers might therefore decide to hold on to their old cars for a year or two longer, and that as a result more than one hundred thousand auto workers might lose their jobs. [50] Of course, just the opposite happened with worse results: The U.S. market rejected Detroit's big cars because they were not fuel efficient enough and over 200,000 auto workers lost their jobs. What if, however, Detroit's nightmare about getting ahead of the market came true?

Not surprisingly, the Congress in 1975 built more than ample safeguards into the fuel economy law to protect the automobile companies from serious damage if the standards should turn out for any reason to be too ambitious. The Jackson-Magnuson proposal would maintain and even increase these protections: The Secretary of Transportation would be authorized to lower the 1995 fuel economy standard to 35 mpg and could lower it still further subject only to a one House Congressional veto. Furthermore, the penalty for a company which did not achieve the fuel economy standards would continue to be a civil penalty of $50 per car per mpg of shortfall—hardly a draconian amount [51]—and even that penalty could be reduced on the recommendation of the Federal Trade Commission for a manufacturer in serious financial trouble.

Finally, it is difficult to envision any likely future development which would lead to a sudden shift of consumer demand toward less efficient cars. Since the increase of the fuel economy standards will be relatively gradual—about 1–2 mpg per year if we have a target of 40 mpg by the year 1995—any situation in which the fuel economy standards get ahead of the market will therefore develop relatively slowly, giving ample time for corrective action before a serious gap can open up.

Any concerns about market rejection due to overshooting the consumer demand for fuel efficiency are likely to remain as groundless in the future as they have been in the past, however. If the world's future petroleum situation continues to look as serious as it does now, it is all too likely that the nation's biggest dislocations will continue to result from overestimates of the length of time which we have to shift over to cars with the fuel efficiency which fortunately VW has already shown to be achievable.

Safety: Concern is often expressed that the trend towards smaller cars will result in a higher automobile accident fatality rate. Indeed, this concern is widely enough shared so that it may be slowing the market shift. Paradoxically, although most Americans refuse to use their automobile seat belts, many of them justify buying larger heavier cars than they need because they believe that larger cars are safer. [52]

It is certainly true today that, in collisions between typical large and small cars, the occupants of the small cars are much more likely to be killed. [53] For this reason the National Highway Traffic Safety Administration (NHTSA) has over the past few years consistently pushed for safety related design improvements in small cars especially. Some recent progress in this area is indicated by the fact that, of the four model year 1980 US cars which NHTSA found provided a high level of protection for seatbelted passengers in 35 mph front and rear crashes into massive barriers (the legal requirement is such protection at 30 mph), two were subcompacts (the Plymouth Horizon and the redesigned Ford Mustang) and another was one of GM's radically downsized X-body cars. [54]

NHTSA also has a demonstration program to show how much automobile safety can be improved. In this program the agency has modified a VW Rabbit diesel to obtain a composite EPA fuel company of 60 mpg and to provide occupant protection in 40 mph frontal crashes, [55] and has developed another light research safety vehicle which provides protection to front seat occupants in frontal crashes at speeds up to 50 mph as well as substantially enhanced protection in crashes of other types. [56] It appears therefore, that a national commitment to higher fuel economy standards need not result in increased carnage on the highway *if* it is accompanied by a renewed national commitment to increased automotive safety.

Diesel Pollution: The issue of diesel pollution is currently also quite controversial. Diesel engines are today 20–30 percent more fuel efficient than spark ignition engines, [57] but without emission controls they also emit about one hundred times the weight of small particles produced by comparable gasoline engines and the particles carry absorbed carcinogens of as yet unknown potency. [58]

Assuming that these carcinogens have the same potency as those associated with coke oven emissions, an EPA task force estimated in 1979 that, if 25 percent of the US light vehicle fleet were diesels emitting 1.08 grams of particles per mile, an additional 600 cancer deaths per year might ultimately result. [59]

The emission level assumed is appropriate to a diesel engine for a "large automobile or light truck," however. The particulate emissions from the current VW Rabbit diesel are approximately three times lower, and apparently, as this engine is modified to reduce its fuel consumption, its particulate emissions are also reduced. [60] Furthermore, exhaust gas treatment devices are being tested by the Environmental Protection Agency which are expected to make possible a reduction of diesel particulate emissions to one third of their uncontrolled level. [61]

It appears therefore that it should be possible to reduce the particulate emissions from small diesel engines down to an acceptable level. It is important to "keep the pressure on" the designers of diesel engines to make them as clean as is practicable, however. In this connection it is fortunate that there is at least one engine in an advanced stage of development, Ford's "PROCO" stratified charge spark ignition engine, which has a fuel economy which is comparable to that of the currently commercialized version of the diesel but which does not share the diesel's particulate emission problems. [62]

Conclusion

It appears that the time has come to retire American gas guzzlers in favor of smaller, more efficient vehicles which will provide us with the transportation we need without consuming more fuel than is consistent with a stable international political situation. Higher fuel prices are pushing us in this direction, but not predictably enough for either the national security or Detroit's long term product planning. We need federal fuel economy standards and the automobile industry may need federal help in raising the capital that will be required to retool to meet these standards.

References and Notes

1. U.S. DOE Energy Information Administration, Annual Report to Congress, Vol. 3, pp. 69 and 71.

2. Data for figure 1 derived from the following sources: *Gasoline prices:* 1960–1973, U.S. DOE, *State Energy Fuel Prices by Major Economic Sector from 1960 through 1970* (Preliminary Report, July 1979), p. 40; 1974–1977, U.S. DOE EIA *Annual Report to Congress,* 1977, Vol. III, p. 45; 1978–1979, U.S. EIA *Monthly Energy Review,* March 1980 [DOE/EIA 0035/03 (80) p. 83]; and March 1980, personal observation. *GNP Deflators:* 1960–1970, U.S. DOC, *Historical Statistics of the United States, Colonial Times to 1970,* Part 1, p. 224; 1971–1979, US Congress, Joint Economic Committee, *Economic Indicators,* March 1980, p. 2; March 1980, extrapolation at 1979 rates.

3. In 1976 the U.S. consumed 29%, Western Europe 23%, the USSR 13%, Japan 9%, Latin America 6.5%, Eastern Europe 3.1%, Canada 3.0%, Southeast Asia 3.0%, the Middle East 2.5%, China 2.3%, Africa 1.9%, Australia 1.3%, and South Asia 1.1%. Total world consumption was 58.8 million barrels per day. [British Petroleum Company, *Statistical Review of the World Oil Industry, 1976,* (London, 1977), p. 21.]

4. *Energy Policy and Conservation Act of 1975* (Public Law 94-163), Title III. According to the Act, fuel economy "shall be measured . . . in accordance with testing and calculation procedures established by the EPA Administrator, by rule. Procedures so established with respect to passenger automobiles shall be the procedures utilized by the EPA Administrator for model year 1975 (weighed 55 percent urban cycle and 45 percent highway cycle), or procedures which yield comparable results. Procedures under this subsection, to the extent practicable, shall require that fuel economy test be conducted in conjunction with emissions tests conducted under section 206 of the Clean Air Act."

Average fuel economy for an automobile manufacturer according to the Act by calculating the production weighted average fuel consumption measured in gallons per mile and then taking its reciprocal. The pre-1985 automotive fuel economy standards are: 1978—18 mpg; 1979—19 mpg; 1980—20 mpg; 1981—22 mpg; 1982—24 mpg; 1983—26 mpg; and 1984—27 mpg. See e.g., U.S. DOT, *Automotive Fuel Economy: Second Annual Report to the Congress,* (January 1978).

5. See e.g., U.S. DOT, *Report on Requests by General Motors and Ford to Reduce Fuel Economy Standards for MY 1981–85 Passenger Automobiles* (DOT HS–804 731), June 1979.

6. See e.g., Hearings before the Subcommittee on Environment, Energy, and Natural Resources of the House Committee on Government Operations, January 29 and Feb. 1, 1980.

7. See e.g., *Motor Vehicle Fuel Efficiency,* Hearings before the Subcommittee on Energy and Power of the House Committee on Interstate and Foreign Affairs, March 13, and 14, 1979.

8. The *Detroit Free Press* (April 4, 1980, p. 4C) in a story titled, "Lay-offs Worst Since '75 Slump" reported that 29% of the blue collar workforce of the major manufacturers had been laid off—223,000 out of 779,000. Since the time Ford and G.M. have laid off another 15,000 and 12,000 workers respectively. (*Automotive News,* April 21, 1980, pp. 1 and 2.)

9. A Dodge advertisement on the front page of the special Automobile Advertising Supplement of the April 11, 1980 *Washington Post* captures the worst of the hard sell for domestic large cars. The headline reads: "Special Attention: Honda, Toyota and Datsun Buyers, A $10,000 Business Proposition for the Thoughtful Car Buyer." It then goes on to state:

"According to the purchasing agent of a large fleet, the average price for a Honda Accord XL, Toyota Celica Supra, or a Datsun 810 is $8500 . . . and they give average gas mileage of 21 MPG according to the Environmental Protection Agency . . . You can buy a [1979] Dodge [Diplomat, St. Regis, or Magnum] for under $6,000 and save yourself $2,500 . . . and most have engines that deliver 16 MPG according to the EPA . . . you would have to drive the small import for an unbelievable 120,000 miles just to get your $2,500 back in gasoline savings [at $1.40 per gallon] . . . For most people this would take ten years of driving.

"It's simple arithmetic . . . all you have to do is take the $2,500 you save . . . and invest it in a savings and loan investment certificate . . . if you can get 15% for your $2,5000 investment you will increase your savings to well over $10,000 [in ten years] . . . According to Joan Claybrook, head of NHTSA [National Highway Traffic Safety Administration] in crashes in 1979 involving subcompacts and larger cars, 85% of the persons killed were riding in the subcompact . . . The Honda Accord XL, Datsun 810 and Toyota Celica are all subcompact cars."

The following is a partial listing of the problems with this advertisement.

(i) The 1980 Honda Accord XL, Toyota Celica Supra and Datsun 810 are each the most expensive models put out by their manufacturers (except for the Datsun 280 ZX two seater). Most of the 1980 models sold by these manufacturers list in the $4000–6000 range, i.e., generally cheaper than the 1979 Dodges. [*ref. New and Used Foreign Car Prices,* Summer 1980, (Buyer's Guide Reports].

(ii) The models listed in the Dodge Advertisement are also at the bottom end of each manufacturer's fuel economy range. For the three manufacturers the average sales weighted EPA "estimated" (city) fuel economy is approximately 30 mpg. [EPA, *1980 Gas Mileage Guide*]. *At $1.40 per gallon, the difference between a 30 mpg and a 16 mpg vehicle would cumulate to $2500 in 60,000 miles typically after 4–5 years instead of the 120,000 miles after 10 years calculated by the Dodge dealers for the 21 mpg imports.*

(iii) The 15 percent rate of interest assumed by the Dodge advertisement will only prevail if there is approximately a 15 percent rate of inflation. In that case, after 10 years the $2500 will be worth no more *in 1980 dollars* than it was in the beginning, yet most savers would have to pay a substantial fraction of their "interest" in taxes. An alternative way to see the effect of inflation is to note that, even if gasoline prices increased no faster than inflation (an unlikely assumption), after 10 years at a 15 percent inflation rate gasoline would cost $6.27 per gallon not the $1.40 constant prices assumed in the Dodge advertisement.

(iv) The question of the relative safety of small cars will be discussed below.

10. The latest price hike by GM averaged 2.2 percent and ranged from 4 percent on the X-body cars (Buick Skylark, Oldsmobile Omega, Chevrolet Citation and Pontiac Phoenix), and 3.7 percent for the Chevette—all cars at or near the top of the fuel economy range in their size classes (see Table 1)—to no increase for the Chevrolet Camaro which is near the bottom of the subcompact fuel economy range. *Automotive News* noted that:

"The X-cars have had a rather fantastic history of price increases ever since they were introduced on April 19, 1979.

They are GM's best selling models and the corporation has boosted them accordingly. In less than a year, the new front-wheel-drive compacts have jumped an average of $954 or 19.98 percent over their introductory stickers."

(John K. Teaken Jr., "GM Increases Prices by an Average of $186; 2.2 Pct. Hike Had Been Expected," *Automotive News,* April 7, 1980, p. 3.)

11. *Automotive News,* March 17, 1980, p. 8.

12. EPA, *1980 Gas Mileage Guide.*

13. Unweighted averages over calendar year, 1978 and 1979 market shares [David L. Greene *et al* "Monthly MPG and Market Share (3MS) Date System," Oak Ridge National Laboratory, Jan. 22, 1980.]

14. "Light Truck Registrations off 12.5 Pct.: Domestic Light Trucks Suffer Most in 1979," *Automotive News,* February 25, 1980, p. 8. (Small light trucks are those under 6000 pounds gross vehicle weight.)

15. Data for import of the US car market: 1964–1972, *Automotive News 1973 Almanac,* p. 10; 1973–1978, *Automotive News 1979 Market Data Book Issue,* p. 24; 1979, *Automotive News,* Feb. 25, 1980, p. 48; and Jan.-Feb. 1980, *Automotive News,* March 10, 1980, p. 38.

16. "Detroit: Hitting the Skids," Newsweek, April 28, 1980, p. 58.

17. According to a recent statement from G.M.: About 4 to 5 years is required to produce an entirely new automobile under normal conditions. This timing could vary somewhat depending, for example, on the availability of tooling industry capacity. If the entire auto industry is in the process of major retooling, the time to obtain new tools and equipment is extended.

[*Answers to Questions Posed in Connection with General Motors Testimony of April 30, 1980, Before The Senate Committee on Energy and Natural Resources,* p. 5.]

18. In a recent DOE survery of the in-use fuel economy of model years 1974–78 automobiles the following "best fit" relationship was obtained between the in-use fuel economy (Y) to EPA composite fuel economy (X): $Y^{-1}=0.765\times X^{-1}+0.024$. For X =27.5 mpg this relationship gives us Y=19.3 mpg. [Barry D. McNutt *et al* (DOE), "Comparison of EPA and In use Fuel Economy of 1974–1978 Automobiles," Society of Automotive Engineers Paper #790932 (1979)]. The 1974–1979 new car fleets had the following average estimated EPA composite fuel economies: 1974—14.2; 1975—15.8; 1976—17.5; 1977—18.3; 1978—19.6; and 1979—20.1. The estimated in-use fuel economy of the 1974–1979 fleets at 4000 miles were: 1974—13.2; 1975—13.8; 1976—14.1; 1977—14.7; and 1978—15.8. For the model year 1979 fleets, information on in-use fuel economy is only available from GM and Ford. These preliminary data indicate that the in-use fuel economy of the model year 1979 fleet will be in the range 15.7–17.2 mpg. [Ref. EPA, Draft Report to Congress, *Passenger Car Fuel Economy:* EPA and Road (January 1980)].

19. Amendment #1664, submitted as an amendment to S. 2015, *The Transportation Energy Efficiency Act of 1979.*

20. The measured EPA composite fuel economy of the VW Rabbit diesel equipped with a five speed manual transmission is 47 mpg. [EPA, *Test Car List* used to compile the *1980 Gas Mileage Guide.*] The best fit relationship between EPA (X) and on-road (Y) fuel economy obtained for diesel powered vehicles by McNutt *et al* (ref. 17) is $Y^{-1}=1.17\ X^{-1}-0.001$. At X = 47 mpg this relationship gives Y = 42 mpg. The interior volume of VW Rabbit hatchback is 91 cubic feet [*1980 Gas Mileage Guide* [vs. the 1979 estimated fleet average of 113 cubic feet. [J.D. Murrel (EPA), "Light Duty Automotive Fuel Ecomony . . . Trends Through 1979," SAE Paper #790225 (1979)].

21. Charles L. Gray, Jr., *The Potential for Improved Automobile Fuel Economy,* Statement to The Senate Committee on Energy and Natural Resources, April 30, 1980.

22. VW's program to develop a "Research Vehicle 2000 with a size between the compact and subcompact class [an] inertia weight [curb weight plus 300 pounds] of 1730 lbs. . . . and airdrag area smaller than 0.55 m^2, [and a] 1.2 liter supercharged Diesel using a control system which stops the engine at idling and deceleration modes, [which] is expected to attain a combined cycle fuel economy of more than 65 mpg . . . together with . . . all the other requirements with respect to pollutant emissions and to vehicle safety" is described in U. Seiffert *et al* (VW) "Improvements in Automotive Fuel Economy," (paper presented at the First International Fuel Economy Research Conference, Washington, D.C., October 31–November 1, 1979).

23. Data on ratio of light trucks to automobiles in new light vehicle fleet: 1968–1974, R. Knorr *et al., Projections of Automobile, Light Truck, and Bus Stocks and Sales, to the Year 2000* (Argonne National Laboratory, ANL/CNSV-TM-22, 1979, p. 8); 1975–1976, *Automotive News 1977 Market Data Book Issue,* pp. 46 and 68; 1977–1978, *Automotive News 1979 Market Data Book Issue,* pp. 14 and 44; 1979, *Automotive News,* Jan. 14, 1980, p. 34 and Feb. 25, 1980, p. 8.

24. Thus, for example, the fuel economy standards for model year 1982 light trucks which will be marketed beginning in September 1981 were only finalized in

March 1980. Standards for model years 1983–1985 are expected soon, however. [Helen Kahn, "Fuel Standard for Light Trucks Placed at 18 MPG for 1982," *Automotive News,* March 31, 1980, p. 1.]

25. One adjustable parameter in the EPA fuel economy test is the average load which the vehicle is expected to carry. In the case of automobiles, this average load is assumed to be the driver plus one passenger, each of average weight, for a total average load of 300 pounds. In preparing the regulations for the light truck tests for model year 1978, the EPA proposed that, because they are bought for their load carrying or hauling capabilities, it should be assumed for purposes of the tests that light trucks carry on average a total load of 500 pounds. When this proposal was attacked by the manufacturers, however, EPA could find no data to support the position that on average light trucks carry more load than passenger cars and therefore ended up assuming for fuel economy testing purposes that they carry the same average load. [Action Memorandum, EPA, Ann Arbor, "Regulations for 1978 and Later Model Year Light Trucks" (1976).]

26. In 1979 there were an estimated 104 million cars and 29 million light trucks (pickups, vans etc. of less than 10,000 pounds Gross Vehicle Weight) registered in the U.S. [Barry McNutt *et al* (US DOE), "On-Road Fuel Economy Trends and Impacts," Feb. 17, 1979 as updated April 19, 1979.] In 1977 U.S. automobiles traveled an average of about 9,800 miles and "single unit" trucks (mostly light trucks) traveled an average of 9,400 miles. The average fuel economy of the automobiles was estimated at 13.9 miles per gallon and of the single unit trucks 10.1 miles per gallon. [US DOT, *Highway Statistics,* 1977 (FHWA-HP-HS-77), p. 100.] I have increased these fuel economy numbers in the text to reflect improvements since 1977 and to compensate for the lowering effect of trucks (over 10,000 pounds Gross Vehicle Weight) on the average fuel economy of single unit trucks.

