DOCUMENT RESUME

ED 230 428 SE 041 923

TITLE	Engineering and Science Manpower Act of 1982. H.R. 5254. Hearings Before the Subcommittee on Science, Research and Technology of the Committee on Science and Technology. U.S. House of Representatives, Ninety-Seventh Congress, Second Session (April 27, 29, 1982).
INSTITUTION	Congress of the U.S., Washington, D.C. House Committee on Science and Technology.
PUB DATE	Apr 82
NOTE	241p.; Some pages are marginally legible due to small print.
PUB TYPE	Legal/Legislative/Regulatory Materials (090)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Educational Improvement; Elementary Secondary Education; *Engineering Education; *Federal Aid; *Federal Legislation; Financial Support; Government Role; Hearings; Higher Education; *Industry; *Labor Force; Manufacturing; Mathematics Education; Policy Formation; School Business Relationship; *Science Education; Technological Advancement; Technology
IDENTIFIERS	Congress 97th; *Proposed Legislation

ABSTRACT

Provided are hearings on the H.R. 5254 (National Engineering and Science Manpower Act of 1982). The purpose of this legislation is to establish a national policy which will insure an adequate supply of scientists and engineers necessary to meet the needs of the United States in the future. Testimony was presented by John Glenn (U.S. senator from Ohio), Edward David (Exxon Corporation), James Rutherford (American Association for the Advancement of Science), Eugene Zwoyer (American Association of Engineering Societies), Delbert Tesar (engineering professor), Charles S. Robb (Governor of Virginia), Ike Skelton (congressman from Missouri), Douglas Pewitt (Office of Science and Technology, Executive Office of the President), Sheldon L. Glashow (physicist, Harvard University), and Reena Beth Gordon (a Westinghouse scholar, providing a student's perspective on the improvement of precollege science/mathematics education). The testimony addressed various issues in support of the legislation, including current engineering faculty shortages, the need for scientific/technical manpower to operate in a technologically-based society, foreign competition, problems in secondary science/mathematics education, and others. In addition, current and future prospects for resolving the problem were addressed, including government/school industry cooperative efforts. (JN)

H.R. 5254

ENGINEERING AND SCIENCE MANPOWER ACT OF 1982

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-SEVENTH CONGRESS

SECOND SESSION

APRIL 27 AND 29, 1982

[No. 107]

Printed for the use of the
Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE
96-196 O WASHINGTON: 1982

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[1] On assignment to Budget Committee for 97th Congress.

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WITNESSES

H.R. 5254—ENGINEERING AND SCIENCE MANPOWER ACT OF 1982

TUESDAY, APRIL 27, 1982

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to call, at 9 a.m., in room 2318, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Mr. WALGREN. The subcommittee will come to order.

Today opens 2 days of hearings by the Subcommittee on Science, Research and Technology on the bill known as H.R. 5254, the National Engineering and Science Manpower Act of 1982. This bill was introduced in the last Congress by Mr. Fuqua, the chairman of the full Science and Technology Committee, and myself. We hope this year to bring this kind of important legislation to fruition.

The purpose of this legislation is to establish a national policy which will insure an adequate supply of scientists and engineers necessary to meet the needs of our country in the future. In testimony heard by this committee over the last several years, there have been repeated expressions of concern about serious shortages of trained manpower, both in universities and in industry. This problem is particularly severe with regard to engineers and computer scientists. In an economy which is increasingly dependent on scientific and engineering skills to remain competitive, the warnings that we in the government have received cannot be ignored.

Of course, the development of graduate level scientists and engineers represents only the tip of an educational pyramid which must be kept strong in all of its dimensions. We can insure the quality of our top professionals only by being sure that the talent pool from which we draw them is as broad and as deep as possible. Young people in that talent pool must be given the basic skills and enthusiasm for science that will motivate and allow them to move on. Moreover, we need to be sure that as our scientists and engineers further transform our economy into one based on modern technology, we then have a working population with basic science and mathematical literacy to support and participate in that transformation.

This means that the Nation must attend to its entire structure for science and engineering literacy and professional training, and not simply look at the supply of specialists at the end of the pipeline. This entire structure is certainly not the direct management responsibility of the Federal Government, but the Federal Government must be an informed and reliable partner with State and local authorities, and the private sector, in carrying out their responsibilities and fulfilling their needs.

The legislation embodied in H.R. 5254 reflects the conviction of Mr. Fuqua and myself that there is an urgent need for the Federal Government to act in addressing these issues. The problem will not just go away; indeed, its dimensions appear to be increasing and certainly are greater now than when the bill was first introduced. We anticipate that these hearings will aid in further clarifying the issues, and we want to welcome the witnesses and invite them to work with us in this area.

I would like to hold the record open for a statement Mr. Fuqua might wish to enter.

[The statement of Mr. Fuqua follows:]

OPENING STATEMENT OF HON. DON FUQUA

I am pleased to join my colleague from Pennsylvania, Chairman Doug Walgren in these important hearings on H.R. 5254, the National Engineering and Science Manpower Act of 1982. Mr. Walgren and I introduced this bill late last year primarily as a means of focusing attention on what is evolving as a critical problem for the country—providing for our engineering and science manpower needs. As we have said many times before, it is obvious that implementing the vital programs of economic recovery and national defense being called for will prove impossible without the necessary human resources in engineering and the sciences.

I recently had the privilege of joining a distinguished group of leaders from industry, academia, and the Government to discuss these issues at the National Engineering Action Conference in New York. I understand we will hear today from Dr. Ed Davis who helped organize that conference and who will speak on industry's view of the situation.

Mr. Walgren, myself, and others who have joined us in sponsoring H.R. 5254 do not see this proposal as a panacea to the problems of technical, engineering and science human resources now confronting us. Rather, we view the bill as a beginning—although an important beginning—of bringing together various public and private sector initiatives to establish a comprehensive set of strategies for addressing this complex issue. The comments and ideas we have received on our bill to date from hundreds of experts in policy and education have been extremely helpful and encouraging. I look forward to hearing from our witnesses today, and to continuing to work with our outside frineds, on means to improve the bill and move towards enactment.

Mr. WALGREN. I want to recognize my colleague from Ohio, Mr. Shamansky, who has maintained a consistent interest in science and technology matters in his time in the Congress. Mr. Shamansky.

Mr. SHAMANSKY. Thank you, Mr. Chairman. I just merely want to welcome Senator Glenn, my fellow Ohioan and neighbor in Columbus, Ohio, to the committee.

I appreciate the chairman's comments on my interest in science and technology. Although I come from a totally liberal arts background, I can't think of anything more importent for the future, not only of our country, but especially for our community. I welcome the Senator.