27. US DOT, *National Transportation Statistics, 1979,* p. 100. We have converted 1976 to 1979 dollars using a GNP inflator of 1.125 taken from *Economic Indicators* (ref. 2).

28. In June 1975 some European prices of regular gasoline per gallon (converted at March 1, 1979 exchange rates) were: France—$1.50, Italy—$1.29, United Kingdom—$1.18 and West Germany—$1.70 [CIA, *International Statistical Review,* 12 March, 1980, p. 20.]

29. General Motors has estimated, from 1976 Belgian, German, and Swedish fuel consumption data, an overall in-use automobile fuel economy of 21 miles per gallon. [Reed M. Brown (G.M.) *Overseas Automotive Fuel Economy Study* (Environmental Activities Publication No. A-3678, 1978).]

30. Statement of Will Scott, Vice President, North American Governmental Affairs, before the Senate Committee on Energy and Natural Resources, April 30, 1980.

31. Arthur Anderson and Co. (Detroit), *U.S. Automotive Industry Trends for the 1980's.*

32. M. J. Collins *et al, Automobile Monthly MPG and Market Share Newsletter* (Oak Ridge National Laboratory, April 1980).

33. Jim Plegue, "Pontiac Grooms Mid-Engine, 2-Seat Commuter," *Automotive News,* January 28, 1980, p. 1.

34. A VW supercharged direct injection 1.2 liter three cylinder diesel engine which turns off during deceleration and idle is mentioned briefly in the January 28, 1980 *Automotive News* (p. 16) story by Jan P. Norbye, "VW Spends Big on Total Energy Research: All its Projects Have Definite Goals."

35. Exxon Company USA, *Energy Outlook, 1980–2000,* p. 16.

36. The White House, *Fact Sheet on The President's Import Reduction Program,* July 16, 1979.

37. US DOE, Office of Conservation Policy and Evaluation. "Summary of Post-1985 Automobile Fuel Economy Technology (and Corporate Average Fuel Economy Impacts)—Preliminary Analysis," (Draft Attachment to the Statement of Lester P. Silverman, US DOE before the Senate Committee on Energy and Natural Resources, April 30, 1980.)

38. In 1976, 52 percent of all U.S. households owned two or more cars. Among households purchasing new cars, 75.9 percent owned two or more cars [U.S. News and World Report Marketing Department, Automotive Market: 1977 Report.]

39. In January 1980, some gas taxes per gallon of regular gasoline (at March 1, 1979 exchange rates) were: France—$1.62, Italy—$1.83, United Kingdom—$0.89, and West Germany—$1.14) CIA *op. cit.* in ref. 27).

40. See e.g., R. H. Williams, "A $2 Per Gallon Political Opportunity." (Princeton University, Center for Energy and Environmental Studies, March, 1980.)

41. Difference between the average composite EPA fuel economies of the new cars sold in the U.S. during the periods Sept. 1978–February 1979 and March–August

1979 (not adjusted for differences in monthly sales totals) [David L. Greene *et al*, "Monthly MPG and Market Share (3 MS) Data System," Oak Ridge National Laboratory, January 22, 1980].

42. Roger Rowand, "No Magic, No Miracles in Boosting Economy: Solid, Down-to-Earth Engineering Gives '80 Models Better MPG," *Automotive News*, October 22, 1979.

43. Difference in the average composite EPA fuel economies of the new cars sold in the U.S. during the periods September 1978–August 1979 and September–December 1979 (not adjusted for differences in monthly sales totals) [David Greene *et al*, op. cit. in ref. 35].

44. One bushel of corn would yield approximately 2.6 gallons of ethanol [gross not *net* yield [US DOE, *The Report of the Alcohol Fuels Policy Review*, DOE/PE-0012, p. 13, 1979]]. Production of corn in the U.S. in 1978 totaled 7 billion bushels (US DOC, *Statistical Abstract of the United States*, 1979, p. 709). The consumption of gasoline by U.S. automobiles in 1977 was 80 billion gallons [US DOT, Highway Statistics, 1977 (FHWA-HP-HS-77), p. 100]. The energy content of a gallon of ethanol is approximately two thirds of that in a gallon of gasoline.

45. The proposed "Synthetic Fuels Corporation Act of 1979" sets the goal of "the equivalent of at least 2 million barrels of oil per day of synthetic fuels from domestic resources" by 1992 and would authorize the Corporation to make commitments of up to $88 billion in price guarantees, purchase agreements, loan guarantees, loans, and/or joint ventures. Commitments beyond $20 billion would be contingent on Congressional approval. [ref: "Statement of Conferees on S. 932, February 7, 1980 (revised February 26, 1980)].

46. Richard R. John (DOT), "Transition to the Post-1985 Motor Vehicle," (First International Automotive Fuel Economy Research Conference, Washington, D.C., October 31–November 1, 1979). Included is the estimated cost of expanding the production capacity of the industry by 16 percent between 1985 and 1995. The higher end of the quoted mid-1990's fuel economy range assumes a complete shift to diesel engines.

47. In 1979 General Motors estimated that its average annual rate of capital investment to "repair, [replace] capacity, etc.," in the absence of "government mandated" investments in fuel economy, pollution control and safety improvements would be $2.9 billion. [G.M., "Economic Issues and Alternatives Associated With the Fuel Economy Program," February 1, 1979, Exhibit I.] In 1979 GM sold 56 percent of all domestically produced vehicles (see ref. 15). At GM's rate of investment per car sold, the total U.S. automobile industry would therefore have invested approximately $5 billion annually. Over the ten year investment period (1985–1995) investment at this rate would cumulate to approximately $50 billion.

48. According to a recent study funded by General Motors, "The major vehicle redesign year . . . generally occurs in a cycle of six to eight years—at GM it is five to six years." (Boston, Harbridge House Inc., *Energy Conservation and the Passenger Car*, September 1979).

49. W. Bach, J. Pankrath, W. Kellog, eds., *Man's Impact on Climate* (Elsevier, Amsterdam, 1979). Because of the energy intensity of gasoline production from coal (the conversion efficiency would at best be about 65 percent), and the approximately 40 percent higher carbon content per unit of energy content of coal relative to crude petroleum, the amount of CO_2 released to the atmosphere as the result of the combustion of a gallon of coal-derived gasoline would be more than twice that released at the result of the combustion of a gallon of today's petroleum-derived gasoline.

50. See e.g., "Statement of General Motors to the National Highway Traffic Administration on 1981–84 Passenger Automobile Average Fuel Economy Standards," reprinted in *Energy Conservation-Motor Vehicles' Fuel Efficiency*. Hearings before the Subcommittee on Energy and Power of the House Committee on Interstate and Foreign Commerce, U.S. Congress, April 25, 1977, PP. 247–248.

51. One perspective on the magnitude of the civil penalty can be obtained by considering it to be a "gas tax" on the extra gasoline which would be consumed as a result of the shortfall. For a shortfall of one mpg the extra gasoline consumption in a 100,000 mile automobile lifetime relative to a fuel economy level of 20, 30, or 40 mpg would be about 260, 115, or 65 gallons respectively. The $50 fine imposed by the fuel economy law would therefore correspond to a tax of 20, 45 or 75 cents per gallon. (It is interesting to note that the increasing fuel economy standards tend to offset the eroding effect of inflation on this "gas tax.")

52. "As was the case for comfort, respondents are unwilling to trade safety characteristics for fuel economy, particularly since safety is strongly associated with size and weight." [Market Facts—Washington, "A Study of Consumer Behaviour

Towards Fuel Efficient Vehicles, Task D: Focus Group Analysis," Report Submitted to US DOT (DOT-HS-7-01781), May 1978, p. 16.]

53. A preliminary analysis of 1979 traffic fatalities by the National Highway Traffic Safety Administration indicates that, in crashes involving subcompacts and larger cars or light trucks, the occupants of the subcompacts had an approximately eight times higher probability of being killed than those of the larger vehicles. [US DOT, NHTSA *1979 Traffic Fatalities Preliminary Assessment.* DOT—HS-805-253, Feb. 1980] Table 1.

54. The fourth car, the Dodge Magnum, is a mid-sized car. [US DOT Fact Sheet, "The US Department of Transportation's New Car Crash Protection Assessment Program," Feb. 28, 1980.] The forces experiences by a car crashing into a barrier at 35 mph are roughly equal to the forces it would experience in a head-on collision at 30 mph with a car 40 percent heavier.

55. Volkswagen of America (Washington, D.C.) Press Release, "Integrated Research VW," July 16, 1979.

56. US DOT NHTSA *Research Safety Vehicle,* (DOT HS 803 882, March 1979).

57. See the survey of comparative results in E. G. Barry *et al,* "If Autos Go to Diesel Fuel," in *Hydrocarbon Processing,* May 1977, p. 111. Comparison of gasoline and diesel fuel economy are made on a volume basis in this review. Diesel fuel #2 contains approximately 15 percent more energy per gallon than gasoline but the EPA has concluded that shifting the refinery mix toward diesel would save the energy equivalent of approximately 0.1 gallons of gasoline in refinery process energy per gallon of refinery output shifted from gasoline to diesel fuel. The EPA has therefore decided to treat gasoline and diesel fuel as representing the same amount of crude oil per gallon. [US EPA, Technical Support Report for Regulatory Action, *Method for Calculation of Diesel Fuel to Gasoline Fuel Economy Equivalence Factor,* (May 1976).

58. See e.g., South Coast Technology Inc., "Unregulated Diesel Emissions and Their Potential Health Effects," in US DOT, *Automotive Fuel Economy Contractors Coordination Meeting,* Dec. 11-13, 1978, Summary Report (DOT HS-803 706), p. 1-4-1.

59. EPA Carcinogen Assessment Group, "Initial Review of The Potential Carconogenic Impact of Diesel Exhaust" and attachments (June 11, 1979).

60. B. Wiedemann *et al,* "Data Base for Light-Weight Automotive Diesel Power Plants," (SAE Paper #780634, 1978).

61. Jake Kelderman, "Tough Standards for Small Diesels Delayed Until '85," *Automotive News, Feb. 25, 1980, p. 1.*

62. A. J. Scussel *et al* (Ford), "The PROCO Engine Update," SAE Paper #780699 (1978) [See also E. Mitchell *et al,* "Texaco Controlled-Combustion System-Multifuel, Efficient, Clean and Practical," *Combustion Science and Technology 8* (1973), p. 39]; "Ford's PROCO Test Fleet to Start Rolling," *Automotive News,* October 22, 1979, p. E-3.

TABLE 1.—FUEL ECONOMY VERSUS DAYS-SUPPLY OF DOMESTICALLY PRODUCED 1980 MODELS ON MARCH 1, 1980

	EPA "estimated" MPG [1]	Days-supply [2] (Mar. 1, 1980)
Subcompacts:		
VW Rabbit diesel	42	32
Chevette	25	39
Pontiac Sunbird	24	52
Chevrolet Monza	24	51
Plymouth Horizon	24	61
Olds Starfire	24	73
Dodge Omni	24	62
Lincoln Capri	22	75
Lincoln Bobcat	22	71
Ford Mustang	22	76
Chevrolet Camaro	19	96
Buick Skyhawk	19	86
Pontiac Firebird	16	119
Compacts:		
Buick Skylark	22	17
Olds Omega	22	23
AMC Concord	20	101
AMC Pacer	18	136

TABLE 1.—FUEL ECONOMY VERSUS DAYS-SUPPLY OF DOMESTICALLY PRODUCED 1980 MODELS ON MARCH 1, 1980—Continued

	EPA "estimated" MPG [1]	Days-supply [2] (Mar. 1, 1980)
Mercury Monarch	17	93
Ford Granada	17	109
Lincoln Versailles	15	119
Midsize:		
Chevrolet Citation	22	30
Mercury Zephyr	22	39
Ford Fairmont	22	43
Pontiac Phoenix	21	17
Buick Century	20	42
Oldsmobile Cutlass	20	37
Oldsmobile Supreme	20	54
Buick Regal	20	68
Pontiac Grand Prix	20	124
Chevrolet Malibu	19	79
Pontiac Lemans	19	94
Chevrolet Monte Carlo	19	125
Mercury Cougar	18	78
Ford Thunderbird	18	74
Oldsmobile Toronado	17	64
Plymouth Volare	17	125
Chrysler LeBaron	17	119
Chrysler Cordoba	17	214
Dodge Aspen	17	142
Dodge Diplomat	17	143
Dodge Mirada	17	199
Buick Riviera	16	57
Cadillac Seville	14	77
Cadillac Eldorado	14	51
Large:		
Oldsmobile 88	18	53
Chevrolet	18	79
Popntiac	18	95
Buick Le Sabre	18	69
Oldsmobile 98	17	66
Mercury	17	79
Buick Electra	17	71
Ford	17	130
Dodge St. Regis	16	127
Plymouth Gran Fury	16	86
Chrysler	16	126
Cadillac	15	73
Lincoln Mark VI	15	123
Lincoln	15	161

[1] City cycle. Configuration with smallest engine and automatic transmission (where available). EPA 1980 Gas Mileage Guide.
[2] Automotive News, Mar. 17, 1980, p. 8.

Senator STEVENSON. The next witnesses are Mr. T. F. McDonnell, chairman of the American Society for Testing and Materials, Fuel Efficient Oils Task Force, of AMOCO Chemicals Corp.; Dr. David R. Jones, vice chairman, Fuels and Lubricants Committee of the American Petroleum Institute Marketing Department, Chevron U.S.A., Inc.; and John Fahey, vice president of the Independent Oil Compounders Association.

I will invite all of these gentlemen to come forward and we will proceed with all of their statements.,

If you can summarize your full statements, I will be happy to enter them into the record.

We also have Mr. Sydney Andrews of the American Society for Testing and Materials. We will proceed with him first.

STATEMENTS OF SYDNEY D. ANDREWS, VICE PRESIDENT, AMERICAN SOCIETY FOR TESTING AND MATERIALS; ACCOMPANIED BY T. F. McDONNELL, CHAIRMAN, FUEL EFFICIENT OILS TASK FORCE, AMOCO CHEMICALS CORP.; WALTER WADDEY, CHAIRMAN, SECTION B, PASSENGER CAR ENGINE OIL, PRODUCT RESEARCH DIVISION, EXXON CORP.; DAVID R. JONES, VICE CHAIRMAN, FUELS AND LUBRICANTS COMMITTEE, AMERICAN PETROLEUM INSTITUTE MARKETING DEPARTMENT, CHEVRON U.S.A., INC.; AND JOHN FAHEY, VICE PRESIDENT, INDEPENDENT OIL COMPOUNDERS ASSOCIATION

Mr. ANDREWS. Thank you, Mr. Chairman. I am Sydney D. Andrews, director of the Division of Standards, Florida Department of Agriculture and Consumer Services. I am privileged to serve as vice president of the American Society for Testing and Materials, a nonprofit corporation organized according to the laws of the Commonwealth of Pennsylvania for the "development of standards on characteristics and performance of materials, products, systems, and services; and the promotion of related knowledge." I am also chairman of the Society's Committee D–2 on Petroleum Products and Lubricants, and it is in this capacity that I appear before you today.

In order to properly comment on the proposed legislation which is the subject of this hearing, I need first to say a thing or two about ASTM itself, and then about Committee D–2 on Petroleum Products and Lubricants. Since I have my written testimony I am going to try to brief over it as best I can.

The main function of the core management organization is to insure understanding and adherence to ASTM's procedures in standards development. It also provides various administrative and management services which are so essential in a management system for the development of consensus standards.

Since the technical area assigned to committee D–2 is so large, the committee itself is organized into a main committee, then is subdivided into technical and research divisions on matters such as gasoline, automotive lubricants, fuel oil, jet fuels, et cetera, and then further subdivided into sections and task groups. The total membership of committee D–2 at the moment, and of its subdivisions is about 1,400. It is probably appropriate for me to add that it is without question the most impressive collection of technical expertise across the broad spectrum of petroleum use, organized as an ongoing entity, anywhere in the world. We are quite proud of the participants in the work of D–2.

Committee D–2 has for many, many years—since 1904—been developing standards and related technical publications having very important commercial and regulatory impact, and is—under ASTM's strict procedures—known as a classified committee. Without going into great detail, this simply means that in order to operate, the committee has to conform to ASTM's standards developing procedures which provide, among other things, for a balance of interest within the committee, and for the adherence to the

ASTM principles of due process, as the committee addresses itself to standards problems.

At the moment, the committee has jurisdiction over that is to say it is responsible for, something over 371 standards and some very important related published materials.

The scope of committee D–2 is as follows:

> The promotion of knowledge of petroleum, of petroleum products (including products derived in part from petroleum), of aliphatic, olefinic, naphthenic, and aromatic hydrocarbons and hydrocarbon products, and of lubricants, and the recommendation of standards pertinent to these materials.

Under ASTM procedures, this scope describes the field of technical activity within which the committee has been authorized by the ASTM board of directors to work. The scope of Technical Division B on automotive lubricants is:

The promotion of knowledge, specifications, methods of test and nomenclature for Automotive Lubricating Oils. This scope in turn was approved by the main committee of D–2.

I have with me, incidentally, a current listing of the membership of Technical Division B which I would be pleased to make available to the subcommittee.

Having provided this background, I think it is timely for me to say now that ASTM has no position on whether or not there ought to be a fuel economy of motor oils program, as envisioned by this legislation. We are not chartered to take this kind of position. We are here to provide information that will, we hope, inform the committee to make the best possible decision in such matters. We simply don't have the mechanism for developing these kinds of positions within the society.

Further, the society has long felt that to enter contention on either side of public policy questions would derogate the prestige and credibility ASTM has developed in almost an 82-year period in the field to which it confines its activities—voluntary consensus standards.

While we have no position on whether or not there ought to be such a program, we have been working in committee D–2 to develop the various methodologies that would be required if such a program were indeed inaugurated, either through legislation or in some other way.

We are here in response to your invitation to provide the committee with the results, thus far, of the technical deliberations on fuel-saving oils in committee D–2.

It is my privilege to have with me colleagues from committee D–2 to give you details of a program on which the committee has embarked through one of its task forces.

I am privileged to introduce Dr. Walter Waddey who is chairman of our section BI on passenger car engine oils, which is the parent group of this task force. Dr. Waddey is head of engine lubricant research and the Product Research Division of Exxon Corp.

To actually make the presentation on what the task force program is all about, we are privileged to have here Mr. Tom McDonnell who is chairman of that Task Force on Fuel-Efficient Engine Oils. Mr. McDonnell is industry liaison coordinator for AMOCO Chemicals Corp., and until March of this year was senior research engineer for the Ford Motor Co.

I'd like at this time, Mr. Chairman, to introduce Mr. Tom McDonnell who will present the details of our task force's fuel-efficient engine oil program.

[The statement follows:]

STATEMENT OF SYDNEY D. ANDREWS, VICE PRESIDENT, AMERICAN SOCIETY FOR TESTING AND MATERIALS

Mr. Chairman and members of the subcommittee: I am Sydney D. Andrews, Director of the Division of Standards, Florida Department of Agriculture and Consumer Services. I am privileged to serve as Vice-President of the American Society for Testing and Materials (ASTM), a nonprofit corporation organized according to the laws of the Commonwealth of Pennsylvania for the "development of standards on characteristics and performance of materials, products, systems, and services; and the promotion of related knowledge." I am also chairman of the Society's Committee D-2 on Petroleum Products and Lubricants, and it is in this capacity that I appear before you today.

In order to properly comment on the proposed legislation which is the subject of this hearing, I need first to say a thing or two about ASTM itself, and then about Committee D-2 on Petroleum Products and Lubricants. As I proceed, it would be helpful to all of us if we could think of ASTM in the shape of a solar system with 137 main technical committees in orbit around the central management core. This concept is important because it emphasizes the Society's main role in life—the development of voluntary consensus standards—and also the fact that the technical expertise in any area to which the Society addresses itself is located—not in the central administrative management core—but in one or the other, or perhaps in several, of its technical groups. ASTM Committee D-2 on Petroleum Products and Lubricants is one of these groups.

The main function of the core management organization is to ensure understanding and adherence to ASTM's procedures in standards development. It also provides various administrative and management services which are so essential in a management system for the development of consensus standards.

Since the technical area assigned to Committee D-2 is so large, the committee itself is organized into a main committee, then is subdivided into technical divisions on matters such as gasoline, automotive lubricants, fuel oil, jet fuels, etc., and then further subdivided into sections and task groups. The total membership of Committee D-2 at the moment and of its subdivisions is about 1,400. It is probably appropriate for me to add that it is without question the most impressive collection of technical expertise across the broad spectrum of petroleum use, organized as an ongoing entity, anywhere in the world.

Committee D-2 has for many, many years—since 1904—been developing standards and related technical publications having very important commercial and regulatory impact, and is—under ASTM's strict procedures—known as a "classified" committee. Without going into great detail, this means that in order to operate, the committee has to conform to ASTM's standards developing procedures which provide, among other things, for a balance of interest within the committee, and for the adherence to the ASTM principles of due process, as the committee addresses itself to standards problems.

At the moment, the committee has jurisdiction, that is to say it is responsible, for over 371 standards and some very important related published materials.

The scope of Committee D-2 is as follows:

"The promotion of knowledge of petroleum, of petroleum products (including products derived in part from petroleum), of aliphatic, olefinic, naphthenic, and aromatic hydrocarbons and hydrocarbon products, and of lubricants, and the recommendation of standards pertinent to these materials".

Under ASTM procedures, this scope describes the field of technical activity within which the committee has been authorized by the ASTM Board of Directors to work. The scope of of Technical Division "B" on Automotive Lubricants is:

"The promotion of knowledge, specifications, methods of test and nomenclature for Automotive Lubricating Oils." This scope in turn was approved by the main committee of D-2.

I have with me a current listing of the membership of Technical Division "B" which I would be pleased to make available to the subcommittee.

Having provided this background, it is probably timely for me to say now that ASTM has no position on whether or not there ought to be a Fuel Economy of Motor Oils Program, as envisoned by this legislation. This again is the result of ASTM's basic policy which is related in turn to its chartered purpose. With the exception of standards development methodologies as these may be included in

legislation such as this, ASTM takes no position on matters of public policy. We simply do not have a mechanism of any kind within the Society to develop these kinds of positions. Further, the society has long felt that to enter contention on either side of public policy questions would derogate the prestige and credibility ASTM has developed in almost an 82-year period in the field to which it confines its activities—voluntary consensus standards.

While we have no position on whether or not there ought to be such a program, we have been working in Committee D–2 to develop the various methodologies that would be required if such a program were indeed inaugurated, either through legislation or in some other way.

We are here in response to your invitation to provide the committee with the results, thus far, of the technical deliberations in Committee D–2.

Senator STEVENSON. Mr. McDonnell.

Mr. MCDONNELL. Thank you, Mr. Andrews. Mr. Chairman, I will first present a brief background describing the coordination of the American Society for Testing and Materials, the American Petroleum Institute, and the Society of Automotive Engineers in the development of new engine oil classifications, and then I will respond to each of the three specific issues cited in your April 25, 1980, letter to me.

The interrelationship of ASTM/API/SAE is formally defined in SAE recommended practice J183 titled "The Engine Oil Performance and Engine Service Classification," which is (appendix 1)[1] and is summarized as follows:

SAE—Define and promulgate categories of engine oils. SAE defined a need for a fuel-efficient oil category in 1978.

ASTM—Develop test techniques and limits—technical language—for definition of a new category. ASTM initiated action in March 1978.

API—Develop identification—symbols and labeling—and user language for definition of new categories. API initiated action in March 1978.

Issue (1). The status of ASTM's program to develop reliable classification test procedures for rating fuel efficiency of motor oils.

ASTM's actions to date are summarized in our April 1, 1980 letter to Dr. R. L. Strombotne of the National Highway Traffic Safety Administration. This letter is included as attachment A to appendix 2, which is ASTM's response to C. L. Gray of the Environmental Protection Agency, who had requested comments on the proposed EPA recommended practice for evaluating, classifying, and labeling fuel-saving engine oils. A synopsis of that response follows:

MEMBERSHIP OF TASK FORCE

Automotive manufacturers—three.
Oil additive companies—five.
Oil companies—11.
Consultants—two, including one from the EPA.
Liaison—API, CRC—coordinating research council—and SAE.

SCOPE

Establish a test technique whereby the degree of fuel efficiency of engine oils for passenger cars and other light-duty vehicles can be determined.

[1]The materials referred to in this statement have been retained in the committee files.

OBJECTIVE

Follow items 6 and 7 of "The Engine Oil Performance and Engine Service Maintenance Procedure—SAE J1146" to select a test procedure, performance criterion, and reference oils for definition of fuel-efficient engine oils. A copy of this procedure is included as appendix 3.

PILOT PROGRAM

A pilot program of 22 cars was conducted using the ASTM modified EPA 1975 FTP/HFET test procedure on 20 oils, including both conventional and fuel-efficient products. This program was completed in December of 1978. The results indicated the tentative procedure and reference oil to have potential for discriminating between oils of differing fuel efficiency.

INTERIM BALLOT

The encouraging results of the pilot program and the potential for significant reduction in national fuel consumption led to an interim ballot within ASTM to adopt the ASTM and other statistically significant vehicle and dynamometer fuel-saving engine oil test procedures on an interim basis. This ballot failed on the basis that additional confirmation of the ASTM procedure and reference oil was required, including testing of oils containing a variety of fuel-saving engine oil technologies.

There is a note that the EPA consultant expressed the viewpoint prior to the ballot that the use of these other procedures would in all probability be unacceptable to EPA administrators.

DEMONSTRATION PROGRAM

A demonstration program was designed to more fully define the efficacy of the ASTM procedure. A summary of this program follows:

SCOPE

Twenty-five cars; five car makes; and thirteen oils; one break-in oil; one reference oil; one flushing oil; four conventional oils of high-market volume; six fuel-saving candidate oils; four non-carryover; two carryover, with residual effects; and four test laboratories.

OBJECTIVE

Determine the following for reliable classification of fuel-saving engine oils:

One. The car-to-car variability; that is, variability within a make on a specific fuel-saving oil.

Two. Engine break-in criteria.

Three. Engine flushing technique acceptability.

Four. Minimum fuel economy improvement limits.

Five. Minimum fleet size.

FUNDING

Program costs are estimated at approximately $700,000. ASTM members have pledged sufficient funds to cover this amount.

TIMING

The present schedule for completion of the demonstration program and balloting of the procedure and acceptance limits is February 1981 as shown in appendix 4.

ISSUE 2

The compatibility of that—ASTM—program with the proposed requirements of amendment 1662 to S. 2015.

In ASTM's opinion, the efforts of API/ASTM/SAE to develop a classification for fuel-saving engine oils is totally compatible with the objectives of title V of amendment 1662 of S. 2015. However, a detailed review of title V in comparison to the established and proven ASTM/API/SAE coordination guide for development of new engine oil categories shows that title V is redundant. We have included this procedure, "The Engine Oil Performance and Engine Service Classification Maintenance Procedure." This redundancy is illustrated in appendix 5, which indicates the similarities between the specific responsibilities of the respective societies and the corresponding sections of title V. In previous applications of SAE J1146, the cooperative participation by members of the three societies has resulted in widely accepted engine oil test procedures and the associated engine oil performance categories.

In response to issue 3, the overall feasibility of the proposed amendment and any recommendations relating to it:

ASTM is in complete agreement with the intent and objectives of Amendment 1662 to S. 2015. As a participant in the API/ASTM/SAE activity, ASTM has been actively in support of the objectives to develop procedures for the purpose of classifying fuel-saving oils.

ASTM would ask the consideration of one major recommendation. In section 502(c) of title V, it is stated that:

> The Secretary shall in consultation with the Environmental Protection Agency, the American Society for Testing and Materials, and the Society of Automotive Engineers, develop test procedures for determining the relative fuel economy attributable to the use of specific motor oils compared to the use of other motor oils in the same category.

In contrast to this, it has come to ASTM's attention that the EPA is embarking on a parallel program to develop a proposed recommended practice, including a test procedure and grading system for fuel-saving engine oils. ASTM was requested by EPA to critique this procedure, which was done and reported April 16, 1980, to Mr. C. L. Gray of the EPA. This entire report is included as appendix 2.

The ASTM conclusion stated support of the EPA's basic objective, but emphasized the concern that EPA's duplication of effort was unnecessary and potentially disruptive of industry support of ASTM's efforts. In addition, it was concluded that the EPA's proposed recommended practice was potentially unduly burdensome and, therefore, it is not in keeping with the intent of title V, section 502(f).

It is ASTM's recommendation that, in keeping with the spirit of section 502(c), the EPA actively support the ASTM efforts, as has been done by the National Highway Traffic and Safety Administration, by channeling the facilities and manpower of their parallel

efforts into the ASTM demonstration program. This cooperation, in our opinion, will result in full industry support and a more timely introduction of the best possible test procedure for identifying fuel-saving engine oils.

In conclusion, ASTM is of the opinion that the evidence supplied herein supports the position that the intent and objectives of title V of amendment 1662 of S. 2015, as related to test procedures, are already fulfilled by the proven and established industry system described in SAE recommended practice J1146. A procedure for identifying fuel-saving engine oils is nearing completion using this SAE practice. For these reasons, we do not believe any significant benefits to the country and consumer will result from a duplication of efforts and, therefore, we strongly recommend title V be dropped from further consideration.

Mr. Chairman, we appreciate having had the opportunity of submitting this testimony and will keep this committee advised of ASTM's progress toward accomplishing the objective of identifying fuel-saving engine oils.

Senator STEVENSON. Thank you, Mr. McDonnell.

Mr. Jones.

Mr. JONES. Mr. Chairman, for the record, I'd like to state that I am with Chevron U.S.A. as well as vice chairman of the API marketing department's fuels and lubricants committee.

The petroleum industry appreciates the chairman's invitation to participate in these proceedings and welcomes the opportunity to present its views on S. 2015 and in particular on amendment 1662 dealing with fuel economy of engine oils because we share the subcommittee's interest and concern to conserve energy.

API strongly endorses the testimony which has been given by the American Society for Testing and Materials that a procedure, through coordinated efforts by API, ASTM, and SAE, for identifying fuel-saving engine oils is nearing completion using SAE practice J1146, and which will fit into the long-standing engine oil service classification system.

The engine oil service classification system was introduced in 1947—and there is an attachment hereto which describes its history and development—and has been upgraded as needed by engine performance improvements.

In 1970 the American Petroleum Institute, the American Society for Testing and Materials, and the Society of Automotive Engineers jointly developed the current classification system for engine oils based on performance of oils in standardized engine tests. This system is open ended and allows for the addition of new performance categories and new test methods as the need arises. For example, early this year API service category SF was adopted to meet the needs of car manufacturer warranty requirements for 1980 and 1981 model cars. Engine oils meeting API service SF provide increased oxidation stability and improved antiwear performance relative to oils which were developed for previous service categories. The development of this new category is a good example of the results that can be achieved through the cooperative efforts of these three societies.

A similar cooperative effort has been in progress for about 2 years with the objective of developing test methods, and minimum

economy standards for fuel-saving engine oils. The intent of API, ASTM, and SAE is to incorporate a fuel-saving category into the engine oil service classification system. The target deadline for completing this project is early 1981 which will allow the use of fuel-saving oils by car manufacturers for fuel economy testing of 1982 model cars.

With this background I would now like to address my comments to the following issues listed in your letter of April 25, 1980:

One, the status of the petroleum industry's program to develop fuel-efficient automotive engine lubricants. A brief summary of the cooperative industry program to develop a fuel-saving category for engine oils was discussed above. Many member companies of API are active participants in the ASTM program for fuel economy test development. In addition to this, more than 35 engine oils have been introduced over the past 3 years for which fuel economy benefits are claimed. Almost all major marketers of engine oils have developed such a product and many of these companies are actively promoting and encouraging their use by the motoring public. It is reasonable to expect that most of these oils will meet the fuel-saving performance standard finally approved by ASTM and adopted by API and SAE. Verification must await completion of the ASTM test development program.

Two, the feasibility of classifying, testing, and labeling in accordance with the provisions of amendment 1662 to S. 2015.

If this section of the bill is implemented we do not believe that it will accelerate and, indeed, might well delay the development and adoption of a uniform standard for fuel-saving oils. As stated previously, such a standard is targeted for completion by early 1981 and oils meeting this standard will be widely distributed in commerce and their use encouraged by both the oil and automobile industries. It is most unlikely that provisions of Amendment 1662 can speed up this process.

Three, the likelihood that average consumers would in fact understand and utilize labeling information proposed.

Most consumers today purchase engine oils from retail outlets such as supermarkets and discount stores rather than from gasoline service stations or car dealers. Surveys indicate that at least half of these purchasers do not read the labeling on engine oil containers. Thus, for a large percentage of consumers the type of labeling used to identify fuel-saving properties may have little impact. More effective than container labeling in acquainting consumers with the benefits of these new oils is media advertising and point-of-sale information. Marketers of engine oils will continue to utilize these techniques to promote the acceptance of fuel-saving oils.

Four, the necessity or desirability of the amendment as proposed or recommendations for alterations of the proposed amendment.

As stated above, API does not believe that this amendment is necessary to accomplish our mutual objective of reducing the fuel consumption of motor vehicles. We believe that cooperative industry effort now in progress will produce a technically sound classification system and designation for fuel-efficient engine oils in a timely and economic fashion and that this proposed legislation will not accelerate this process.

I would now like to comment briefly on a recent EPA proposal for evaluating, grading, and labeling the fuel efficiency of engine oils. A cursory review of this EPA "recommended practice" suggests that it fulfills the requirements of sections 502 and 503 of amendment 1662. On close examination, however, the EPA proposal appears to have serious flaws. ASTM has addressed the technical deficiencies in a recent detailed report to the EPA. API believes that the labeling recommendation proposed by EPA is impractical for the wide variety of containers used for engine oils.

In conclusion, API is in full agreement with the objectives of the proposed amendment but believes that this legislation is not required to achieve the national goal of reducing engine fuel consumption through the use of fuel-saving engine oils.

Senator STEVENSON. Thank you, Mr. Jones.

[The attachment follows:]

ATTACHMENT 1

ENGINE SERVICE CLASSIFICATIONS AND GUIDE TO CRANKCASE OIL SELECTION

(API Publication No. 1509—Seventh Edition 1979)

Classification Of Internal Combustion Engine Service*

WHY THE ENGINE SERVICE CLASSIFICATION WAS DEVELOPED

Many years ago, the automotive and petroleum industries recognized the need for a system by which crankcase oils could be classified and described. A first step in this direction was the adoption in 1911 of the SAE Crankcase Oil Viscosity Classification System. However, this system classified crankcase oils in terms of viscosity only.

In response to inter-industry needs for a system which would include factors other than viscosity, the American Petroleum Institute adopted in 1947 a system which established three types of engine oils. In this system, crankcase oils were designated as: Regular Type, Premium Type, and Heavy Duty Type. Generally, the Regular Type oils were straight mineral oils; Premium Type oils contained oxidation inhibitors; and Heavy Duty Type oils contained oxidation inhibitors plus detergent-dispersant additives.

This oil-type classification system did not recognize that gasoline and diesel engines might have different crankcase oil requirements, or that the engine requirements would be affected by engine operating conditions, composition of the fuel and other factors. In time, both oil and engine manufacturers recognized that oil-type definitions were inadequate. As a result, the Lubrication Subcommittee of the American Petroleum Institute, cooperating with the American Society for Testing and Materials, developed in 1952 a new system of Engine Service Classification, which was revised in 1955 and again in 1960.

This API Engine Service Classification System described and classified, in general terms, the service conditions under which engines were operated. It provided a basis for selecting and recommending engine crankcase oils. The system included three service classifications for gasoline engines (ML, MM, and MS) and three for diesel engines (DG, DM, and DS).

While this system was a great improvement over the earlier system, it eventually became apparent that a more effective means of communicating engine oil performance and engine service classification information between the engine manufacturers, the petroleum industry and the customer was required. There was a need for a system that would provide more flexibility in order to satisfy the changing warranty maintenance service lubrication requirements of the automotive industry.

Accordingly, in 1969 and 1970, the American Petroleum Institute (API), the American Society for Testing and Materials (ASTM) and the Society of Automotive Engineers (SAE) cooperated in establishing an entirely new classification system. SAE initially determined that there were eight separate categories of automotive-type engine oils of current substantial commercial interest to be considered. ASTM established the test methods and performance characteristics and technically described each of the categories (ASTM Research Report RR D2:1002 January, 1970). API prepared a "user" language, including new engine service letter designations, for each of the eight different operating conditions for which the eight different types of engine oil were suited. These eight engine service classifications were correlated to the ASTM technical descriptions and primary performance criteria. SAE then published the entire project result as SAE Recommended Practice J 183.

This entire classification system enables engine oils to be more precisely defined and selected according to their performance characteristics than heretofore, and to be more

*Applies to passenger cars, gasoline and diesel-powered trucks, off-highway equipment and inboard marine engines only.

easily related to the type of service for which each is intended.

Late in 1970, a ninth class of service had been added to reflect the anticipated service requirements of new model automobiles. This addition is technically described in the January, 1971 revision to ASTM Research Report RR D2:1002 and published in SAE Recommended Practice J 183a.