Mr. WALGREN. Thank you, Mr. Shamansky.

[The prepared statements of Mrs. Heckler and Mr. Brown follow:]

PREPARED STATEMENT OF HON. MARGARET M. HECKLER

Thank you, Mr. Chairman.

The issue of our nation's shortage of engineering and technical talent has been the subject of several hearings of this Subcommittee, including a hearing in Boston at the Massachusetts Institute of Technology. I requested the Boston hearing because an adequate pool of engineers and other technical talent is a critical element in the Massachusetts and the national economy.

In the last five years we have witnessed enormous growth among high technology companies in Massachusetts as well as the rest of the country. This growth, however, is threatened by competition from abroad and from a scarcity of qualified people, especially in computer science, microelectronics, software engineering and manufacturing engineering involving highly complex materials processing. This latter factor, the shortage of engineers and other paraprofessionals, can largely be attributed to our nation's educational system which doesn't seem to adequately motivate or prepare students to enter engineering programs. The lack of emphasis on math and science at every level of education should be a national concern.

The U.S. ranks a poor fourth in scientific literacy behind the Soviet Union, West Germany, and Japan. In addtion, in our graduate schools one out of every three Ph. D. candidates is a foreign national.

In the Boston Globe the recruitment section appears unbelievably thick for a job-short economy. Most of the ads are for the high tech industry. The main reason for this is that the industry is people poor. To illustrate this point, in June 1980 there were approximately 9,000 technical and professional positions available in the state. Companies were only able to employ 6,000, some 3,000 jobs went unfilled. Many New England companies, especially small ones, have been prevented from expanding because of the lack of engineers. Even more significant, it is estimated that for every engineer employed, there are five additional technical, support and administration employees hired, and for each 100 new jobs in the manufacturing sector, an additional 74 jobs are created in other areas such as finance, construction, retail, and so on. This means that the 3,000 unfilled positions represent lost employment for appoximately 30,000 people.

To maintain its technological edge in world markets, the U.S. must reemphasize science and engineering on our agenda of national priorities. When the Soviets launched Sputnik I, a remarkable engineering accomplishment, the U.S. rose to the challenge with new dedication to science and technology. Today our technology lead us again being challenged, not just by the Soviet Union, but by Japan, West Germany and others.

Therefore, if we are to meet this challenge with the same dedication the space program had, we must shift science and engineering back toward the top of our national priority list.

The National Science Foundation, while reducing funding levels in science and engineering programs, has established the Commission on Precollege Education in Mathematics, Science and Technology. The 18 Members of the Commission were just announced last week and I think we can expect some very positive results from their actions.

Nevertheless, some members of this committee have been prompted by the immediate seriousness of the problem to sponsor the bill before us today. I am looking forward to the coming days of testimony, and I am especially grateful for the honorable gentleman from Ohio, Senator Glenn, for taking the time to come before the committee.

Opening Statement of Representative George E. Brown, Jr.

Mr. Chairman, I would like to commend you for holding these hearings on a subject of critical importance to our Nation.

Science and engineering education and manpower concerns needs to be viewed within the context of the much broader issue of technological innovation vital to the renewal and growth of our national economy. We have examined these issues in hearings before this Committee and I am pleased to have the opportunity to consider them within the framework of the legislation before us.

I believe that the federal government should have a strong leading and coordinating role in this area. However, it is clear that we need the active participation of industry and academia if we are to be successful in the implementation of a science and engineering manpower policy. It is difficult to envision the full leadership role on this issue being carried out by the private sector. Government can serve as a catalyst to important private initiatives.

Science and engineering education are critical for achievement of the science and technical literacy necessary to allow all of our citizens to participate in a modern technological world. Participation in this technological world includes making informed decisions about scientific and technological questions, as well as ensuring appropriate development (including commercial) of our scientific and technological capabilities. The bill before us is a start in the right direction of addressing these needs. However, the overall innovation and productivity issues related to this need to be addressed in other ways we well.

I hope we can explore these questions with our witnesses today.

Thank you Mr. Chairman.

Mr. WALGREN. The first witness is the distinguished Senator from Ohio, John Glenn, whose fame precedes him, and it is an amazing thing for me to think that I would ever be in a position of introducing or recognizing somebody that I only saw from a distance as a very young person. It is really a great pleasure to have you here.

I know from several conferences of your real interest in the scientific capabilities of this country on the Federal level. We really appreciate knowing that there is somebody who is as concerned about this area as you are in the Senate.

STATEMENT OF HON. JOHN GLENN, A U.S. SENATOR FROM THE STATE OF OHIO

Senator GLENN. Thank you very much, Mr. Chairman. I appreciate those kind remarks. This is an area of very great concern for me, and I appreciate your invitation to testify before your subcommittee on what I view as the critical issue of technical manpower. It is an issue on which you have provided leadership through your deep and abiding interest.

Mr. Chairman, the recipe that led to the success of America as a world power rests upon four major ingredients: a rich pool of human resources from which the builders of America came; a system of universal education so that every person can obtain the fundamental tools that he or she needs in order to fulfill his or her human potential, including the potential to make significant contributions to knowledge through research; a free society and a free enterprise system that nurtures the human spirit and provides for new ideas to be translated into new products and new services for the benefit of all our people; and an abundance of natural resources to draw upon in realizing our productive capacity.

I could summarize that lengthy paragraph again by saying that we became what we are because we educated our people, first; because we then plowed a greater percent of our gross national product back into research, and a search for new ideas. Then when that new pattern of ideas formed a matrix that was commercially viable, then free enterprise capital jumped on it and provided the jobs, the employment, the products, the new endeavors, the new businesses that put us well ahead of in this world.

We have done well, Mr. Chairman, particularly in this century. In less than 100 years, we have gone from being a technological backwater to being the most advanced technological nation on Earth. So the lesson is out there for all to learn. If nations wish for economic success, for an increase in the standard of living of their people, for enhanced national security, then technological development is the road to take. The result we are seeing is not too surprising, for we are now in a worldwide competition for leadership in technological development by those who have seen what the goose was that laid the golden egg in this country: We are seeing that technological development across a broad range of industrial areas. The maintenance of our own economic health and security demands that we not falter in this competition.

In various speeches and recent statements on the floor of the Senate in December and twice in March, I have documented a trend toward decline in the relative position of the United States vis-a-vis some of the other industrialized countries in research, development and productivity. Of particular concern to me are the growing deficiencies in our educational system that must be overcome if we are to effectively meet the international challenge.