The SAE Crankcase Oil Viscosity Classification System is in no way affected by the new API Engine Service Classification System and, therefore, is used as before to indicate the SAE viscosities of oils.

BASIS OF THE ENGINE SERVICE CLASSIFICATION SYSTEM

In devising the API Engine Service Classification System, it was recognized that the satisfactory performance of internal combustion engines is dependent mainly on a suitable combination of the following factors:

- **Engine Design and Construction**
- **Fuel**
- **Operating Conditions**
- **Lubricating Oil**
- **Maintenance Practices**

These factors fix the lubrication requirements of an engine.

Engine design and construction vary widely in accordance with the emphasis placed by individual engine manufacturers on different features of design and construction.

Fuels, especially diesel fuels, also differ, depending upon the crude oil and the refining method used.

Operating conditions of engines vary from operation under light or intermittent loads, often accompanied by prolonged idling, to extreme overloading; and from driving at low or moderate speeds to continuous high-speed operation. Ambient temperatures may range from subzero cold to desert heat.

Lubricating oil characteristics and performance depend on crude oil source, refining methods used, base stocks selected and the additives which may be incorporated in the finished oils by their manufacturers. Since engine design and operating conditions are so variable, oils are made with different performance properties, some being suitable only for the lightest service, others for a wider range of service.

Maintenance practices of engines vary. Despite good engine design, favorable operating conditions and use of the best fuels and lubricants, unsatisfactory performance will occur from faulty carburetor adjustment; lack of periodic engine tune-ups; improper thermostatic control; improper operation of positive crankcase ventilation (PCV) systems, exhaust and other emission control devices; extended oil drain and oil filter replacement intervals; and failure to maintain clean air filters.

The new API Engine Service Classification System continues to define and explain classes of service for both diesel and gasoline engine applications. It provides a means of identifying service requirements with oil performance from a lubrication standpoint. These requirements range from the mildest—requiring minimum protection against deposits, wear or rust—to the severe requirements imposed on automotive gasoline engines by:

- **Short-trip, start-and-stop service**
- **High-temperature trailer towing**
- **Sustained high-speed, high-temperature driving . . .**

and on supercharged diesel engines operating on high sulfur fuel.

The new system continues the use of letter designations for each service classification. This provides a convenient means for the engine manufacturer to indicate the service characteristics of his various designs and, hence, their lubrication requirements. Similarly, petroleum companies use the letter designation to indicate for which class or classes of service each of their brands of lubricating oil is suitable.

DEFINITIONS AND EXPLANATION OF API ENGINE SERVICE CLASSIFICATIONS

The latest revised API Engine Service Classification System presently includes nine classes of service—five for service stations and four for commercial applications.

It is an "open-ended" system which permits the addition of new categories as required without changing or deleting existing categories. This means that any user, petroleum supplier or equipment manufacturer may petition API, SAE or ASTM to establish a new classification, provided engine design, operating service conditions or a significant change in lubricant performance dictates a new category.

The API letter designations identifying the nine service classifications, with references to the previous API system and to related military and industry designations, are summarized in the following chart.

API Engine Service Classifications	Previous API Engine Service Classifications	Related Designations Military & Industry
Service Station Engine Services		
SA	ML	Straight mineral oil
SB	MM	Inhibited oil
SC	MS (1964)	1964 MS Warranty Approved, M2C101-A
SD	MS (1968)	1968 MS Warranty Approved, M2C101-B, 6041-M (Prior to July, 1970)
SE	None	1972 Warranty Approved, M2C101-C, 6136-M (Previously 6041-M Rev.), MIL-L-46152[1]
Commercial and Fleet Engine Services		
CA	DG	MIL-L-2104A
CB	DM	Supp. 1
CC	DM	MIL-L-2104B, MIL-L-46152[1]
CD	DS	MIL-L-45199B, Series 3, MIL-L-2104C[2]

[1] Oils meeting performance requirements of MIL-L-46152 meet the performance requirements of both API Service SE and CC.
[2] Oils meeting performance requirements of MIL-L-2104C meet the performance requirements of both API Service CD and SC.

The following descriptions of the API Engine Service Classifications are intended as guides to aid in the selection of proper engine oils for significantly different engine service conditions. The performance requirements for these classifications are technically described in ASTM Research Report RR D2:1002, revised January, 1971.

"S"—SERVICE (Service Stations, Garages, New Car Dealers, etc.)

SA-formerly for Utility Gasoline and Diesel Engine Service

Service typical of older engines operated under such mild conditions that the protection afforded by compounded oils is not required. This classification has no performance requirements and oils in this category should not be used in any engine unless specifically recommended by the equipment manufacturer.

SB-for Minimum Duty Gasoline Engine Service

Service typical of older gasoline engines operated under such mild conditions that only minimum protection afforded by compounding is desired. Oils designed for this service have been used since the 1930's and provide only antiscuff capability and resistance to oil oxidation and bearing corrosion. They should not be used in any engine unless specifically recommended by the equipment manufacturer.

SC for 1964 Gasoline Engine Warranty Maintenance Service

Service typical of gasoline engines in 1964 through 1967 models of passenger cars and some trucks operating under engine manufacturers' warranties in effect during those model years. Oils designed for this service provide control of high and low-temperature deposits, wear, rust and corrosion in gasoline engines.

SD for 1968 Gasoline Engine Warranty Maintenance Service

Service typical of gasoline engines in 1968 through 1970 models of passenger cars and some trucks operating under engine manufacturers' warranties in effect during those model years. Also may apply to certain 1971 and/or later models as specified (or recommended) in the owners' manuals. Oils designed for this service provide more protection against high and low-temperature engine deposits, wear, rust and corrosion in gasoline engines than oils which are satisfactory for API Engine Service Classification SC and may be used when API Engine Service Classification SC is recommended.

SE for 1972 Gasoline Engine Warranty Maintenance Service

Service typical of gasoline engines in passenger cars and some trucks beginning with 1972 and certain 1971 models operating under engine manufacturers' warranties. Oils designed for this service provide more protection against oil oxidation, high-temperature engine deposits, rust and corro-

sion in gasoline engines than oils which are satisfactory for API Engine Service Classifications SD or SC and may be used when either of these classifications is recommended.

"C"—COMMERCIAL (Fleets, Contractors, Farmers, etc.)

CA for Diesel Engine Service

Service typical of diesel engines operated in mild to moderate duty with high-quality fuels and occasionally has included gasoline engines in mild service. Oils designed for this service provide protection from bearing corrosion and from ring belt deposits in some naturally aspirated diesel engines when using fuels of such quality that they impose no unusual requirements for wear and deposit protection. They were widely used in the late 1940's and 1950's but should not be used in any engine unless specifically recommended by the equipment manufacturer.

CB for Diesel Engine Service

Service typical of diesel engines operated in mild to moderate duty, but with lower-quality fuels which necessitate more protection from wear and deposits. Occasionally has included gasoline engines in mild service. Oils designed for this service provide necessary protection from bearing corrosion and from ring belt deposits in some naturally aspirated diesel engines with higher sulfur fuels. Oils designed for this service were introduced in 1949.

CC for Diesel Engine Service

Service typical of certain naturally aspirated, turbocharged or supercharged diesel engines operated in moderate to severe-duty service and certain heavy-duty gasoline engines. Oils designed for this service provide protection from high-temperature deposits and bearing corrosion in these diesel engines and also from rust, corrosion and low-temperature deposits in gasoline engines. These oils were introduced in 1961.

CD for Diesel Engine Service

Service typical of certain naturally aspirated, turbocharged or supercharged diesel engines where highly effective control of wear and deposits is vital, or when using fuels of a wide quality range including high sulfur fuels. Oils designed for this service were introduced in 1955 and provide protection from bearing corrosion and from high-temperature deposits in these diesel engines.

USE OF API LETTER DESIGNATIONS

Selection of the appropriate API letter designations by engine manufacturers and oil manufacturers requires knowledge of the lubrication requirements of engines, taking into consideration engine design and operating conditions. This is the responsibility of the oil manufacturer and of the engine manufacturer, both individually and jointly, and it requires the mutual exchange of technical information between the two industries. Proper use of the API letter designations by the end-user and oil marketer requires knowledge of the engine manufacturer's recommendations and the API service classification of the oil brand names.

(a) It is the responsibility of the oil manufacturer to establish that the oil has the performance characteristics essential for the service classification for which the oil is recommended. In other words, an oil recommended or designated for a given class of service should satisfy all known requirements for this class of service. Where multiple designations are used, precautions are necessary to ensure that the oil has the characteristics essential for each of the classes of service designated.

(b) It is the responsibility of the engine manufacturer to evaluate the class of service applicable to the particular engine design and intended use, and to recommend the appropriate API letter designation.

(c) When the letter designations are used by the oil marketers or engine manufacturers to indicate the service for which oils are suitable or required, it is the intent that they be preceded by the words, "API Service." To illustrate, a service station oil suitable for servicing new cars under warranty would be referred to as "API Service SE." If oils are suitable for more than one service, it is appropriate that these oils be so designated. For example, "API Service CC and SE."

The representation of an oil as meeting the requirements of a given API Service, such as "API Service SE", is wholly the responsibility of the marketer of that particular brand of oil. It is expected that his knowledge of the performance characteristics of his product, including evidence of satisfactory performance in the engine tests described in SAE Recommended Practice J183, provides the basis for proper API Service letter designation.

Senator STEVENSON. Mr. Fahey.

Mr. FAHEY. Good morning, Mr. Chairman. This is a summary of the statement we have presented to the committee.

My name is John Fahey. I am employed by the Metalcote Grease and Oil Co. of St. Paul, Minn., and am vice president of the Independent Oil Compounders Association, on behalf of which I appear today.

Accompanying me is Elizabeth Warwick, executive director of IOCA. IOCA thanks the committee for the opportunity to present its views on Senate amendment—the proposed amendment—which would amend S. 2015, the Transportation Energy Efficiency Act of 1979, by adding a new title, "Title V—Fuel Economy of Motor Oils."

We are a nonprofit trade association composed of approximately 150 small, independent companies which compound, package and/or market lubricating oils and greases. Sales by independent oil compounders constitute approximately 20 percent of the lubricants market and approximately 1.5 percent of all petroleum industry sales.

IOCA fully supports and encourages the development of fuel-efficient engine oils. However, the association has serious reservations regarding the proposed amendment as presently written. If the amendment were enacted in its present form, many independent oil compounders, unable financially to comply with its provisions, would be forced out of business.

One of IOCA's principal concerns regarding the proposed amendment is its definition of the word "manufacturer." This term would include all independent compounders, because such firms normally perform the final steps in producing the finished product, that is, lubricants and greases. The definition, however, would exclude two other groups which are essential to the production of engine oils—additive manufacturers and suppliers of base lube stocks. Base lube stock suppliers are primarily the major oil companies.

Similar to other areas of the petroleum industry, there are many steps in the process through which engine oils move from a barrel of crude oil to the ultimate end user. Limiting the scope of the coverage of the term "manufacturer" to one who mixes the base stock and additive package together, that is, an oil compounder, is not consistent with the manner in which the lubricants business is structured and has operated historically.

IOCA's concern with this definition is highlighted when the legal and financial responsibilities of manufacturers under the proposed amendment are considered. Section 502 of the proposed amendment requires the individual testing of all existing categories of motor oils. The American Society of Testing and Materials has estimated that the average cost per test would be $40,000.

An IOCA member could have up to 60 categories of engine oils depending on the final language of the legislation. The cost of complying with the test procedures required under the proposed amendment could be as much as $2.5 million. Several of IOCA's smaller members do not even generate that amount of revenue in a year. Even the association's larger members would have great difficulty if forced to incur such costs of compliance. The obvious conclusion is that many independent oil compounders, which are small

businesses, would be forced to cease operations. The infliction of such an injury on small business and the corresponding reduction of competition in the lubricants market clearly is not the intent of this committee or Congress.

As mentioned previously, each lubricant is produced by combining a particular additive package with a certain percentage of base stock. Because there are numerous elements which make up an additive package, the test procedures in the proposed amendment would require new testing anytime a compounder changed either additive manufacturers or a particular component in the additive package. Changes in both occur due to market conditions and the availability of supply. Moreover, because of variations in crude oils used to produce base lube stocks, there are variations in such products. The variances in base lube stocks and additive packages would add greatly to the testing costs which the proposed amendment would ask independent compounders to incur, thereby amplifying the financial difficulties IOCA members would experience, if they still existed.

A practical concern of IOCA's is the lack of an adequate number of testing laboratories in the United States to handle the volume of testing which would be required under the proposed amendment. These tests, which are extremely complicated and time-consuming, involve a substantial amount of expensive equipment and personnel, so it would not be easy to facilitate the startup of additional testing laboratories. IOCA understands that one analysis has estimated that it would take until 1991 to test all of the engine oils currently on the market. IOCA urges the committee to give this factor, and its practical consequences, its full consideration.

IOCA favors the development of fuel-efficient engine oils. However, its concerns regarding (1) the definition of the word "manufacturer," (2) the costs of the required testing procedures, (3) the number of variables included in the production process, and (4) the inadequate number of testing laboratories prevent IOCA from supporting the proposed amendment as currently drafted.

IOCA urges the committee to consider an alternative method of developing fuel-efficient engine oils, which would be more cost-effective and practical, particularly from the perspective of an independent oil compounder. IOCA proposes that the cost of the required test procedures be borne initially by the firms which have the greatest control over varieties in the components of lubricants and sufficient financial revenues to bear this burden; additive manufacturers and lube base stock suppliers. Additive manufacturers and base lube stock suppliers could recover their testing costs by passing them through to their purchasers on a cents-per-gallon basis.

This recommendation is not new. In fact, it is the manner in which the lubricants industry currently operates. Today, additive manufacturers and base lube stock suppliers financially sponsor numerous engine oil tests to identify the physical characteristics of a finished product; as well as to determine its performance. All engine oils currently undergo actual engine tests conducted under the auspices of a tripartite industry group, composed of the American Petroleum Institute, ASTM, and the Society of Automotive Engineers. These tests, which have been done for many years, are

accepted throughout the petroleum industry as a legitimate way to evaluate and grade the physical characteristics and performance levels of engine oils. The costs of these tests are recovered by the additive manufacturers and base lube stock suppliers by including a cents-per-gallon charge in the price of the product to purchasers, such as independent compounders.

This method of doing business works and has allowed IOCA members to be viable and effective competitors in the lubricants market. IOCA proposes that additive manufacturers and base lube stock suppliers be permitted to continue to certify to the purchasers that when a certain additive package is blended with a particular base lube stock, that the finished product will meet or exceed the industry-developed test specifications and the congressionally approved fuel-efficient engine oil tests. The purchaser, such as an independent oil compounder, would certify that it mixed the required percentage of base lube stock with the additive package in order to produce the finished lubricant. The additive manufacturer or base lube stock suppliers would mark up its product by an additional amount to recover the costs of the new testing required for the fuel-efficient engine oils.

IOCA asks the committee to consider its recommendation and to reword the language of the proposed amendment in such a manner that the test procedures developed for fuel-efficient engine oils would be incorporated into the existing network of engine oil tests. Acceptance of this alternative proposal would not adversely affect additive manufacturers or base lube stock suppliers and would allow IOCA members to remain a competitive force in the lubricants market.

Mr. Chairman, IOCA thanks the committee for this opportunity to present its views. This concludes my testimony. Ms. Warwick and I would be happy to answer any questions you or other members of the committee might have. Thank you.

Senator STEVENSON. Thank you.

And thank you all. I don't have any questions. I think you have anticipated our questions in your statements.

How much increased mileage do those new oils you have described that are now being marketed achieve, do you know?

Mr. JONES. That is a good question and it is not too easy to answer because claims vary for the 35-odd brands on the market and different reference oils were used for comparison.

The current ASTM procedure, which is based on the EPA exhaust emission and fuel-economy test procedure, would produce numbers in the 1- to 2-percent improvement range, I would expect, for most of these oils. Consumers may actually experience an improvement in fuel economy somewhat higher than that, and this is one of the unknowns that is still being investigated.

I would like to make a comment, Mr. Chairman, on Dr. Rivlin's statement, if I may.

Senator STEVENSON. Certainly.

Mr. JONES. She had a table in her statement which projected the contribution of various technological improvements to vehicle fuel economy. Under "Lubricants," she shows 1985 starting at zero percent penetration for fuel-saving oils——

Senator STEVENSON. By 1985 she is doing what?

Mr. JONES. She is showing zero use of fuel-saving oils in 1985 and 80 percent by 1995. I don't disagree with the 1995 figure; I think it is probably reasonable. But as of today we believe there is probably something in the order of 10 to 15 percent use of fuel-saving oils and something in the range of 25 to 50 percent would not be unreasonable by 1985. So by 1985 there would actually be a significant contribution made by fuel-saving oils.

Dr. Rivlin's estimate of 5-percent fuel economy improvement, I think, is somewhat optimistic but I think attainable with advanced and improved lubricant technology. It is a little early to say, but I believe that is not an unrealistic target.

Mr. McDonnell, would you care to comment on that?

Mr. MCDONNELL. I am certainly not in disagreement with that number, and may be more in tune with what the customer might achieve in actual service. But it is probably somewhat optimistic relative to what we currently find or would expect to find in the ASTM procedure. There have been a number of reports that have shown some more significant or higher numbers in actual customer service, using different reference oils and different driving techniques than we are currently employing.

Senator STEVENSON. And can you tell us anything about the level of industry investment in research for the development of fuel-efficient lubricants?

Mr. WADDEY. I am Walter Waddey. In addition to my ASTM functions, I work for the Exxon Research and Engineering Co. And I can prepare a more detailed estimate, but it strikes me that over the last—oh, since 1973, I would guess in the $5 to $10 million range.

Senator STEVENSON. $5 to $10 million range?

Mr. WADDEY. In research.

Senator STEVENSON. And is it continuing at that level?

Mr. WADDEY. Yes. This is over this period, $5 to $10 million.

Senator STEVENSON. Since 1973?

Mr. WADDEY. Since about 1973 when we started.

Senator STEVENSON. That doesn't sound like very much considering the magnitude of the potential savings and I would have thought the potential market out there for oils that could produce those savings. And I would have thought the oil industry wouldn't need the incentives or incentives to invest in this research, and yet it is considered a candidate for Government-supported research.

Mr. WADDEY. I am talking about one company only.

Senator STEVENSON. Oh, I beg your pardon.

Mr. WADDEY. No; this is Exxon Corp. only.

Senator STEVENSON. Can you give us an industry figure?

Mr. WADDEY. Perhaps we can get an estimate back to your staff.

Senator STEVENSON. Could you?

Mr. WADDEY. We'll try to get an estimate. And I will firm up my estimate as well.[1]

Senator STEVENSON. Thank you.

Mr. WADDEY. I will be glad to do that.

Senator STEVENSON. Well, I am afraid I am new to all this and it is over my head, but you seemed to be suggesting that we ought to

[1]The API has agreed to furnish an industry estimate, and this will include Exxon research expenditures.

rely on the industry to establish the procedures and the classifications. If that is what you are suggesting basically, won't that produce a classification for fuel-efficient lubricants that reflect the lowest common denominator of the industry and provides the consumer with little guidance beyond that?

Mr. JONES. I think as we develop the test procedures that will allow us to grade oils for their fuel-efficient properties, market forces will be in play that will produce the best possible products. As of today, with the best test methods available to us, we don't have the precise tools needed to allow us to define oils beyond just one category of fuel efficiency.

But that is going to change, and I think we will be able to talk about oils with higher and higher percent improvements when we can measure them accurately and as oil formulating technology continues to develop.

Senator STEVENSON. And they will be labeled at various gradations?

Mr. JONES. Very definitely, yes.

Senator STEVENSON. How long is this going to take?

Mr. JONES. The current fuel economy test procedure is based on vehicle testing; but we are heading toward engine dynamometer testing which should produce a more precise test and has the potential for allowing oils to be graded in terms of percent improvement in fuel economy relative to a standard reference oil.

Maybe, Mr. McDonnell can speak about the ASTM program.

Mr. MCDONNELL. I'd like to comment first on our current dilemma. Mr. Jones commented we are looking for oils in the 1- to 2-percent improvement range, and we are dealing with a procedure that when we undertook to refine it—had a coefficient of variation of approximately 2 percent and now has been refined to the point where it is currently of the average of three-fourths of 1 percent, and some laboratories are running as low as 0.2 to 0.3 percent.

So this in itself has allowed some precision improvement and somewhat greater potential to measure with a little finer yardstick, if you will.

We would hope in the 2- to 3-year period beyond the initial adoption of the current procedure to refine a dynamometer procedure, which is more precise and would allow us further categorization of oils into more precise brackets. We do not feel we have the tools available to us now for this more precise measurement.

Senator STEVENSON. Yes, sir.

Mr. ANDREWS. Mr. Chairman, if I may make a comment, all of this just points up even more dramatically the need for the continued progress on the type of program on which ASTM has embarked. There must be precision before you can grade. Otherwise you don't have the credibility that is necessary in the marketplace.

We spoke earlier about there being a market for this type of product, and that certainly is true, provided the consumer perceives it as a reliable product. And it is absolutely essential that we develop techniques that will assure a grade that is reliable in this system before the consumer is going to have the necessary faith.

One other comment I'd like to make, Senator—and perhaps this is not the appropriate time to do it, but it appears to me to be, so if you will let me I'd like to make it.

We are somewhat concerned that EPA has embarked on what I believe Mr. McDonnell characterized as a parallel program. We in ASTM have been very pleased with the recent issuance of the OMB Circular A-119 which not only encouraged Federal agency participation in voluntary standards organizations, but also encouraged the use of the standards produced. It is our hope that EPA would see this as an opportunity as a Federal agency to join in a program that will ultimately benefit the consumer, rather than embark on a separate program of their own.

Thank you for the opportunity to comment.

Senator STEVENSON. Gentlemen, I think what you say about credibility is right, but won't the credibility of these grades be greater if there is government involvement and approval of the grades to some extent? I don't know who has the least credibility at the moment—the oil industry or the American Government. Maybe the combination would be the worst.

Mr. ANDREWS. I suppose I am basing that somewhat on past history. The motoring public has established a degree of credibility in the present system of grading oils, and I see no reason why they would suddenly abandon that feeling when we go into something a little more precise. There has been universal acceptance of the API, SAE, ASTM system of viscosity classifications, service classifications, and so forth, and I think that is a reasonable assumption.

I agree there is sometimes doubt as to where the least credibility lies nowadays. We all seem to be candidates for that position. I don't think it is one that we seek, but one that sometimes is cast upon us.

By the way, I do not represent the petroleum industry. May I reiterate I am director of the Division of Standards of the State of Florida.

Senator STEVENSON. I know, but you are in this box, too. It is not only the Federal Government. It is State governments also.

Mr. WADDEY. Sir, may I make this one comment. It is not meant to be facetious, but these SAE or API classifications similar to SAE are accepted universally, worldwide, including in Japan and Germany.

Senator STEVENSON. Touché.

I guess that raises another question, though. Can you tell us anything about research or testing procedures by foreign countries or companies? Are there any comparable efforts elsewhere?

Mr. ANDREWS. Well, I'd like to very generally respond to that, Mr. Chairman, in that ASTM, although it bears the designation of American Society for Testing and Materials, we are an international organization and enjoy international participation. I think some 10 to 15 percent of our membership is international now, and we enjoy the cooperation of our counterparts in other countries in ASTM work. Members of committee D-2, as a matter of fact, frequently are from other countries.

Senator STEVENSON. Yes, sir.

Mr. MCDONNELL. I would also like to comment that we are maintaining liaison with the Coordinating European Council. We are also working on the development of test techniques for evaluating of fuel-saving oils. And by virtue of having read their minutes in comparison to our work, it is my opinion that we are in the lead

in terms of development of procedures in classifications for fuel-saving oils.

Senator STEVENSON. And in the lead with respect to the development of oils, too.

Mr. MCDONNELL. In both the development of the oils and of procedure for testing of these oils.

Senator STEVENSON. Thank you very much, gentlemen. That is very helpful to us.

Our final witness is Mr. Thomas E. Cole, vice president of the Tire Manufacturers Association.

STATEMENT OF THOMAS E. COLE, VICE PRESIDENT, RUBBER MANUFACTURERS ASSOCIATION

Mr. COLE. Thank you, Mr. Chairman. At the outset may I make a slight correction. I am vice president of the Rubber Manufacturers Association.

Senator STEVENSON. I'm sorry; thank you.

Mr. COLE. The Rubber Manufacturers Association, in behalf of the domestic manufacturers of automobile tires, is pleased to have this opportunity to express its thoughts on amendment No. 1663 to S. 2015 which has been introduced by Senator Jackson and others regarding fuel economy of automobile tires.

At the outset, it should be made clear that the tire industry in the United States supports the objective of reducing the amount of fuel consumed by our automotive fleet. There is no question but that this is a worthwhile public goal and one, in fact, toward which the tire industry has moved steadily in recent years through technological improvements.

For several years, the reduction of tire-rolling resistance, which is the critical tire performance characteristic in relation to fuel consumption, has been a major concern of tire development engineers. Significant progress has been made, and tires being furnished to automobile manufacturers today represent a substantial improvement over the previous state of the art in that regard. These improvements are also being applied to tires sold in the replacement market, and we anticipate differences will diminish markedly over the next few years.

Mr. Chairman, the tire industry has been and is making concerted efforts to inform the American consumer of the fuel efficiency advantages of radial tires. I have brought a few examples of those efforts for the record, and I will leave them with the committee.[1]

Senator STEVENSON. Thank you.

Mr. COLE. That significant headway is being realized is evidenced by the fact that adoption by the motoring public of this type of tire is steadily increasing. We estimate that some 55 percent of all automobiles on the road today are riding on radial tires. This represents savings already realized of approximately 1.3 billion gallons of gasoline per year.

At the time of the 1973 Arab oil embargo, only 17 percent of new cars made in this country came equipped with the more fuel-efficient radial tires, and a scant 13 percent of tires sold in the replacement market were radials. Today more than 95 percent of

[1] The materials referred to have been retained in the committee files.

all new cars come equipped with radials, and approximately 50 percent of the replacement tires sold are radials. By 1984 virtually all new cars will be on radials, and this type tire will account for 75 percent of the tires sold in the replacement market. This means that 80 percent of all cars on the highway will be equipped with radials by that time. Thus, forces of the marketplace will have brought about total fuel savings conservatively estimated to be approximately 1.9 billion gallons of gasoline per year, approaching the maximum potential to be realized from conversion to radials.

As desirable as it might seem initially to force these numbers to 100 percent, it must be recognized that the radial tire, despite its many advantages, is not an appropriate choice for all applications. Vehicle use requirements, vehicle age, initial cost, et cetera, will dictate the selection of nonradial tires for some drivers, and it is important that the marketplace retain this element of choice for the consumer.

However, another large untapped resource for the improvement in rolling resistance in all tires can be found in the maintenance of proper tire inflation pressure. This is nearly as important as tire construction type when it comes to impact on fuel economy. An underinflated tire, regardless of type, uses considerably more fuel than a properly inflated tire. Time and again studies have shown underinflation to be a national problem. Surveys continue to indicate that nearly one out of every four cars is riding on seriously underinflated tires. It has been estimated that if all cars ran on properly inflated tires, the annual fuel savings would be approximately 875 million gallons of gasoline. Even tires that have low rolling resistance tend to lose that advantage when underinflated.

Not only is an underinflated tire a fuel waster but it also wears out faster, which is an additional waste of petroleum and energy, and runs hotter. Since excessive heat can lead to tire failure, improper inflation has serious safety connotations as well.

Since almost immediate results could be achieved, we urge that a comprehensive program aimed at getting the American motorist to realize the maximum potential fuel economy from whatever tire he has through proper inflation and care also be considered by this committee.

If the Government were to assist industry in promoting proper tire inflation and proper tire care by the consumer, such action could have both an immediate and a long-term impact on fuel consumption and tire safety.

Mr. Chairman, tire manufacturers, through their advertising and promotional campaigns, as I have already said, are already informing the public concerning the effect of radial tire usage and proper tire inflation on fuel consumption. And, as has been noted earlier, conversion of our automobile fleet to radials is progressing rapidly via the marketplace.

We are convinced that the very real fuel economies resulting from radial tire usage can be realized without additional legislation, thus avoiding further economic burdens on an industry already severely impacted by the current economic climate. We are ready, however, to meet with appropriate congressional representatives to discuss alternative means of informing the public concerning rolling resistance characteristics of tires.

That concludes my statement, Mr. Chairman, and I'd be glad to answer any questions you might have.

Senator STEVENSON. Thank you, sir.

What is the foreign tire producer penetration of the domestic tire market?

Mr. COLE. Looking at automobile tires only, it is in the neighborhood of 12 percent.

Senator STEVENSON. Does that seem fairly stable at 12 percent right now?

Mr. COLE. It is for the time being. I should add that one of the major importers is now a domestic producer, so that has served to stabilze the import share.

Senator STEVENSON. Michelin?

Mr. COLE. Michelin is now making tires in this country.

Senator STEVENSON. Is that penetration mostly from Michelin?

Mr. COLE. No; there are several major importers of tires. Michelin is one, Bridgestone, Dunlop, Continental in Germany—there are companies from all over—primarily Europe and Japan.

Senator STEVENSON. You say that,

> Forces of the marketplace will have brought a total fuel-savings conservatively estimated to be approximately 1.9 billion gallons of gasoline per year approaching the maximum potential to be realized from conversion to radials.

I have the impression that the real force in the marketplace was Michelin, and that it was Michelin that pioneered the development of the radial tire, marketed it aggressively, and brought about a response to the domestic producer.

Is that a fair impression?

Mr. COLE. There is no question but that Michelin was the first producer of radial tires, yes, sir, and domestic industry, U.S. industry, was several years behind Michelin. They are not any longer.

Senator STEVENSON. I ask that because the importance of the past is only what it tells us about the future, and I have a strong feeling that we tend to assume the world is going to stand still. I don't know if you were here earlier when we discussed the automobiles likely to be produced by foreign producers in 1995, but I have an idea that Michelin remains the pioneer in research on new automobiles. Their research activities are tightly controlled and guarded, and that they are at work on still more energy and fuel-efficient tires.

Is that a fair impression? You say we have about reached the maximum for radials. But what comes after radials, and from whom?

Mr. COLE. I don't think anybody knows the answer to that. As to what Michelin is up to, only Michelin knows. But I can assure you the U.S. manufacturers are as heavily invested in new technology research as it is possible to be. And whether the next major break in tire construction will come from the United States or abroad, nobody knows, but I will not say the United States is behind any country.

Senator STEVENSON. There will be another generation.

Mr. COLE. We are already into what GM refers to as their third generation of original equipment tires with the X-bodied cars. Obviously, vehicle manufacturers are continuing to put pressure on tire

manufacturers to improve the characteristics of the tires they are buying for their automobile fleet.

Senator STEVENSON. It is very much in the interest of the domestic tire manufacturers. They are going to go down with that industry.

Mr. COLE. Well, for every car that is not sold, there are five tires that are not sold; correct.

Senator STEVENSON. Are there, in your opinion, potentials for significant fuel efficiency in the development of new tires beyond the radials, I guess?

Mr. COLE. Well, I really can't answer that because such knowledge, if available, is closely guarded within the industry. Rolling resistance values today are about 35 percent better than they were on the bias-type tire. How much farther it is possible to go and what the relative fuel efficiencies will be is very difficult to predict. There are estimates that the total involvement of the tire in the fuel efficiency of a vehicle ranges from 12 to 20 percent. So assuming you could go to zero rolling resistance, which is impossible, we are already halfway there.

Senator STEVENSON. Is amendment 1663 feasible?

Mr. COLE. Well, it creates a problem, we think. A labeling program for consumer purposes historically has not provided the benefits it supposedly would. Beyond that, the only benefit to be derived from the legislation, as we see it, is to promote the use of radial tires; because that is where the real advantage comes, in the use of radials versus nonradials. And market forces are accomplishing that already.

It is true there are some small differences in fuel economy between radials but as technology advances, those differences will diminish. So we don't perceive any benefit to come from the adoption of the legislation.

Senator STEVENSON. Wouldn't labeling help the marketplace opt for the most fuel-efficient tire?

Mr. COLE. I think the answer to that, Senator, is that the American consumer is becoming acutely aware of his energy consumption and is looking toward fuel-efficient automobles, as you have been discussing for the last several weeks. The tire industry is a tremendously competitive industry, and if what the tire buyer wants is a fuel-efficient tire, they will make it and they will promote it.

Senator STEVENSON. But how does the consumer know which is the most fuel-efficient without some labeling?

Mr. COLE. Again, how would you establish a labeling program that would define that for him? You would necessarily have to have at least some broad categories into which tires would fall. Otherwise you'd be constantly shooting at a moving target and what is a class A today might not be a class A tomorrow.

Senator STEVENSON. And for different kinds of vehicles different kinds of tires are required.

Mr. COLE. That is right.

Senator STEVENSON. I would like to place in the record a statement of Senator Magnuson.

[The statement follows:]

STATEMENT OF HON. WARREN G. MAGNUSON, U.S. SENATOR FROM WASHINGTON

Last week, the Subcommittee heard testimony on the feasibility of extending fuel economy standards beyond 1985. I believe the 40 mile per gallon 1995 goal established in the legislation which Senator Jackson and I have introduced would have widespread benefits. Unfortunately, the fuel savings that would result from extending fuel economy standards would not accrue for a number of years.

In the meantime, we must take steps which can have an immediate impact on the volume of fuel we consume. To meet this short-term need, our package of fuel efficiency amendments provides for the testing and labeling of brands of motor oil and tires for fuel economy.

It is already known that certain types of motor oils and tires can extend fuel economy. However, standardized tests have not been performed on the relative fuel economy of these automotive products.

The oil companies, recognizing increasing consumer demand for products which stretch gasoline supplies, are offering new motor oils which they promote as improving fuel economy. But consumers have no way of comparing the fuel efficiency of these new products.

Motorists shopping for new tires can be equally frustrated. The automakers, who have access to data on the rolling resistance of tires, have generally supplied their new cars with tires which add to fuel economy. However, two-thirds of the tires manufactured in the United States are sold on the replacement market, where consumers and even dealers have no information on the gas-saving potential of the various types of tires.

The testing and labeling of motor oils and tires for fuel economy could save this nation thousands of barrels of oil every day within only a few years. With little government interference or expense, we have the opportunity to lend a helping hand to Americans who are attempting to save energy. Commonsense tells us that if we are going to spend billions on alternative forms of energy in order to reduce our dependence on foreign oil, we should also take this small step to provide consumers with this energy-saving information.

Senator STEVENSON. The subcommittee is adjourned.

[Whereupon, at 12:25 p.m., the subcommittee was adjourned.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT OF HON. WARREN G. MAGNUSON, U.S. SENATOR FROM WASHINGTON

I strongly support the provisions of S. 2015 before the Subcommittee this morning which would create a cooperative government/industry automotive research program.

The events of the past year make it abundantly clear that we must reduce our dependence on foreign oil. Automobiles alone account for 30 percent of the petroleum consumed in the United States. For the sake of our national security, our economic well-being and the survival of the U.S. auto industry, we must begin producing cars with improved fuel efficiency.

A study prepared for the Department of Transportation last year concluded that a 40 to 50 mile per gallon vehicle fleet is feasible in this country by the turn of the century. The report concluded, however, that new product and manufacturing process technology were required to produce affordable fuel efficient cars that did not sacrifice the comfort and drivability consumers have come to expect.

Historically, the cooperation of government and industry in basic research has been of mutual benefit. This type of public-private cooperation has made the United States a leader in the fields of computer and aerospace technology. I would also point out to my colleagues that West Germany, which already produces highly fuel efficient vehicles, has recently launched a four-year government/industry "Vehicle of the Future Program" similar in concept to the proposal before the Subcommittee.

I am confident this program will be fruitful. The development of fuel efficient vehicles will allow us to maintain our present standard of living despite the uncertain fuel supplies likely in the coming years. Federal support and stimulation of automotive research will also assist domestic automakers become more efficient and competitive in world markets.

I strongly urge my colleagues to support this program which will harness American technological knowledge to reinvent the car.

NEW YORK STATE DEPARTMENT OF TRANSPORTATION,
Albany, N.Y., May 9, 1980.

Hon. ADLAI E. STEVENSON,
Chairman, Subcommittee on Science, Technology, and Space, Senate Committee on Commerce, Science, and Transportation, Dirksen Senate Office Building, Washington, D.C.

DEAR SENATOR STEVENSON: I am writing in support of the extension—in time, in scope, and in level—of the present federal automotive fuel economy program. I believe new, significantly improved, mandatory corporate average fuel economy (CAFE) standards not only to be necessary and desirable for public fuel conservation and personal mobility objectives, but also to be entirely feasible to accomplishment and in the best interests of consumers and the automobile industry alike.

Obviously, the fuel efficiency of the private automobile is not the only requirement to achieve national, and State, energy conservation and mobility goals. Other actions range from improved driving practices and increased auto occupancy to the maintenance, utilization and support of public transportation systems. But the opportunity of improved vehicle fuel efficiency is too great, and too readily accomplished, to be let slide.