Let us examine for just a couple of minutes the magnitude of the problem we may be faced with a few years down the road. Last year, the American Electronics Association conducted a national survey of its members asking them to project their technical work force needs in 21 job categories through 1985. Approximately one-third of the entire industry responded in the survey. Now, I recognize the flaws that are associated with forecasting of this kind, especially in an industry where optimism runs rampant. However, we can certainly look at the figures that came out of that survey as a worst-case possibility and, in that case, we see the following results:

There will be a need for an additional 113,000 technical professionals in light-job categories—that is an increase over current staff of 76 percent.

There will be a need for an additional 140,000 technical paraprofessionals in 13 job categories—an increase over current staff of 102 percent.

The projections through 1985 for degrees to be awarded in the area of electrical engineering and computer science from all U.S. colleges and universities will be about 70,000 graduates. The demand, based on the survey, will be for nearly 200,000 graduates, thus the shortfall between supply and demand for computer engineers and for electronic engineers will be about 25,000 annually. That means that to meet the needs of the electronics industry alone, the engineering schools would have to triple—to triple—their output of electrical engineering and computer science engineers each year for the next 5 years.

I suggest, Mr. Chairman, that even if the shortfall is only a fraction of this, we could still be in serious difficulty. It is important to understand that shortfalls are not our only manpower problem in the area of science and engineering. There are technical areas in which surpluses have occurred and in which underutilization of technical talent is the rule rather than the exception. A recent survey of the membership of the IEEE, the Institute for Electrical and Electronic Engineers, revealed that this problem is as serious to some people as the problem of shortages may be to others.

Regardless of the extent of shortages of technical personnel and where such shortages actually may be, there is no denying the fact that whereas the United States graduated 58,000 engineers in 1980, the Japanese, with half our population, graduated 74,000 engineers, and the Soviet Union has reported to have graduated 300,000 engineers in that same year. It should be noted that approximately 70 percent of Soviet graduate students are enrolled in science and engineering fields, where as the most recent data suggest that only about 20 percent of U.S. graduate students are in science and engineering, mostly the former.

Our system is failing to provide sufficient incentives for young people to go on to graduate study in science and engineering fields. Low stipends for graduates fellowships, poor salaries for university professors, and obsolete laboratory equipment are turning American science and engineering graduates to private industry which offers high pay and state-of-the-art equipment with which to work. The result: 46 percent of our engineering Ph. D.'s in the United States in 1980 were foreigners. I would repeat that: 46 percent of our engineering Ph. D.'s in the United States in 1980 were foreigners. And two-thirds of those were here on temporary visas.

Now, I happen think that the education of foreigners is one of the best things we can do as far as foreign policy goes. I think that for the long haul, for the 15 to 20 to 25-year look ahead on our relationships around the world, our American educational system provides a tremendous opportunity. But think what is happening here at home when 46 percent of the engineering Ph. D.'s in 1980 were foreigners, and two-thirds of them were on temporary visas.

It is estimated that 10 to 15 percent of the total number of engineering faculty positions in the United States are currently unfilled. Using electrical engineering as an example, we had 490 fewer masters degrees in electrical engineering awarded in 1980 than in 1970, and 356 fewer Ph. D.'s in electrical engineering awarded in 1980 than in 1970, a decrease of 40 percent. Similar figures are available for other fields of engineering, making it apparent that the current faculty shortfall is going to be perpetuated in future years.

Mr. Chairman, some of these problems are going to be alleviated, to some extent, by cooperation between industry and universities. I am very complimentary to those companies that take that initiative. Graduate fellowship programs are being or have been set up by various companies and associations, including Exxon, IBM, DuPont, the Semiconductor Industries' Association, and others. I repeat my compliments to them for doing this.

Cooperative arrangements allowing faculty to have access to industry state-of-the-art equipment for research purposes are blossoming in some places. Other initiatives involving the establishment of endowed chairs and adjunct professorships are proceeding. Yet, I think it is important to note that despite all this activity, all this activity is just a drop in the bucket in comparison to the need that we face. Ultimately, the end must be met from the pool of young people who have made a decision, their own free-will decision, to enter science and engineering careers. That means, Mr. Chairman, that it is the precollege school system, the primary and secondary schools, that must provide at least some of the motivating force that causes young people to choose such careers. I think that this may well be the weakest link in the chain that has been forged.

In 1979, the President of the United States required the Director of the National Science Foundation and the Secretary of Education to submit to him a report concerning the state of science education in the United States. That report indicated that a serious crisis exists, not just sometime in the future, but it exists today. That report said that we are slipping in our ability to attract and properly train sufficient scientists and engineers of the highest quality, that the business, political, educational, and other nonscientist leaders in the Nation are not receiving an education in science and mathematics appropriate to the times and to the kinds of problems and issues they face in their everyday work; that our security and our economic health are being undermined by our failure to produce high school graduates who are well enough educated in science and math to meet the needs of the armed forces and the industrial and public service enterprises; and that the gap between the public understanding of science and technology and the requirements of citizenship in a participatory democracy is wide and growing.

Mr. Chairman, there are some other statistics that were very impressive to me also. A recent study of State-legislated curricula shows that only half the States in the United States require even one science course before high school graduation, five require two or more courses, and the rest mandate none. In seven States the mandated course is physiology, and in five States health and hygiene courses satisfy the science requirement.

Teachers receive very little continuing education in science and mathematics. Low salaries and poor working conditions have created an extreme shortage of high school teachers of science and math. I was much interested in a recent interview in the New York Times, in which the Dean of Science at the City College of New York—in an article on April 6—pointed out that in the State of Connecticut last year, there were no graduates produced that were equipped to teach high school science. In the State of Minnesota, only one such graduate was produced. It is not surprising, therefore, to find that there is only one certified physics teacher for every two high schools in the city of Chicago.

Meanwhile, students in Germany, Japan, and the Soviet Union receive a much heavier emphasis on science and mathematics in their primary and secondary schools and, as a result, graduates of secondary schools in those countries are much better prepared than graduates of American high schools to deal with technical matters, and are much more inclined to enter the technical work force. Is it any wonder then that only 6 percent of American undergraduate students major in engineering, just 6 percent, whereas in Japan it is 20 percent, and in Germany it is 35 percent?

Yet, at the very time when it is becoming more and more apparent that we have a serious problem with respect to technical, scientific, and engineering manpower, and with respect to our educational system, the Federal Government, instead of moving ahead with programs and support to bolster the educational system and to meet our needs, is retreating and appears to be about to abandon altogether any serious effort to help upgrade the quality of American science education.