I urge your deliberations on S. 2015 to recognize recent positive moves—voluntary as well as mandated—toward a fuel efficient vehicle fleet, and to incorporate improved as well as extended standards in pending Congressional actions. As a minimum, I recommend extension of CAFE standards to 35 miles per gallon in 1995.

I have expanded on this recommendation in a brief attachment and have enclosed several of our analyses documenting New York's recent experience. I hope that

these comments will serve as a positive addition to the Subcommittee's May 9th hearing record.

Sincerely,

W. C. HENNESSY,
Commissioner.

Attachment.

EXTENSION OF CORPORATE AVERAGE FUEL ECONOMY STANDARDS

The Energy Policy and Conservation Act (EPCA) of 1975 established fleet average mileage efficiency standards for passenger automobiles sold by car manufacturers each year. More recently standards for light duty trucks and four wheel drive vehicles have been established.

Under EPCA, corporate average passenger car fuel efficiency standards are scheduled to reach 27.5 miles-per-gallon (mpg) in 1985. Since the passage of this legislation, these efficiency standards have become the single most important factor in conserving transportation fuels, especially gasoline, which is the fuel base for approximately 60 percent of the transportation sector. Since 1975—particularly in the last two years—the auto manufacturers have demonstrated their ability to market product fleets that meet and surpass these corporate vehicle standards with existing and developing technologies, and the car buying public has increasingly demonstrated its willingness—eagerness—to switch to these smaller, more fuel efficient vehicles.

Figure I-3—in the NHTSA Fourth Annual Report to Congress of the Automotive Fuel Economy Program, illustrates the reduction in fuel consumption based upon anticipated compliance with the fuel economy standards. It shows a significant projected reduction in century 2000 of 28 billion gallons resulting from existing passenger car standards than otherwise would have been consumed. However, what is also shown in Figure I-3, but not clearly emphasized in the related text, is the fact that when the federally mandated efficiency standards for new cars stops increasing after 1985, the effective annual improvement in overall fuel savings also stop increasing. By 1990, overall fuel consumption will again begin to grow. This shift from an increasing to a decreasing savings picture occurs primarily due to the fact that the fuel standards apply only to the new model year cars; continually increased savings require continually improved new car standards. The average age of the passenger car fleet is 6 years, but that fleet is comprised of vehicles up to 16+ years in age. Thus, it is easily understood why continued improvement of new car standards and the continued impetus of a temporal extension of these standards is necessary for improved fuel efficiency beyond 1985.

In view of this I think that the justification and desirability of continued and increasingly higher fuel economy standards should be the primary objective of the outcome of these Senate hearings. Our own analysis, prepared to assist the NYS Energy Office and as input to the NYS Energy Master Plan, clearly indicates that extensions in the federally mandated fuel economy standard beyond 27.5 mpg in 1985 to be a beneficial activity. Our analysis indicated that if the CAFE standards were to be increased to 35 mpg by 1995—an easily achievable goal—then it would be possible, through new car purchasing and vehicle fleet turnover, to obtain increased reduction in gasoline consumption of 10 to 13 percent above that achievable under the current 27.5 mpg in 1985 standards were they to be held constant through 1995.

Additionally our continued analysis and monitoring of new domestic cars purchased in New York State indicate, for the 1979 model year, that consumer purchases, the existing fuel economy standards mandated for new cars, coupled with vehicle fleet turnover, enabled the domestic new cars to exceed the 19 mpg standard and the domestic fleet to realize a savings of 146.9 million gallons of gasoline in New York State. In fact, these actions alone accounted for over 40 percent of all the gasoline saved in New York during the 1979 energy crisis. Consumers are buying small cars in record numbers, seeing it is the best way to conserve gasoline and mobility. But Congress should insist that manufacturers make such cars available to all willing purchasers, through enactment of tight CAFE standards. We are attaching our own recent analyses of auto fuel use, recent car purchasing and consumer responses during 1979.

Current consumer purchasing patterns reflecting the consumer's concern about the availability and the increasingly higher price of gasoline have sounded the end to the big car market as we have come to know it. There is every reason to believe that this trend will continue, especially as increased consumer interest in fuel efficient autos, and competitive pressures within the automobile industry demands a vehicle mix with substantially improved fuel economy.

In general, the industry has established a trend toward downsizing and the increased utilization of more fuel efficient technologies. These actions may be viewed as the results of manufacturers' following the successful lead of one company and/or of their desire to increase or maintain market share in the face of intense competition from foreign imports. Therefore with the new car sales distributions obviously being influenced by the necessity of even larger shares of fuel efficient vehicles by a combination of forces, such as consumer demand, industry competition for market positions and federal regulation there is little question that the established federal fuel economy standards can and will be met through 1985 * * * or that significantly improved new standards can be met beyond that time.

We recognize the economic implications of a major push toward smaller cars. We further know the impact on certain states, but the alternative of continued foreign oil dependence is worse.

Based on the above, we recommend the following:

(1) 1995 CAFE levels be set at least 35 mpg (preferably 40 mpg) for new cars ("city" mileage); uniform steps between 1985 and 1995 should be instituted.

(2) Foreign manufacturers should be required to meet these standards too (foreign car CAFE in New York averaged 25.7 mpg in 1979).

(3) Parallel standards (that increase at parallel rates) should be set for light trucks and recreational vehicles.

(4) Manufacturers should be required to display on new car stickers the dollar costs (or savings) of each new car for its fuel use above (or below) the standards for that year.

(5) The energy and dollar costs (or savings) of all options should be included on all new car stickers.

(6) If feasible (we believe it is, since we routinely do it for New York) manufacturers should meet CAFE standards at the state level. Some states, particularly on the coasts have beaten the federal standards while others lag behind.

STATEMENT OF ANDREW J. BENEK JR., PRESIDENT, LOCAL 2182 AFGE AND LYLE WRIGHT, PRESIDENT, LOCAL 28 LESA, AFL-CIO

We are pleased to find that the Senate Committee on Commerce, Science and Transportation is addressing the problems in personal transportation and the economic health of the auto industry. If the United States is to maintain personal transportation, action must be taken immediately. Our Committee advocates an approach that could address this long range problem; namely, give the responsibility for automotive research and technology to NASA as proposed in the Harkin bill, H.R. 4678.

The problem of producing a fuel efficient, non-polluting automobile that can compete both in domestic and foreign markets is basically technological. It is logical, therefore, to select the organization with both the highest internal technological and management capabilities in the government. In addition, NASA already has the internal programs, facilities, and skilled manpower to effectively solve the future problems in automotive R. & T.

NASA at present has programs for the development of Stirling and Gas Turbine engines. The program goals are to show 30 percent, and more, fuel economy gains over internal combustion engines, meet emission standards, use alternate fuels and be sold competitively. NASA also has programs in electric and hybrid vehicles with goals to provide near term support for existing industry, to provide technology development for higher performance and lower cost, and to enable commercialization. NASA's responsibilities in these areas are as a result of the foresight of the Congress to amend the National Aeronautics and Space Act through the Solar Energy Resources, Development and Demonstration Act (1974), the Electric and Hybrid Vehicle Act (1976), and the Automotive Propulsion R. & D. Act (1978).

A model for such an approach to automotive R. & T. already exists within NASA.

In aeronautics NASA has managed a successful partnership of government, industry, and universities for the advancement of aeronautical technology, especially in fuel economy. In this role NASA has managed the development of new technology which is then passed on to industry for commercialization. Aeronautics is second only to agriculture in balance of payments surplus. We have a 10 billion dollar balance of payments deficit in automotives. Additional manpower and funding are required for an effective, comprehensive automotive R. & D. program. NASA can begin now to provide for effective deployment of new funds and new personnel.

No new bureaucracy need be created if NASA assumes total responsibility for automotive research and technology development. No other current or proposed programs are equal to the NASA approach. The administration has the CARP program. This is an example of too little too late. Administration sources admit this

program will not adequately deal with future needs. Relying solely on the auto industry also has little promise. Chrysler has had financial problems. Ford has had to drop the promising Stirling engine and is dropping the 8 cylinder PROCOL engine because of limited resources. Japan will out produce the American auto industry for the first time. American auto engineers have rated American cars third in quality to Japan and Germany in Ward's Auto News. The financial and technical manpower resources of U.S. companies are at their limits just dealing with short term problems. Foreign governments do not hesitate in providing the technical support necessary to enhance the competitive position of their basic industries. Giving responsibility to other federal services is another possibility. D.O.T. is basically a regulatory agency. Having them take on an additional role without internal technical competence and management experience could lead to waste in little efficiency and lost time. D.O.E. has had poor success in advancing energy independence. This is largely because it has little internal expertise and management experience in advancing high technology. It was created from a basically regulatory agency with only contracted technical competence. Creating a new agency would compound the problem and waste taxpayers dollars in duplication of effort.

New facilities and equipment would be required and personnel would have to be trained. We no longer have the time to wait. Only NASA has the facilities and trained manpower that with additional funding and personnel could immediately work toward future fuel independence and re-establish the competitive position of the U.S. auto industry. The time to act is now or our industry may find itself trying to play catch up and never quite succeeding in establishing its former preeminence.

NASA has a proven track record of accomplishments in difficult areas of technology advancement, in both research and development. It is a goal oriented, problem solving agency, and as such, is a vital national resource. NASA is unequaled in its ability to transfer new technology to private industry so that it can quickly reach consumer markets. With appropriate additional funding and additional manpower, NASA can immediately intensify its current efforts to provide for this most vital need, energy efficient automotive propulsion systems.

VOLKSWAGEN OF AMERICA, INC.,
Washington, D.C., May 12, 1980

Hon. HOWARD W. CANNON,
Chairman, Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: We are pleased to provide comments regarding provisions of S. 2015 that relate to extension of the automotive fuel economy program beyond 1985.

We would like to emphasize our firm belief that legislation concerning fuel economy requirements beyond 1985 is not necessary. Market conditions dictated by the consumer and the rising price of fuel will sufficiently motivate auto manufacturers to produce the fuel efficient autos that this country requires. To legislate fuel economy standards beyond 1985 may very well continue the current problems that the industry faces today.

The Corporate Average Fuel Economy (CAFE) for Volkswagen of America (VWoA) is already above the 27.5 mpg standard enacted for 1985. Our 1979 CAFE increased even though our 1978 CAFE was almost 10 mpg above the standard. The consumer's marketplace preferences, not Federal regulations, are forcing all manufacturers including VW to increase their fuel economy.

We must improve our CAFE in the 1985 to 1990 period, assuming continued consumer awareness of and interest in fuel economy. this improvement will probably occur with diesel as well as gas vehicle fuel economies and some significant changes in product mix. We must stress, however, that we believe the free market system will and should make this determination, not a Federal law or regulation.

We have the following observations on Amendment No. 1664 to S. 2015:

The modification of the Motor Vehicle Information and cost Savings Act by adding paragraph (6) to Section 502(a) provides an unknown target which can only create confusion for automotive manufacturers. We believe that the amendment adding Section 502(a)(4)(B) will serve no real purpose. It stands to reason that either the standard is reasonable at 40 mpg or it is not. Our position generally is that, unlike emissions and some safety items which are generally intangible and not items upon which consumers base their decisions to buy automobiles, fuel economy is a very real factor in a consumer's car purchase decision and, therefore, Federal regulation should not be needed.

The consumer's preference for fuel efficient vehicles has already made fuel economy a top priority for auto manufacturers. The above legislative requirement will

only result in a drain of industry resources from the development area in order to deal with this regulation at a time when the industry is suffering severe financial restrictions.

The addition of Section 503(d)(1)(B) is another moving target that could create lead time problems for future development. If the testing and calculation procedures are incorrect, they should be corrected and the original fuel economy standards reevaluated to determine their validity.

In any case, these numbers are only good as a "yardstick." It is well established that individual driving characteristics have more effect on in-use fuel economy than any other factor. Therefore, the consistency of this yardstick is critical to its usefulness for comparing improvements.

Specific VW models, such as our diesel Rabbit, can achieve 40 mpg by 1995. However, we do not think, considering all the regulations required by the Federal government, that it is feasible to achieve a 40 mpg CAFE by 1995 for Volkswagen of America's total vehicle fleet.

VW is concentrating its engineering efforts on improving fuel economy. We are studying aerodynamics for lower rolling resistance, power train improvements and vehicle weight optimization. The results of this work are introduced annually if the benefit to the consumer is greater than the cost which must be paid for these changes. Transferring these improvements to mass production is dependent upon customer acceptance (cost) and the ability of the manufacturing process to accept the changes.

We support Amendment No. 1665 to S. 2015 which provides tax incentives for investment in equipment used in manufacturing facilities producing fuel efficient automobiles.

VWoA's Westmoreland, Pennsylvania plant will produce approximately 200,000 Rabbits and 24,000 light pickup trucks in 1980. These vehicles may be purchased with either gas or diesel engines. The diesel Rabbit and diesel pickup truck are the most fuel efficient vehicles produced and sold in the U.S. with EPA highway ratings of 56 and 53 mpg, respectively.

VW's other facilities in the U.S. include a stamping plant located in Charleston, West Virginia which supplies sheet metal parts and body stampings for U.S. built Rabbits and pickups. In March 1980, we opened a new plant in Fort Worth, Texas which manufactures automobile air conditioners, heaters and other parts.

We have signed a preliminary agreement with the State of Michigan to acquire government-owned property for a second assembly plant. This Sterling Heights, Michigan facility will nearly double our production capacity to approximately 375,000 units per year. We believe we would comply with the qualifying definitions contained within Amendment No. 1665 and, therefore, support this amendment and its goal of encouraging U.S. production of more fuel efficient vehicles.

We hope our comments on the provisions of S. 2015 relating to the extension of the automotive fuel economy program beyond 1985 have been helpful to the Committee. We respectfully request that this letter be included in the hearing record.

Sincerely yours,

PHILIP A. HUTCHINSON, JR.,
Director, Government and Industry Relations.

DEPARTMENT OF ENERGY,
Washington, D.C., May 15, 1980.

Hon. ADLAI E. STEVENSON,
Chairman, Subcommittee on Science, Technology and Space, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: As a result of discussions between members of your staff and the staff of the Office of Legislative Affairs of the Department of Energy (DOE), I am submitting a statement for the record in conjunction with your recent hearings on S. 2015 (the Transportation Energy Efficiency Act of 1979).

My statement includes DOE's view of the Cooperative Automotive Research Program (CARP). The current status and accomplishments of the DOE research and development work in advanced automotive propulsion systems and electric and hybrid vehicles are also highlighted. For your information, I have enclosed a copy of the April 30, 1980, testimony of Lester P. Silverman, Principal Deputy Assistant Secretary for Policy and Evaluation of DOE, before the Senate Committee on Energy and Natural Resources; his testimony covers DOE's position for improving automotive fuel economy goals beyond 1985. All these topics relate to improved fuel economy in future automobiles.

I am taking this opportunity to express DOE's relationship with the National Aeronautics and Space Administration (NASA) and our views on a related bill, H.R.

4678 (the National Automotive Research Act of 1979), which would transfer current DOE management responsibility for automotive research and development to NASA. We believe that the existing arrangement is working effectively and efficiently in meeting the urgent national need for energy conservation in the transportation sector. The change proposed by H.R. 4678 is not needed.

I hope that this information is of assistance to you.

Sincerely,

T. E. STELSON,
Assistant Secretary,
Conservation and Solar Energy.

Enclosures.

STATEMENT OF THOMAS E. STELSON, ASSISTANT SECRETARY FOR CONSERVATION AND SOLAR ENERGY, DEPARTMENT OF ENERGY

Mr. Chairman and Members of the Committee, I appreciate this opportunity to provide, for the record, the Department of Energy's (DOE) views on automotive research and development in conjunction with your hearings on S. 2015 (the Transportation Energy Efficiency Act of 1979). We have included herein our views on the Cooperative Automotive Research Program (CARP), the status of our ongoing hardware development programs, and our views on H.R. 4678 (the National Automotive Research Act of 1979).

DOE is the leading Federal agency, in terms of its budget, in the support of automotive research and development designed to improve the efficiency of energy use. Except for some basic research supported by the Office of Energy Research, all the DOE automotive activities are managed by our Office of Transportation Programs within the Office of the Assistant Secretary for Conservation and Solar Energy. These activities are board and cover basic research through to system demonstrations. However, the DOE support for these types of activities reaches out beyond the Department to other initiatives of the Administration. For example, we solidly endorse the Administration's new initiatives in basic automotive research, the Cooperative Automotive Research Program (CARP), which will provide an even broader research base in the physical and engineering sciences. Among the research areas to be further examined are combustion, thermal, and fluid sciences; aerodynamics; materials sciences; electrochemistry; and control systems. DOE feels that CARP can assist the auto industry by studying these critical areas at fundamental levels—levels that do not duplicate current programs but can help meet the industry's need for basic research data. This important base of technical information, to be generated by CARP, will provide now, fundamental understanding of the sciences that can be brought to bear in the creation of more fuel-efficient automotive transportation. We at DOE are excited about future participation in CARP.

With the able assistance of the National Aeronautics amd Space Administration (NASA), DOE has moved vigorously to implement the requirements of legislation pertinent to research and technology development on automotive propulsion systems and fuels as well as into basic research on combustion and materials.

There is considerable legislative support for the current DOE programs of automotive research and development. These laws include: The Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), the Department of Energy Organization Act (P.L. 95-91), the Automotive Propulsion Research and Development Act of 1978 (Title III of P.L. 95-238), and the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 (P.L. 94-413, as amended). Our programs to implement these laws are well underway; much progress has already been made to meet the mandated goals of more efficient, nonpolluting vehicles, as well as the intent of Congress in passing these laws. DOE commitment to these goals is apparent by the high caliber of program management and technical personnel dedicated to this work and by strong, top management interest currently exhibited by the frequent reviews of progress made in each program. It is obvious that achievement of one program goal, significantly higher fuel economy than possible with current systems, could lead to meaningful decreases in U.S. petroleum consumption, if industry produces these now experimental systems.

From the earliest days of this program in the Environmental Protection Agency (EPA), we have been aware that this work had to be shared as well as coordinated with other Government agencies. We also realized that we should continue to rely primarily on industry to perform hardware development and testing. Therefore, the Energy Research and Development Administration (a predecessor of the DOE automotive R&D work) chose NASA as the project manager to carry out many forms of automotive propulsion research and development. This relationship with NASA, particularly Lewis Research Center (the laboratory dedicated to propulsion exper-

tise), has developed and flowered into an excellent example of interagency cooperation. Through the joint efforts of the two agencies, this program has achieved a level of credibility with the U.S. auto industry that is perhaps unsurpassed by that of any single Federal agency working alone.

Both the automotive propulsion and electric and hybrid vbehicle programs have been continually coordinated with the Department of Transportation (DOT) and EPA. In fact, there are program and project reviews with DOT each year to prevent duplication of effort and to better determine those projects to which DOT could contribute directly. For example, DOT is always well represented at our semiannual Contractor Coordination Meetings, as we are at theirs. The program/project management team relationships are solid, and communications are open, frequent, and effective. The accomplishments made thus far with program management residing within DOE attests to the integrity of these programs and why the programs should be continued in its present location.