Funds for the Science Education Division of the National Science Foundation for 1983 have been eliminated, except for $15 million for graduate fellowships. The Director of NSF, Dr. John Slaughter, has accordingly disestablished the Science Education Division and is instead contemplating naming a commission to deal with the problem.

In my view, Mr. Chairman, nothing short of a statutorily mandated effort by the Federal Government can deal with this problem. We need a national policy on technical scientific and engineering manpower and education and a mechanism for implementing it. Mr. Chairman, the bill we are discussing today, H.R. 5254, and the bill I introduced on April 22 of this year in the Senate, S. 2421, provide appropriate legislative frameworks for dealing with these issues.

There are some differences between our bills, Mr. Chairman. In particular, the Senate version gives a bit more emphasis to the overall problem of science education. This is reflected in the makeup of the Council and in some of the policy statements. Accordingly, the word "education" appears in the title of the Council. More importantly, at a time of fiscal austerity, it is essential that we scrutinize very carefully the activities and the output of all governmental organizations and particularly any new ones that we create.

In this particular case, the Council is dealing with the interests of so many diverse groups in dealing with the manpower and education problem that we must be sure that we understand fully and precisely what the goals and strategies that are that the Council sets in carrying out its responsibilities.

Therefore, in the Senate bill, the Council's major initial activity is the formulation and presentation of the national technical manpower and education plan which is designed to let the Congress and everyone else know what the Council perceives as the problem and the goals and strategies that are needed in order to alleviate or solve the problem. This plan is to be updated annually and would be an important tool for the Congress to use in evaluating the work of the Council and in performing oversight activities generally.

I think it is important to emphasize, Mr. Chairman, that in both the House and Senate bills the Engineering and Science Manpower and Education Fund is expended through a system of matching grants on a one-to-one basis with such other private or public sector funds as may be made available. That means that the Council is expected to work cooperatively with other Government agencies and with the private sector in dealing with the problems under its jurisdiction. In addition, both bills contain a sunset provision whereby the funds would disappear after 5 years unless specifically reauthorized by the Congress.

Mr. Chairman, I think we both recognize that there is much discussion that will need to take place before the Congress takes so important a step as the establishment of the Council and the fund which are contained in within our bills. I believe it is important to raise the visibility of this most important issue, to indicate that a substantial Federal role is needed in this area, and to get the debate going that will lead to a consensus position on precisely what the Federal role ought and should be.

We cannot afford to wait or to be complacent. Action is needed if we are to halt the erosion of our store of human and educational resources that have made America the great Nation that it is. If we do not make the investment and the effort to produce the technical, scientific, and engineering manpower that we are surely going to need in great numbers in the future, we will one day look back with regret at this time and mark it as the time when the United States began its slide into becoming a second-rate technological power. Nothing less than our future economic health and national security are at stake.

Mr. Chairman, I am reminded of a statement I heard not too long ago when someone was talking about something being too expensive for our budget this year. In this particular area of education, I would only say this: If we think it is too expensive, let us not try ignorance. That is going to be more expensive.

Thank you very much.

Mr. WALGREN. Thank you very much, Senator Glenn.

I know that you have some time constraints. I want to recognize Mr. Shamansky for comments and questions.

Mr. SHAMANSKY. I just want to say, Senator, that it is very reassuring to me to hear this testimony from you because it represents the same conclusions that I have reached after 15 months of hearings here in this committee: It is absolutely on point.

I do want to give you the good news that the majority of this committee has added back $30 million to the $15 million that the administration chose to restrict science education within NSF response to the very thing that you were talking about.

I don't mind telling you that I found the response of the National Science Foundation to the idea of doing away with the Science Education Division very unfortunate. I realize they operate under great constraints from the Office of Management and Budget. I think Dr. Slaughter chose a very poor way of responding to that. In our hearings here, frankly, I think it is fair statement to say that I brought it to the attention of Dr. Branscomb that I didn't think his job depended on the administration, and merely to rubber stamp whatever they had done was not the role I saw of his group. I thought that was highly unfortunate.

Specifically I want to mention that, on a tour of Ohio University chemistry labs, I went to the laboratory I had chemistry in over 35 years ago. Nothing had changed. The smell was the same, everything was exactly the same.

Senator GLENN. You are fortunate. Most labs have deteriorated.

Mr. SHAMANSKY. They weren't even holding their own. As I said, they held their own.

But the President of Ohio State had said that it would cost about $50 million to $55 million to reequip. And yet, the men directly involved think that a figure of $85 million is more realistic. If that is just that one university, what are the figures across the country?

I realize you have to go, but I really find your testimony very reassuring because I think it parallels the conclusions that we have drawn here.

Senator GLENN. Thank you.

Mr. SHAMANSKY. Thank you, Mr. Chairman.

Senator GLENN. Thank you very much, Mr. Chairman. I appreciate very much your letting me come on first. I do have a hearing over there at 9:30 that I do have to get back to since I am involved directly with it this morning. So I appreciate it very much.

Mr. WALGREN. I would like to recognize Mr. Skeen for a greeting.

Mr. SKEEN. Senator, I won't hold you long. I appreciate your time constraint, but I want to thank you for one contribution you have made to us this morning. You have reassured Mr. Shamansky, which is not an easy task to do. He is great guy, but he has been very unreassured here.

I do bring you greetings too, from an old classmate of yours from Mexico, Jaime Bermudas. I will visit with you later about an invitation he has made to you.

Senator GLENN. Very good. He and I were in school back at Muskingum College in Ohio together, more years ago than either one of us would like to remember. Thank you, I appreciate that.

Mr. SKEEN. Thank you, Senator.

Mr. WALGREN. And if I could, Mr. Dymally.

Mr. DYMALLY. Just a brief observation, I notice in the legislation that there is no provision for Members of Congress. I would just like you to think about an amendment to include one Member from the House and one from the Senate.

Senator GLENN. All right. That might be a good addition. We will be working closely together with the two versions of this thing. The staffs will be working together, and I look forward to working individually with each one of you here on this. I think it is that important that we really have to get on with this.

Mr. WALGREN. Thank you, Senator Glenn, very much. We appreciate your coming.

Senator GLENN. Thank you.

Mr. WALGREN. The next witness is Dr. Edward David, the former Science Adviser to the White House and presently president of Exxon Research Engineering Corp. We welcome you to the committee, Dr. David. Your written statement will be made part of the record as a matter of course, and please proceed in the most effective way from your point of view. We are glad you are here.

STATEMENT OF EDWARD DAVID, PRESIDENT, EXXON RESEARCH & ENGINEERING CORP.

Dr. DAVID. Thank you, Mr. Chairman. It is a great pleasure to be here this morning with this committee, and I thank you for the opportunity to appear and describe the results of the National Engineering Action Conference.

This conference was held in New York on April 7, and it was organized to address issues which are among those which concern your subcommittee today: specifically, the problems of engineering faculty and the overall quality of engineering education in the United States. The current state of affairs in engineering education and the importance of these problems drew over 50 university presidents, chief executive officers of major corporations, heads of engineering societies, government leaders, and members of their staffs to the National Engineering Action Conference in New York.

I might add that the commitment of the attendees, which included the chairman of your committee, Congressman Fuqua, was such that they made their way to New York despite the heavy snowfall which was delivered by the great spring blizzard of 1982.

These leaders did not come as representatives of individual institutions, but as representatives of more than 20 key national associations and government institutions directly concerned with engineering education. They know that the economic progress and national security of the United States depend critically upon the quality of the training received by the cohort of young engineers who will enter industry and government in the coming years. I think Senator Glenn's remarks are particularly appropriate here.

The people who came also recognized that if the present trends continue, for example, an increase in the more than 1,600 engineering faculty positions that are now vacant and deteriorating engineering laboratories on campus, that the young men and women who want to become engineers will not receive the education that they deserve, that they want, that they need, and that the times require.

The conference participants issued a call to action advocating initiatives appropriate to local circumstances and institutions. They also produced a suggested action agenda and action examples illustrating the agenda which they are taking back to their organizations for consideration. Not a few organizations have already taken some of the actions described in these documents. A chief goal of the conference—which we call NEAC—was to inspire others to join in—to preserve and increase the momentum of efforts that are already underway.

The full listing of proposed actions appears in the conference documents which I will submit for the record. A very brief summary of some of the recommendations is as follows:

For higher education: Increase incentives, rewards, and recognition for undergraduate teaching of engineers. Set engineering faculty compensation at a level recognizing realistically the market for such talent in industry.

Recommendations for industry include providing direct financial support to U.S. resident masters and doctoral candidates in the form of traineeships, scholarships, and awards, and to create opportunities for junior faculty to increase their income through consulting, summer employment, tutorials, and grants.

For the academic and professional societies, the conference recommended expanding scholarship and fellowship aid to engineering doctoral students and making direct grants to the schools. Also to encourage their memberships—that is the memberships of the professional societies—to make financial contributions in support of engineering education and, where possible, to take advantage of corporate matching grant programs.

For the States and for the Federal Government, the recommendations were to encourage re-examination of policies, especially at the State level, which may preclude making the pay of engineering faculty and the educational environment competitive with that in industry. Also, to encourage engineering doctoral study by providing additional fellowships and other aid under the aegis of the National Science Foundation, the mission agencies, and other government organizations.

Mr. Chairman, we hope that the National Engineering Action Conference will prove to have been successful in producing positive action and drawing attention to these problems in engineering education. To establish a point of contact and sustain some of the momentum which has been created, the American Society of Engineering Education, through its offices here in Washington, will continue its recently inaugurated program to act as a clearinghouse for information on the situation. For our part, we at NEAC have pledged our efforts to find and apply the remedies, and we have urged our colleagues to join with us. In the words of MIT President Paul Gray, who conceived NEAC and asked me to chair it:

The Nation must begin now to make stronger efforts to solve the problem and to avoid future substantial declines in either the quantity or quality of engineering graduates on which so much of our future national well-being must depend.

Mr. Chairman, with your permission, I will submit the conference documents which I have just described for the record. These will include the list of conference participants. While time does not permit me to mention all of the leaders who were present, I should note that in addition to Chairman Fuqua, we were fortunate to have Dr. George Keyworth, who is also scheduled to be one of your witnesses, as our luncheon speaker. Dr. Keyworth delivered a message to the conference from the President, and the text of President Reagan's message, as well as Dr. Keyworth's remarks, are among the documents I will submit for the record.

I want to thank you again for the opportunity to present this report on NEAC and hope it will be useful as you consider the crucial issues of engineering education and manpower. Thank you very much.

Mr. WALGREN. Thank you very much, Dr. David.

Without objection, those submissions will be made a part of the record.

[The attachments to Dr. David's statement follow:]

REMARKS BY
DR. GEORGE A. KEYWORTH, II, DIRECTOR
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
EXECUTIVE OFFICE OF THE PRESIDENT, AND
SCIENCE ADVISOR TO THE PRESIDENT
NATIONAL ENGINEERING ACTION CONFERENCE
NEW YORK, NEW YORK
APRIL 7, 1982

IN LISTENING TO THE VARIOUS SPEAKERS THIS MORNING I WAS STRUCK BY TWO THINGS. ONE WAS THE STRONG AGREEMENT THAT THE COUNTRY FACES SOME SPECIFIC PROBLEMS IN ENGINEERING MANPOWER. THE OTHER WAS HOW MANY INNOVATIVE APPROACHES ARE BEING CONSIDERED TO DEAL WITH THEM. WE SHOULD BE DELIGHTED TO SEE THIS DIVERSITY, BECAUSE THE MOST IMPORTANT THING THAT CAN COME OUT OF THIS CONFERENCE IS THIS CONCEPT OF SHARED RESPONSIBILITY AMONG ACADEMIA, INDUSTRY, PROFESSIONAL SOCIETIES, AND THE STATE AND FEDERAL GOVERNMENT. WE ALL HAVE UNIQUE GOALS AND RESOURCES, AND OUR CHANCES FOR EFFECTIVE ACTION ON THE MANPOWER PROBLEM ARE ENHANCED BY UNDERSTANDING HOW THE CONCERNS AND PLANS OF THE DIFFERENT SECTORS COMPLEMENT EACH OTHER.

IT IS ALSO IMPORTANT THAT WE KEEP IN MIND HOW VOLATILE ENGINEERING EDUCATION PROBLEMS ARE. TECHNOLOGY CHANGES RAPIDLY, AND SO DO MANPOWER NEEDS. A NEW FIELD HEATS UP, AND ANOTHER MAY FADE IN IMPORTANCE. FOR THAT REASON THE ADMINISTRATION IS PLEASED WITH THE KIND OF MULTI-FACETED APPROACH THAT THIS COALITION IS ENCOURAGING. WE SHOULD RECOGNIZE THAT RESPONDING TO TODAY'S SITUATION WITH SOME CENTRALIZED, MONOLITHIC ORGANIZATION OR MECHANISM WOULD ALMOST CERTAINLY BRING RIGIDITY TO A SITUATION THAT CALLS FOR FLEXIBILITY. THE PRESIDENT RECOGNIZES AND SUPPORTS THIS CONFERENCE'S WISE APPROACH, AND HE HAS ASKED ME TO READ THE FOLLOWING MESSAGE FROM HIM TO THOSE OF US ASSEMBLED HERE TODAY:

96-106 O - 82 - 2

THE WHITE HOUSE

WASHINGTON

March 19, 1982

TO THE NATIONAL ENGINEERING ACTION CONFERENCE:

I am pleased to send greetings to those attending the National Engineering Action Conference.