The basic strategy of the Title III of P.L. 95-238 program has been to concentrate efforts on advanced automotive propulsion systems that could provide major advantages in performance and efficiency over present engines.

Considerable progress has been made in implementing the automotive propulsion and electric and hybrid vehicle programs. Some highlights of these programs include:

Stirling cycle engine hardware development has reached the point of a design freeze for the MOD I engine; we expect to have that engine available for laboratory tests in about 10 months. The Stirling-powered AMC Spirit, which meets all Federal emission requirements currently anticipated for the decade of the 1980's with the MOD O engine, has been displayed at several locations around the country within the past 6 months.

Two contracts have been signed to develop and advanced gas turbine engine for automobiles. The two teams are from General Motors and from AiResearch/ Ford. Each team is working on building a ceramic gas turbine engine with the goals of at least a 30 percent improvement in fuel economy over a conventional internal combustion engine, ability to meet all emissions and particulate levels, and ability to use any liquid fuel. A third team—Chrysler Corporation and Williams Research Corporation—is in the process of rebidding their previously proposed effort.

A fleet of 4 turbine powered Greyhound buses has concluded one phase of revenue service between Washington and Philadelphia. Another route will be beginning soon out of the Chicago terminal to several Midwest cities.

Five transit buses powered by gas turbine engines will begin regular service in Baltimore this June. Ethanol will be one of the nonpetroleum-based fuels to be used on regular runs.

A turbocompound diesel truck (Cummins) has completed 50,000 miles of revenue service and demonstrated a 6 percent fuel economy improvement. Total fuel economy improvement could be 8-10 percent in the next phase of work.

A "bottoming cycle" (waste heat recovery) system is being road tested on a Mack truck. The tests aim to verify laboratory test results of 10-15 percent fuel economy improvement.

A study funded by DOE is underway to assess the impacts of increased automotive fuel economy performance as compared to use of synthetic fuels as a means to reduce further petroleum consumption by automobiles beyond 1985.

Lastly, the automotive propulsion program was the very first DOE program to be elevated to the major systems acquisition status when, in Janauary 1979, DOE approved the Advanced Automotive Heat Engine Systems Development Project Energy Systems Acquisition Project Plan. The Electric and Hybrid Vehicle Project Plans have been similarly approved.

With regard to the electric and hybrid propulsion program, the basic strategy we are following is to demonstrate the best available performance of existing technology while pressing forward with the development of new technology, especially in the vital areas such as batteries. Some highlights of this program work include:

Electric vehicles incorporating off-the-shelf technology and components have been delivered to DOE from four small business firms for extensive testing. We anticipate that the improvements developed under these contracts can move rapidly into the marketplace.

The number of electric vehicles committed to market demonstrations increased by the end of fiscal year 1979 to almost 800, and the number of demonstration sites rose from 16 to 57. Each demonstration is individually designed and runs for 4 years. The degree of participants' cost sharing is approximately 50 percent for about $15 million through fiscal year 1979.

Two all new experimental electric test vehicles incorporating extensive advances in the state-of-the-art have been developed by GE/Chrysler and the Garrett Corporation. These vehicles will utilize technology amenable to mass production by 1985.

Proposed rules will be published in the Federal Register within the next few days setting forth proposed equivalent petroleum-based Corporate Average Fuel Economy values for electric vehicles.

Eight separate battery companies have entered into cost-sharing contracts with DOE to develop new technology for nickel/zinc, nickel/iron and improved lead/acid batteries—all near-term batteries.

Advanced AC and DC electric propulsion systems such as electric traction motors, controllers, transmissions, chargers and auxiliary equipment for electric and hybrid vehicles are now under development.

Two loan guarantees for electric and hybrid vehicle production have been conditionally approved. One loan is for 10 years for $3 million to Jet Indusries, Inc., to expand their electric vehicle production capability to meet projected market demand. The other loan is for 8 years for $2.5 million to Electric Vehicle Associates, Inc., to increase their production capacity to 200 vehicles by the end of the project.

In addition to vigorously implementing the specific provisions of Public Law 94-413 as amended, the Department has selected the electric and hybrid vehicle technology for emphasis on the acceleration of the commercialization process. A resource manager for electric and hybrid vehicles will recommend actions that might help overcome the barriers to an early market penetration of this technology.

I want to stress that additional automotive-related research and development is underway in several DOE divisions and is coordinated through the Assistant Secretary for Conservation and Solar Energy. In our Office of Energy Research, technical advances have been made in DOE's basic research programs relating to the automobile. For example, sophisticated modeling of complex transient combustion phenomena and experiments to confirm the model have enhanced our knowledge of emissions formation and better ways to utilize fuel in spark ignition and diesel internal combustion engines. Fundamental experiments on ceramic materials have contributed toward a better understanding of the behavior of these materials under a variety of conditions. Further work on R&D on advanced, high-temperature batteries for electric vehicles is being carried out in the Energy Storage Program, now under the Assistant Secretary for Conservation and Solar Energy.

We have a broad-based effort ranging from fundamental research through technology development and commercial and field demonstration of both existing and new technology. We are not looking at the automobile in isolation, but as an integrated automobile-fuel system.

Thus, DOE has a strong ongoing automobile research and development program with considerable technical strength supplied within the Department and by NASA. Significant and measurable technical accomplishments have been made in these programs, and these will continue. In addition, our working relationships with NASA and with industry and academia have been exemplary. We also wish to continue in this vein.

H.R. 4678 (the National Automotive Research Act of 1979) would alter these relationships. We believe that H.R. 4678 would not be a positive step toward moving the Federal Government faster or more effectively into the important area of automotive research and applied technology development because there is a critical need for automotive R&D to be closely coordinated with the development of alternative fuels and other supply and conservation programs. This DOE focus is very necessary to assure the transition to alternative fuels and to renewable alternative energy resources. Shifting automotive R&D to NASA also would be an undesirable precedent for shifting other conservation end-use programs out of DOE. This would be particularly unfortunate given the momentum that has developed in our programs.

We are working closely with the auto industry, the industry that stands to gain much and has the critical role in making the decision to commercialize this technology. The auto industry has already voiced its concern with Government duplication of auto industry efforts. In fact, the recently named Director of the DOE Office of Transportation Programs, Henry Stadler, comes to us from Ford's R&D group, and he is looking closely at just this problem. In addition, he brings to DOE a clear, top-level management approach that is concerned with the ultimate commercialization of the technologies now under development and the need to involve the industry closely.

Finally, a transfer to NASA of DOE's automotive R&D programs is likely to fractionate even further the Federal Government's transportation policy and pro-

gram responsibilities. DOE has the policy role that should guide the direction for R&D so that key national policy problems can be solved, such as reconciling our need for mobility with the need to be much more efficient and less dependent on imported petroleum. The ongoing programs and agency relationships are working effectively and efficiently in meeting the national need for reducing petroleum consumption. Let's keep it working.

ACHESON INDUSTRIES, INC.,
Port Huron, Mich., August 19, 1980.

Hon. ADLAI E. STEVENSON,
Commerce, Science & Transportation Committee,
U.S. Senate, Washington, D.C.

DEAR SENATOR STEVENSON: Enclosed please find a copy of our new brochure entitled "Conserve Energy". Had we been present at the May 14 hearing of the Subcommittee, the data reviewed here would have been part of our presentation.

After you have read this publication, I am sure you'll see why we take a different view than those who testified before the Subcommittee. At recent meetings of the API, SAE and ASTM, I have heard of the success of the oil and additive interests in delaying the passage of the Jackson amendment. This is due, primarily, to the oil company reluctance to apply graphite additive to their motor oils.

In one field test of 140 passenger cars, a graphite motor oil produced an average fuel economy improvement of 4.85%. Statistical analysis of this data shows that the 95% confidence level for this average improvement is 0.96% to 8.74%. This test was conducted in typical service in a midwestern metropolitan area. Hence, based on this test, it can be said that an overall savings of 4.5–5.0% can be expected with graphite motor oils.

This fuel saving benefit remains largely unrealized because of oil company reluctance to pay the additional cost of the graphic additive without being fairly compensated. We, therefore, feel it is very important that an incentive be built into the grading of fuel economy motor oils—one which would allow the marketer who provides more fuel economy for the consumer's dollar to so indicate it on his package.

We, therefore, request that you make our brochure [1] and the letter a part of the record of the hearing and that we be advised if the subject is taken up again by the Subcommittee.

In the meantime, if there are any questions, please feel free to contact us.

Yours very truly,

R. KENNEDY SMITH.

STATEMENT OF LESTER P. SILVERMAN, PRINCIPAL DEPUTY ASSISTANT SECRETARY, POLICY AND EVALUATION, DEPARTMENT OF ENERGY

Mr. Chairman and members of the Committee, I welcome the opportunity to be here this morning to discuss the subject of improving automotive fuel economy in the period beyond 1985. Automobiles, including light trucks, are major users of petroleum in this country, currently using over one-third of all our oil, and they will continue to use large quantities of oil for the foreseeable future. The automobile and the automobile industry are also major elements of this country's economic and social structure. Changes in the design, manufacture, efficiency or use of autos are important to this country's economic and energy situation.

Your letter of invitation indicated that this hearing would focus on the potential for, the cost of, and the most effective means to achieve more fuel efficient automobiles in the 1985 to 1995 period. While your letter contained a number of specific questions for DOE, they can be grouped into four general areas;

Projections of automotive fuel demand and oil imports;

Post-1985 fuel economy improvements;

The respective roles of market forces and government regulations and financial incentives in bringing about fuel economy improvements; and

Comparison of fuel economy improvements and synthetic fuels production.

My testimony will deal with each of these topics in order.

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[1] The attachment was not reproducible and is in the subcommittee files.

PROJECTIONS OF AUTO FUEL DEMAND

We expect petroleum demand by automobiles to continue to decline slightly between now and the late 1980s. If there were no improvements in new automobile fuel economy beyond 1985, gasoline (and light duty diesel fuel) demand would start increasing in the late 1980s after reaching a minimum of about 6 MMB/D. By 1995 we estimate fuel consumed by automobiles would reach about 7 MMB/D. The increase in fuel demand would be caused by the growth in the total number of vehicles on the road and in the use of those vehicles.

However, we believe gasoline consumption is sensitive to a number of factors including the price of imported oil, which we assume will continue to rise at about 2 to 3 percent per year in real terms over the long term, and to economic growth. In particular these factors will affect the market for new autos; the actual post-1985 rate of improvement in auto mileage will be strongly affected by those factors.

As events of the last year have demonstrated, we cannot count on unrestricted access to Middle East oil. Given the long leadtime for making major changes in auto design, if new car fuel efficiency is to make a major contribution, it is important that industry begin soon to develop the necessary new car technology. Supply restrictions and higher oil price growth would tend to accelerate further efficiency improvements driven by the changing nature of market demand.

As I have noted, our estimates show a relatively high—though declining—level of petroleum demand by automobiles, through the late 1980s. We see a sizable potential for reducing petroleum demand and oil imports thereafter, through improved efficiency in the design and use of our automobile fleet. These reductions could be achieved through: improvements in the performance of the existing fleet of vehicles on the road through better driving and maintenance practices and fuel efficient tires and oils; more effective use of the vehicles through trip planning and carpooling; as well as increased fuel economy of new cars and light trucks.

Indeed we are already observing consumer response. Gasoline usage decreased about 8 percent so far this year compared to the same period last year. This decrease comes from decreased driving and the purchase of more fuel efficient cars. The fuel economy of new cars sold in the first six months of the 1980 model year was 2.8 mpg higher than those sold during the entire 1979 model year. This increase resulted from improvements to the fuel economy of cars in each size class as well as a shift to smaller model cars. Small car sales increased from 54 percent of total sales for all of 1979 to about 62 percent for the first quarter of 1980. There has also been an increase in small truck sales.

I want to emphasize the importance of considering light trucks along with automobiles. Many of the technological improvements that have been or will be made in passenger cars to improve fuel economy can also be applied to light trucks.

POST-1985 FUEL ECONOMY IMPROVEMENTS

The Department of Energy has been analyzing various aspects of automobile fuel economy for the past several years. These studies have included detailed analysis of the 1981 to 1985 fuel economy standards, the difference between EPA and actual on-road fuel economy, and the costs and feasibility of making significant improvements in light truck fuel economy. We have recently started a detailed analysis of post-1985 passenger car fuel economy improvements and costs. While this analysis will not be complete until later this year, we do have some initial findings to share with the Committee today.

Fuel economy improvements in new automobiles in the post-1985 period can come through a number of changes:

Increased use of currently available fuel efficient technologies such as reduced weight, more fuel efficient engines including diesels, reduced rolling and aerodynamic resistance, and improved powertrain efficiency;

Development and application of new technology not currently in use, such as variable valve timing, advanced transmissions, new diesel engines and alternative propulsion systems such gas turbine and stirling engines (and others not included in our preliminary analysis);

Introduction of new model cars including two-seater urban cars and electric vehicles; and

Changes in the size mix of cars being sold towards more smaller cars.

Based on the results of the preliminary analysis conducted by DOE, we project the maximum technically feasible corporate average fuel economy levels for domestic manufacturers to be in the range of about 35 to 40 mpg by 1990 and about 43 to 50 mpg by 1995. However, marketing, financial capability or environmental limitations may affect these ranges. There are several comments I would like to make about these figures and the technical analysis on which they are based.

First, there is no guarantee that all the technologies we have considered will be successfully developed or that our list of technologies covers everything that will become available between now and 1955. However, these preliminary findings are consistent with the findings reported in other studies. All these studies conclude that a fleet average fuel economy level of 40 to 50 mpg would be technically feasible in the 1990s.

Second, I want to point out the importance of improved technology as contrasted with changes in the size mix of small and large cars sold. The improvement in the fuel economy of all cars through technological changes (including new models of cars) could produce a 13 to 15 mpg improvement over the 1985 to 1995 period at a constant size mix. This compares with an improvement of 3 to 5 mpg, depending on the manufacturer, which could result from the further shift towards 1985-vintage small cars between 1985 and 1995. This means that any substantial improvement will depend upon the auto industry making an early commitment to the research and production facilities required to develop and introduce this advanced technology. We cannot achieve higher fuel economy levels for new cars simply by building more contemporary small cars.

Third, I want to draw your attention to the importance of diesel engines in reaching substantially higher new car fuel economy levels. We estimate that the expanded use of diesel engines over levels projected for 1985 can increase the technically feasible average fuel economy levels by about 2 mpg in 1990 and by about 4 mpg in 1995. Alternatively, if diesels were eliminated, the reduction in the maximum technically feasible levels would be about 3 mpg and 8 to 9 mpg in 1990 and 1995 respectively. As you are aware, there are a number of environmental uncertainties associated with diesel engines that could limit or substantially reduce their use and thus the savings we can expect from their greater fuel economy. These uncertainties will have to be resolved possibly with the requirement for further technical improvements in the engine's emission characteristics if we are to get the full benefit of the available and future diesel technology. The Administration has underway an active program of research, regulation and policy studies to address the diesel question.

Fourth, these estimates of maximum technical feasible fuel economy levels are based on the performance of new vehicles and technologies on the current EPA testing procedure. Should that test procedure be changed significantly, the estimated fuel economy levels would be correspondingly lower.

The potential energy savings that can be expected from the improving fuel economy beyond 27.5 mpg in the post-1985 period are considerable. A new car fleet average fuel economy of 40 mpg in 1995 would reduce consumption about 200 thousand B/D in 1990 and about 650 thousand B/D by 1995 as compared to a level of 27.5 mpg. Higher levels of 39 mpg in 1990 and 49 mpg in 1995 which we estimate to be toward the high end of the technical feasible range would reduce consumption about 600 thousand B/D in 1995. In either case, the full impact, or savings, would not be realized for another 10 years when the whole on-road fleet of vehicles would have reached the fuel economy level of the 1995 new cars.

Another way of expressing this is that a 1 mpg improvement in the fuel economy of the passenger car fleet beyond 27.5 mpg is worth about 100,000 B/D of savings once that improvement has worked its way into the entire fleet. These estimates have not accounted for improvements in light truck fuel economy beyond 1985. If such improvements do occur, in parallel with passenger cars, the overall fuel savings impacts would be correspondingly higher.

These energy consumption estimates assume that the differences or shortfall between EPA-measured and actual on-road fuel economy will be reduced or improved from those relations quantified in earlier DOE work. Such a reduction in shortfall could come from changes in vehicle design to technologies such as front wheel drive or diesels whose fuel economy test results are closer to actual on-road performance than current vehicle designs.

To restate, without continued improvements in new car fleet average fuel economy beyond 27.5 mpg in 1985, petroleum use by passenger cars and light trucks would start to increase in the late 1980s. If an average of 40 mpg for new cars is achieved by 1995, fuel use would likely continue decreasing through this century, but at a relatively slow rate after 1985. Of course, if a new car fleet average of 49 mpg is achieved in 1995 petroleum use by automobiles would decrease faster.

We are not yet ready to provide estimates of the costs and benefits of the range of fuel economy technologies which will be available after 1985. Our analysis of the technologies used through 1985 shows them to be very cost-effective for consumers. Technologies which were not cost-effective in the pre-1985 period may well become cost-effective after 1985. We expect that electronic engine controls and new lightweight materials will offer substantially improved benefits at lower cost after

1985 than before 1985. Additional changes in engine and transmission designs will also be available after 1985. The relatively long leadtime to develop advanced technologies, such as variable valve timing and continuously variable transmissions, means that several post-1985 technologies were not available in the pre-1985 period. But until our analysis is complete I would not want to offer firm conclusions on the expected costs of technological changes to achieve significantly higher post-1985 fuel economy.

THE ROLE OF REGULATIONS AND MARKET FORCES

I would like to turn now to the very important issue of the respective roles of market forces and government regulation in bringing about improvements in auto fuel economy. I would also point out that careful consideration must be given to regulatory requirements being imposed by the U.S. government, including safety, emissions, and fuel economy. To make decisions in one area without careful consideration of the others could have major adverse effects.

We have witnessed significant changes in the automobile market since January 1979. Since the Iranian revolution, consumers have experienced higher gasoline prices and shortages and have realized that future imports of petroleum cannot be taken for granted. The price of gasoline rose almost 60 percent between January 1979 and January 1980. Partly as a result, the sales of even the downsized, midsize and large cars fell. Car buyers are responding to higher fuel prices by demanding more small efficient cars. This trend will likely continue in response to our policy of making the true cost of gasoline quite clear to the consumer. Some have suggested that these events decrease the need for government regulation of automotive fuel economy.