Your conference is an important initiative, and I hope you will impress upon your colleagues in academia, industry, and government the importance of engineering to the future of the nation. Our nation's engineering institutions and the faculty who train our young engineers have helped to sustain our position of leadership in this technological world. The preservation and growth of this resource is essential to a healthy economy and to the national security.

I am particularly encouraged by the emphasis of your conference on private sector initiatives, with government playing a supportive but not dominant role. It is important that the kinds of cooperative, voluntary measures you propose be acted upon. I appreciate your willingness to take action toward assuring the continued quality and vitality of our engineering faculty.

You have my best wishes for a productive meeting and for continued success in the future.

Ronald Reagan

THERE ARE TWO OVERRIDING ISSUES BEHIND THE ADMINISTRATION'S CONCERN FOR ENGINEERING MANPOWER SHORTAGES. ONE, OF COURSE, IS THE AVAILABILITY OF QUALIFIED ENGINEERS AND TECHNICAL PERSONNEL FOR NATIONAL SECURITY NEEDS--IN THE DEPARTMENT OF DEFENSE, IN OTHER GOVERNMENT LABORATORIES, AND ON THE STAFFS OF INDUSTRIAL CONTRACTORS. IT IS IMPORTANT TO REMEMBER THAT THE UNITED STATES DOES NOT DEPLOY LARGE NUMBERS OF MILITARY PERSONNEL AND MATERIEL AS SOME OTHER NATIONS DO. WE RELY HEAVILY ON TECHNOLOGICAL SUPERIORITY TO PROVIDE OUR DEFENSE. THAT BASIC DEFENSE PHILOSOPHY IS IMPORTANT TO US AS A FREE NATION, BUT IT CANNOT WORK WITHOUT A HEALTHY R&D ENTERPRISE.

THE OTHER FEDERAL CONCERN STRONGLY DEPENDENT ON ENGINEERING MANPOWER IS THE PRIORITY THE ADMINISTRATION GIVES TO STRENGTHENING THE AMERICAN ECONOMY--CLEARLY THE MOST IMPORTANT GOVERNMENT GOAL TODAY. IN PARTICULAR, THE ADMINISTRATION IS DETERMINED TO CREATE THE CONDITIONS THAT WILL PERMIT AND ENCOURAGE A RESURGENCE OF INTERNATIONAL COMPETITIVENESS BY OUR INDUSTRIES. THIS OBJECTIVE REQUIRES A STRONG FUNDAMENTAL SCIENCE BASE--LARGELY AN ACADEMIC RESPONSIBILITY--AND AN EFFECTIVE MEANS TO LINK THAT KNOWLEDGE BASE TO INNOVATION AND PRODUCTIVITY--PRIMARILY A FUNCTION OF INDUSTRY. THE UNITED STATES IS THE UNDISPUTED WORLD LEADER IN THE GENERATION OF KNOWLEDGE, BUT IN RECENT YEARS WE HAVE FALLEN DOWN ON THE EVEN MORE IMPORTANT JOB OF MAKING SURE WE WERE USING THAT KNOWLEDGE EFFECTIVELY. AS A CONSEQUENCE, TODAY MANY OF OUR INDUSTRIES ARE STAGGERING UNDER THE LOAD OF FOREIGN COMPETITION. WE NO LONGER DOMINATE THE MARKET FOR TECHNOLOGY-DEPENDENT PRODUCTS--AND THAT HAS WELL-RECOGNIZED AND FAR-REACHING CONSEQUENCES ON OUR DOMESTIC ECONOMY. OUR GOAL MUST BE TO RESTORE HEALTHY PRODUCTIVITY GROWTH TO AMERICAN INDUSTRY.

THE RESTORATION OF OUR INDUSTRIAL COMPETITIVENESS REQUIRES, AMONG OTHER THINGS, WELL-TRAINED ENGINEERS IN CRITICAL FIELDS OF RAPIDLY DEVELOPING INDUSTRIAL OPPORTUNITY. OUR IMMEDIATE CHALLENGE IS TO MAKE SURE OUR UNIVERSITIES CAN HOLD ONTO AND RECRUIT MORE HIGH-QUALITY FACULTY TO EDUCATE ENGINEERS IN THOSE HIGH-DEMAND DISCIPLINES AND TO CONTINUE TO EXPAND THAT KNOWLEDGE BASE.

OUR MEDIUM-TERM CHALLENGE--WHICH IS ALSO BEING CONSIDERED BY THIS CONFERENCE--IS TO PROVIDE A UNIVERSITY CLIMATE THAT IMPROVES THE QUALITY OF THE ENGINEERS BEING GRADUATED. THAT WILL INVOLVE MORE EFFECTIVE TEACHER CONTACT, BETTER INSTRUCTIONAL FACILITIES AND EQUIPMENT, AND A CURRICULUM THAT REFLECTS THE FAST-BREAKING INDUSTRIAL ADVANCES THAT THE STUDENTS WILL SOON BE IMMERSED IN.

BUT WE ALSO FACE A LONG-TERM PROBLEM IN ASSURING THE QUALITY AND QUANTITY OF TECHNICAL MANPOWER. IN GENERAL, COLLEGES AND UNIVERSITIES DON'T DEMAND ENOUGH SCIENCE AND MATH AS ADMISSION REQUIREMENTS, AND HIGH SCHOOLS LET STUDENTS GRADUATE WITH FAR TOO LITTLE EDUCATION IN THOSE CRITICAL AREAS. MOREOVER, THERE IS A SCANDALOUS SHORTAGE OF <u>GOOD</u> HIGH SCHOOL MATH AND SCIENCE TEACHERS, A CONSEQUENCE PRIMARILY OF NON-COMPETITIVE SALARIES. THIS UNDER-VALUATION OF TECHNICAL EDUCATION BY SECONDARY SCHOOLS, COMBINED WITH SOMETIMES DREADFUL TEACHING WHEN COURSES ARE AVAILABLE, TAKES ITS TOLL ON THE POOL OF COLLEGE STUDENTS ACROSS THE BOARD. IT IS ALSO CERTAINLY A FACTOR IN THE ABILITY OF BEGINNING ENGINEERING STUDENTS TO ENTER DEMANDING COLLEGE PROGRAMS AND MAKE THE BEST USE OF LIMITED COLLEGE FACILITIES AND TEACHER TIME.