As I noted before, future shifts in fleet size mix toward small cars will have relatively small effects on average fuel economy if current technology is not improved. For example, further shifts in the size mix by model year 1985 to as much as 75 percent small cars—as compared to 54 percent in model year 1979—will result in less than 1.5 mpg improvement in fleet average fuel economy. In contrast, the general increase in fuel efficiency of the fleet from technical changes will result in 5 mpg increase in fleet average fuel economy over and above that produced by mix shifts. As indicated earlier, we expect the same relative impacts from mix shift and technical improvements in the post-1985 period.

Our analysis of the cost-effectiveness of the 1985 standards, and some early studies of possible post-1985 standards, show that the higher "front-end" costs of fuel efficient cars are repaid about twice over by the fuel savings. Nevertheless, we must inquire whether consumers will be willing to pay these higher costs for technological improvements to achieve higher fuel economy at the maximum technically achievable rate. Studies, conducted by the Department of Transportation, of consumer attitudes (before the 1979 price increases) show that, while consumers demand small cars and technologies such as front-wheel drive, they were reluctant to pay for the multiple, less visible, improvements such as improved transmissions, electronic engine controls lighter weight materials, and other advanced technologies. This may have occurred because people viewed near-term expenses as more tangible than the long-term savings, because of the time period they expected to own their car, because they were uncertain about the technologies—although government fuel economy information program can help reduce such uncertainties—because of inertia, or some combination of these reasons. Manufacturers, who are well aware of the results of these earlier studies may continue to be reluctant to introduce these changes and make their cars of a given size class less price competitive. We need to revisit these studies in light of the 1979 price increases and shortages to see if consumer behavior has changed.

The government also has an important role in automotive fuel efficiency because of our vulnerability to oil import disruptions. Our dependence on unreliable foreign suppliers means we are exposing ourselves to the cost of a precipitous cutoff of imported petroleum and the economic disclocation such a cutoff implies. Further our country and our allies benefit from conservation efforts which reduce pressure on the world oil price, thus keeping it lower than it would otherwise be. For these reasons, it is of value to the nation to conserve oil or to increase domestic oil production from alternative sources, even beyond the levels of these conservation and production activities that would result from a functioning free market. Only the government has the perspective that takes into account these social and national security benefits of reducing oil imports, and other competing social objectives of safety and the environment.

The government must use an effective combination of tools, including information and regulations, to achieve its objectives with regard to automotive fuel efficiency. Information, in terms of correct energy pricing signals, credible new car fuel econo-

my ratings and general information on the full benefits of improved fuel economy, is essential to a better functioning market. These in themselves are not easy goals to achieve. We are attempting to make major improvements, for example, in the new car fuel economy ratings. We are also faced with the fact that consumers are exposed to many sources of information regarding energy supply and price and auto fuel economy improvements which are conflicting. Nevertheless, better information is essential if new car buyers are to make the correct choices.

We also believe there is a need for getting information out to the motoring public on how they can get better fuel economy out of the vehicles they currently own. Better trip planning, maintenance and behind-the-wheel operating practices have an enormous potential for both reducing the nation's gasoline demand and cutting gasoline costs for individuals. DOE tests indicate that the average driver can reduce gasoline consumption by at least 10 percent using the information currently available with no impact on personal mobility.

As the first step in this effort, the President yesterday announced a major initiative, in cooperation with the private sector and all levels of government, to reduce gasoline demand through voluntary actions by the general public and operators of large fleets. This program will utilize government resources, as well as those of major employers and the many companies and associations involved in automotive and travel-related activities, to get effective gasoline conserving information into the hands of those who can make use of, and benefit from it. This is an area where expanded efforts by the Department of Energy are appropriate and we will be stepping up our outreach efforts to achieve these goals.

Fuel economy regulations can move manufacturers and consumers to higher fuel economy levels than they might otherwise choose in the free market, and with greater certainty for the nation. The use of regulations has certain disadvantages relating to the need for government to be able to forecast the future development of technology and the bureaucratic burdens associated with any regulatory program. An important drawback to the current regulatory program is the lack of incentives to achieve fuel economy levels above the mandated CAFE level. Here again the effects of future price growth are critically important. In looking at the post-1985 period we do have the advantage of building on a currently well functioning regulatory program.

In addition, in the market pricing for petroleum products which this Administration is committed to achieve, we have established the gasoline conservation fee (to be supplanted by the indexed excise tax) to begin to reflect the indirect cost of imports in consumer gasoline prices.

I would like to point out that all of the approaches or tools available rely on an accurate measure of automobile fuel economy performance. As you are well aware, the current EPA testing program has a number of shortcomings. While DOE is not directly responsible for this activity, we will continue to work with EPA and others to bring about the required improvements.

SYNTHETIC FUEL PRODUCTION AND CONSERVATION

While it is tempting to draw comparisons, in terms of cost and timing, between improving auto fuel economy and producing synthetic fuels, I believe such comparisons can divert attention from our overall goal of reducing oil imports. Conservation and synthetic fuel production are both essential elements of our overall plan to reduce the nation's use of imported oil. The overall timing is such that improved auto fuel economy will produce energy savings throughout the 1980s and 1990s, while synthetic fuels and many other energy producing technologies will have their major impact in the 1990s. Both will be cost-effective to the nation, when compared to the cost of imported oil and taking into account the national security and economic benefits of reduced oil imports. The great uncertainty about the success of future technologies for energy conservation and production argues strongly for pursuing both conservation and synthetic fuels on their own merits.

In summary, significant fuel economy improvements are possible, and we believe they will bring important benefits to consumers and the nation. However, a balanced approach to achieving these fuel economy improvements is desirable; such an approach should include greater emphasis on information on which the market can function. A number of studies are currently underway in DOT and DOE to evaluate the range of issues associated with post-1985 fuel economy improvements. DOE will be in a better position to provide specific proposals later this year regarding post-1985 fuel economy. Finally, environmental concerns over the use of diesel engines must be resolved soon and better test procedures must be developed to measure fuel economy performance more accurately.

That concludes my prepared statement. I will now be pleased to answer any questions the Committee may have.

TEXACO, INC.,
Washington, D.C., June 2, 1980.

Hon. ADLAI E. STEVENSON III,
Chairman, Senate Subcommittee on Science, Technology and Space of the Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, D.C.

DEAR MR. STEVENSON: Your subcommittee is currently considering Amendment No. 1662 which seeks to amend Senate bill 2015, The Transportation Energy Efficiency Act of 1979 (PL 95-619) by adding Title V—Fuel Economy of Motor Oils. We understand that your committee has received testimony from both the American Petroleum Institute and the American Society for Testing and Materials. We agree with the substance of their testimony as we believe they have touched on many points which your subcommittee should consider. We should also like to furnish our own comments for your consideration and inclusion in the record of the proceedings regarding Amendment 1662.

Testimony has already indicated that the ASTM consists of members acting voluntarily to achieve desired technical objectives. In most instances these actions involve private funding with no government participation. In the matter of the fuel efficiency of motor oils, the need for a suitable method to define oils having this property was recognized some time ago. Cooperative work was initiated and has been underway for over two years spearheaded by the ASTM Task Force on Fuel Efficient Engine OIls. The work of this Task Force has involved a survey of potential test techniques, an examination of the potential precisions of the EPA FTP procedure, the establishment of a pilot program to assess the potential efficacy of this procedure, an analysis of the data from this pilot program, the design of a broader based demonstration program, the review of laboratory capabilities with regard to running this procedure, the solicitation of funds to support this work, and the donation of cars from participating automotive manufacturers. This work is now in its final stages and it is expected to result in the definition of a procedure which will form a basis for the establishment of a classification which will define oils having fuel-saving characteristics.

We believe that such a classification will be in place by early 1981 and would expect that it would be widely adopted by oil marketers. Oils meeting this classification would be identified by can labeling now being proposed by the API. We would also expect oil marketers to rapidly mount an extensive advertising campaign which would increase the public's awareness of this new classification. We have actively supported this activity as it is an obviously desirable national objective.

In view of the progress already made, it is our opinion that Amendment 1662 to S. 2015 is not necessary. The activity stemming from its passage would merely duplicate actions already taken by a cooperative voluntary technical society and would actually be harmful as it would dilute the industry commitment to the ASTM program. In addition, its adoption would not accelerate the promulgation, public acceptance, or usage of fuel-saving oils.

Dealing with the proposed legislation itself, your review will indicate that any procedure resulting from such legislation "shall not be unduly burdensome to conduct". (Page 4 lines 8 and 9 of Amendment 1662.) In anticipation of the passage of Amendment 1662 to S. 2015, the EPA has already proposed a procedure which would require the "grading" of oils as to their fuel saving benefits. The costs associated with the testing of a single oil to define its proper "fuel saving grade" could approximate $400,000. A statistical analysis prepared by a member of the ASTM Task Force (copy attached) will indicate that approximately 100 test cars would be needed to obtain a statistically sound assessment of an oil giving between 1 and 3 percent improvement over the selected "base line". Such costs would be extremely burdensome, especially for the smaller marketers.

This problem was recognized by the ASTM and resulted in the decision to use a common standard against which all oils would be tested. Oils would then be rated as being fuel saving or not. They would not be graded as to their percentage of fuel saving. To do so would incur the costs indicated above and would also tend to confuse the public as normal consumer usage could not differentiate between oils of different fuel saving grades. The cost of the ASTM procedure being considered is estimated at somewhere between $20,000 and $30,000 per oil tested, a more reasonable figure.

Finally, the proposed legislation directs the secretary to "develop categories of motor oils for which test procedures developed under subsection (c) will apply. To the extent practicable these categories shall correspond to existing categories of

motor oil including categories based on viscosity, quality, or other specifications of the Society of Automotive Engineers". (Page 1 lines 24 and 25, page 2 lines 1 thru 4 of Amendment 1662 of S. 2015.) As discussed above, the voluntary participative technical societies have established the oil classifications systems for the viscosity and quality needed to assure proper operation of the automobile and to provide satisfactory protection to the user. As needs have arisen and been identified, these categories have been revised and updated. In this regard the United States is substantially ahead of the rest of the world, precisely because such standards have resulted from the cooperative participative efforts of the technical community. Legislation, regardless of how well intended, would neither alter these needs nor change the speed by which they are met. On the contrary, it is likely that any participation by Federal agencies will merely obscure the definition of the problems and delay action toward their solution.

I should now like to turn to a discussion of the stated rationale for the proposed legislation. (Congressional Record, Feb. 26, 1980, pages 1784–1787.) Chief among these is the statement that the ASTM work was "stymied by lack of funds". The record will show that this is not so. The defining and refining of a test procedure which will have sufficient precision to reliably show a 1 percent difference in fuel economy requires the application of a broad spectrum of technical expertise. As the ASTM testimony has shown, this expertise has been assembled within the ASTM and includes representatives from car manufacturers, oil and additive companies, EPA and NHTSA. The record of the activities undertaken by the Task Force is substantial and clearly indicates that significant progress was made in a very short time. The voluntary funding asked for by the ASTM was oversubscribed and the problem of funding has not resulted in significant delay towards the attainment of the objectives.

In conclusion, we believe that the proposed legislation is redundant and unnecessary as it directly duplicates the activities of voluntary participative technical societies. Secondly, the actions already underway within the ASTM and the API will result in a satisfactory industry performance and labeling standard which we expect would be quickly adopted by all reputable marketers. Finally, in the rationale supporting the proposed legislation, we can find no merit in the comments which indicate that the ASTM activities have been delayed by lack of funding.

We trust that you will find these comments of sufficient interest and substance to be seriously considered in your deliberations pertaining to the pending legislation. Should you have any specific questions regarding any of the comments we have presented, we would be glad to amplify them at your convenience.

Very truly yours,

J. DONALD ANNETT,
Vice President, Texaco U.S.A.,
A Division of Texaco Inc.

Attachment.

NOTE ON CONSTRUCTION OF PROBABILITY PLOTS
IN ASTM RESPONSE TO EPA

The average difference observed in a test using N cars will tend to follow a Normal probability distribution curve, of "width" $\sigma/\sqrt{N}$, centered about the true value of the difference. The EPA proposal to use the lower 95% confidence limit of the mean as a grading criterion effectively shifts the center of the distribution downward by the amount $t(0.95, df)^* s/\sqrt{N}$.

The attached Figure 1 shows the bell-shaped distribution curves for $\sigma = 6\%$, N = 5 cars, and true $\Delta = 2\%$ for both the EPA 95% LCL and simple mean Δ criteria. These illustrate the way in which the A, B, C, and D classification probabilities plotted in Figures I-A-10 and I-B-10, respectively, were obtained. The classification probabilities are the areas under the distribution curves in the A, B, C, and D regions. For the ASTM report, the probabilities were obtained by standard computer program functions from the Statistical Analysis System (SAS, Inc.).

Figure 2, attached, illustrates the effect of increasing the fleet size from 5 to 15 cars, using the mean Δ criterion, again for a true difference of 2% and $\sigma = 6\%$ (reference Figures I-B-10 and I-B-12).

To estimate the fleet size required to give a 95% chance of correctly grading as B an oil with a true difference of 2, we calculate N so that the width of the distribution centered on 2 is just narrow enough to give an area of 95% between the boundaries of the B region (1% to 3%). This occurs at $2 - 1.960 \cdot \sigma/\sqrt{N} = 1$ and $2 + 1.960 \cdot \sigma/\sqrt{N} = 3$ (1.960 is the value of a standard normal variable that gives the required 95% probability). Using either of the above equations yields

$$1.960 \cdot \frac{\sigma}{\sqrt{N}} = 1$$

or $N = (\sigma \times 1.96)^2 = (6 \times 1.960)^2 = 138 \longrightarrow 140$ in Groups of 5

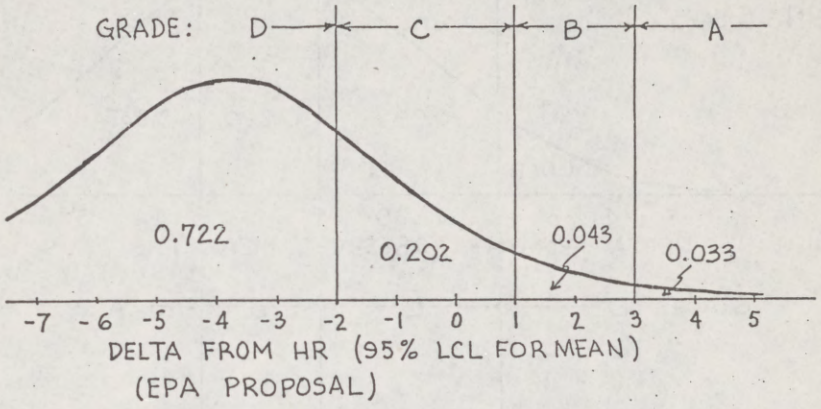
For a 90% probability, $N = (6 \times 1.645)^2 = 97 \longrightarrow 100$ in Groups of 5

L. J. Painter
Senior Research Associate
Chevron Research Company
Richmond, California

12 May 1980

FIGURE 1.

$\sigma = 6$, $N = 5$ Reference Figures I-A-10, I-B-10



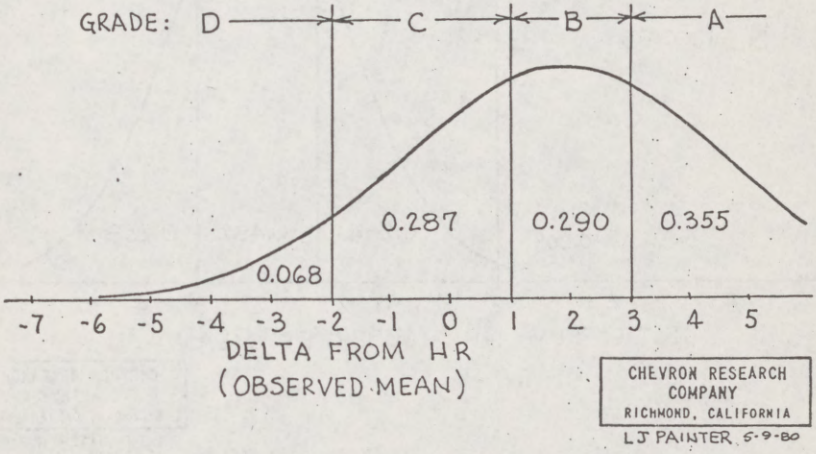


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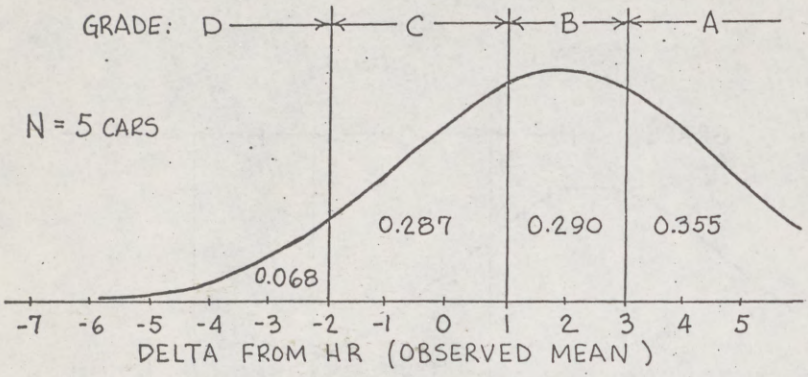
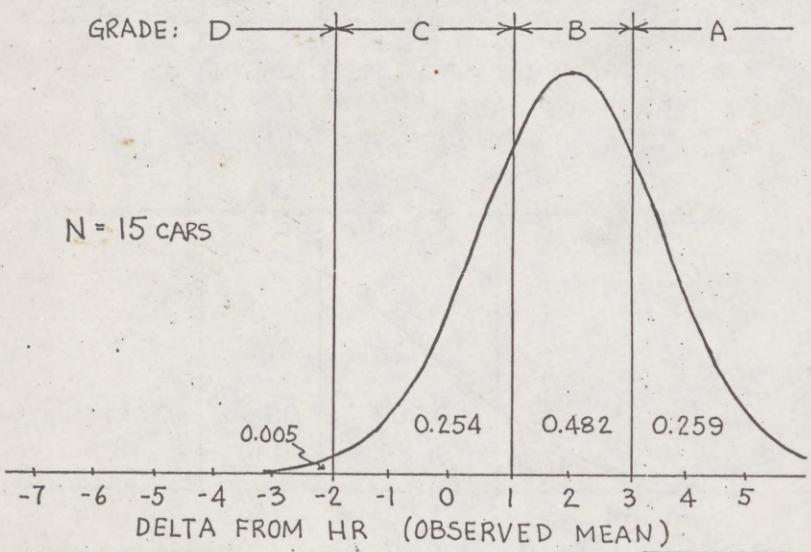
FIGURE 2.

$\sigma = 6$, N = 5, 15 Reference Figures I-B-10, I-B-12





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