THE FACT IS THAT IF WE DON'T TURN OUR EFFORTS TO LONG-TERM IMPROVEMENT OF SECONDARY SCIENCE AND MATH EDUCATION, WE MUST EXPECT CONTINUING DETERIORATION OF ENGINEERING EDUCATION AT THE COLLEGE LEVEL--IN SPITE OF OUR BEST EFFORTS IN GROUPS SUCH AS THIS TO IMPROVE THE ENGINEERING FACULTY SITUATION.

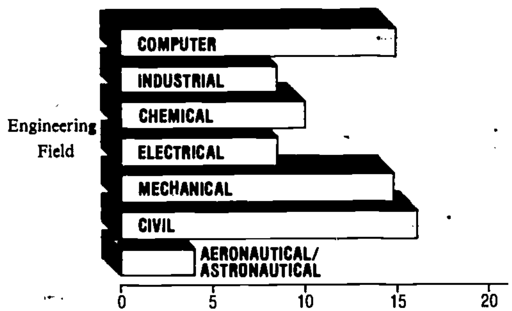
THE FEDERAL GOVERNMENT HAS THE RESPONSIBILITY TO MONITOR HOW WELL THE OVERALL EDUCATIONAL SYSTEM MEETS CRITICAL AND CONTINUING NATIONAL NEEDS. OUR PARTICULAR CONCERN FOR PRE-COLLEGE EDUCATION IS REFLECTED IN TWO IMPORTANT PROJECTS NOW UNDERWAY. ONE IS THE NATIONAL COMMISSION ON EXCELLENCE IN EDUCATION, UNDER THE DIRECTION OF EDUCATION SECRETARY BELL. THE OTHER IS THE NATIONAL SCIENCE BOARD'S COMMISSION ON PRE-COLLEGE EDUCATION IN MATHEMATICS, SCIENCE, AND TECHNOLOGY. FROM THESE TWO AMBITIOUS EVALUATIONS WE EXPECT ACTION PLANS THAT CLEARLY DEFINE THE NATURE OF THE PARTNERSHIP BETWEEN THE FEDERAL GOVERNMENT AND THE OTHER PARTIES WITH RESPONSIBILITIES FOR EDUCATION. IN PARTICULAR WE EXPECT TO HAVE AN AGENDA FOR SCIENCE EDUCATION THAT ADDRESSES THE ISSUES OF THE 1980S AND ENABLES US TO DEFINE A COURSE OF ACTION FOR COMING YEARS.

THE ENGINEERING MANPOWER PROBLEM IS REALLY MANY PROBLEMS. IN A FEW FIELDS WE ARE CONFRONTED WITH OBVIOUS SHORTAGES, BUT IN MANY OTHERS WE ARE NOT SO CERTAIN. DIFFERENT INDUSTRIES--EVEN DIFFERENT FIRMS--HAVE UNIQUE OPINIONS ON THE QUALITY AND QUANTITY OF MANPOWER AVAILABLE TO THEM. AND THERE ARE STILL UNANSWERED QUESTIONS ABOUT HOW WELL EXISTING ENGINEERS ARE BEING USED.

THE FEDERAL GOVERNMENT, TOO, IS EXAMINING ITS ROLE IN ASSURING AN ENGINEERING POOL ADEQUATE FOR NATIONAL NEEDS AND ASPIRATIONS. THE REAGAN ADMINISTRATION IS HIGHLY AMENABLE TO APPROPRIATE NEW PROGRAMS THAT ADDRESS CLEAR, AGREED-UPON, BASIC PROBLEMS WHERE FEDERAL INPUTS COULD HAVE LARGE EFFECTS. I'M THINKING OF PROGRAMS THAT IMPACT MANY STUDENTS OVER TIME. EXAMPLES MIGHT BE INSTRUCTIONAL EQUIPMENT, RESEARCH INSTRUMENTATION, OR IMPROVING THE SKILLS OF SECONDARY TEACHERS. THESE ARE ALSO THE KINDS OF PROGRAMS THAT LEND THEMSELVES TO JOINT SUPPORT BY INDUSTRY AND THE EDUCATIONAL INSTITUTIONS THEMSELVES. BUT I MUST STRESS THAT ANY NEW PROGRAMS WILL HAVE TO TAKE INTO ACCOUNT THE CONDITIONS THAT PREVAIL TODAY.

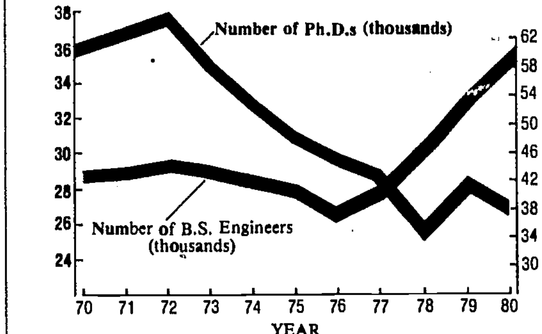
THE MAJOR REASON THAT WE DISCONTINUED FEDERAL SUPPORT FOR MANY SCIENCE AND ENGINEERING EDUCATION PROGRAMS, LIKE THOSE AT NSF, WAS THAT THEY WERE ROOTED IN THE 1960'S. THAT WAS AN ERA OF RAPID ECONOMIC GROWTH IN WHICH THE NATION CONCENTRATED ON DISTRIBUTING BENEFITS AND BROADENING PARTICIPATION. DURING THE PAST TWO DECADES WE CONSUMED OUR KNOWLEDGE AND RESOURCE BASE FASTER THAN WE REPLENISHED IT TO KEEP THE ECONOMIC ENGINE SPEEDING ALONG. BUT TODAY'S CIRCUMSTANCES CALL FOR DIFFERENT STRATEGIES. NOW WE MUST FOCUS ON PRODUCTION--OF NEW KNOWLEDGE, OF NEW USE OF THAT KNOWLEDGE, AND EVEN OF NEW INSTITUTIONS--TO GET OUR ECONOMY IN BALANCE. I SEE THIS CONFERENCE AS A REFLECTION OF THAT REALIZATION. WE LOOK FORWARD TO THE RESPONSES TO THIS CALL TO ACTION.

Engineering Faculty Face Serious Shortages



Source of Data:
National Science Foundation

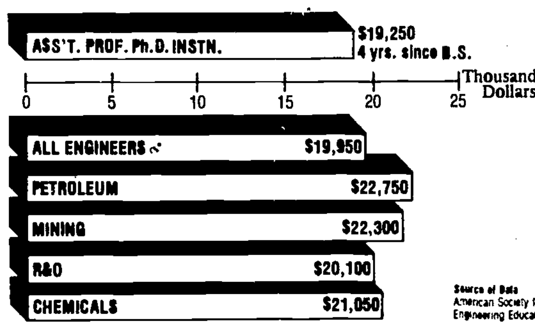
While the number of B.S. Engineers keeps increasing . . .
the alarming drop in Ph.D. degrees becomes more pronounced.



Source of Data: CHEMICAL ENGINEERING, 11/16/81

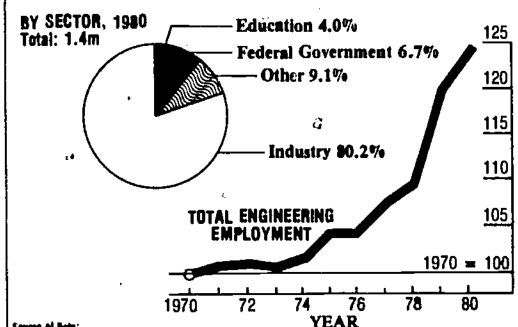
Median Salaries (Mid-1980) for

Assistant Professor 4 years after B.S. Degree VS. **Beginning Engineers, by Industry**



Source of Data
American Society for
Engineering Education

Employing America's Engineers



Source of Data:
National Science Foundation

NE AC *National Engineering Action Conference · April 7, 1982 · New York City*

Report on the National Engineering Action Conference

The Conference was held on April 7, 1982. Dr. Edward E. David, Jr., Conference Chairman, opened the meeting with a statement of the purpose and objectives of the Conference:

> We are all here because we share a common conviction, a common concern, and a common determination. We share the *conviction* that, quite simply, the economic and defensive strength of the United States depends critically upon the *quality* of the training received by the cohort of young engineers who will enter industry and government within the next few years. We share the *concern* that with the shortage of engineering faculty and the deteriorating academic environment for engineering, these young men and women will not receive the education that they want, that they deserve, and that the times require. And we share the *determination* to galvanize action to meet the situation, *effective* action by those with the knowledge, the power, and the resources to act.
>
> Most of us, especially those in higher education, are very familiar with the problem. We have been able to read all about it in the National Press for many months. The contribution of the National Engineering Action Conference (NEAC) is to bring together representatives of the four sectors with the most ability to act on the problem — higher education, industry, the professional associations and government. As individuals, our role is as much inspirational as practical. Nevertheless, it is the membership of the organizations *we represent* who must devise and implement the special, often local solutions that will bring what has been labeled the National "crisis" in engineering education to an end.

The principal conference documents were described — these documents are included here.

The participants were introduced (a list is included here).

Dr. Paul Gray, a principal organizer of the Conference, commented on the background of NEAC and outlined a major concern of the Conference attendees:

> The national and regional system for educating engineers is now at saturation. Its expansion is limited by several fundamental factors, of which the most important is faculty retention and expansion. Solutions to this problem have long time constants, and the most probable outcome of this growing problem will be a significant decline in the quality, if not the quantity, of baccalaureate engineering graduates in the years ahead.

Participants representing higher education, industry, professional societies, and government addressed the concerns of the Conference, as shown by the following excerpts:

NEAC: *Suite 200 / 11 Dupont Circle / Washington, DC 20036*

HIGHER EDUCATION

Dr. Arthur G. Hansen:

The NEAC Conference has focused its attention on a number of important items confronting engineering education today. However, I believe three of the suggested items listed for higher education in the "Action Agenda" (see attached) are essential to the future quality of engineering education in the United States. These items include number 2, dealing with competitive faculty compensation; number 4, increased graduate student stipends; and number 6, modernization of equipment and facilities in university engineering laboratories.

Dr. Robert Q. Marston:

. . . The higher education associations understand clearly the significance of the national engineering problems. They are fully prepared, in my judgment, to support actions to resolve these problems. You need to know, however, of two major concerns.

First, all must recognize that strengthening engineering education requires strong programs in other areas of the university . . . an adequate general education is essential in all professions.

The second concern or caution is that we not repeat the errors made in reacting to the perceived health manpower crisis of the 1960's. In focusing on the realistic problems in engineering, we must discriminate between needed and appropriate action and useless and unnecessary action. This is not the time, for instance, to focus on numbers at the expense of quality . . . New and different forms of cooperation among universities, industry, and state and Federal governments are necessary . . . many universities have shown already the flexibility and willingness to elevate engineering priorities in order to meet the most critical needs, which are:

— Recruitment and retention of faculty

— Improved incentives for resident American graduate students

— Resolution of the shortfall in scientific and technical equipment

— A sensible approach to meeting the national need for numbers of engineering without sacrificing quality.

INDUSTRY

Franklin A. Lindsay:

There are many ways in which an industry/university partnership can be created which can help materially in attracting and holding engineering faculties and in providing major financial support for university research.

One such scheme, in which I am involved, has given 30 percent of the equity of a new genetic engineering company to a special non-profit organization. By its charter, this organization can only use the proceeds from this equity to support future basic research at universities. In addition, the non-profit organization is now funding current research at three universities and has received in return options for limited exclusive licenses on patents developed by that funded research. This arrangement has the advantage that the universities are not direct shareholders in the genetic engineering company, yet will have a 30 percent participation in the future financial success of the company.

This scheme has been funded by six major corporations and is now in operation. It has been accepted by the university administrations and their faculties. We hope that it will become a prototype for other corporations working with other universities and in a broad range of technical disciplines.

PROFESSIONAL SOCIETIES

Dr. Daniel C. Drucker:

Professional societies do have the capability, and welcome the challenge, to implement the manpower supply/demand and education actions suggested for them in items 3 and 5 (see attached) which will help provide the basis for choice of the balance point for the school. Many societies are already actively pursuing several, or all, of the other action items listed for them along with others addressed to higher education, industry and government.

GOVERNMENT

Congressman Don Fuqua:

In an effort to articulate the role the Federal Government has in this area, I have recently proposed legislation entitled the 'National Engineering and Science Manpower Act of 1982.' Federal initiatives to enhance science and engineering education, such as the one I have proposed and others in existence, are important; however, they can reach only a small percentage of the population.

I believe a significant impact can come from the grassroots. Engineers as individuals and as a professional community can do a good deal. This will indeed require funds and guidance from various sectors, but of equal importance will be the influence of those who can clearly convey to the public the value of a technically literate population. The time, energy and concern of technical professionals such as yourselves can provide that influence.

Comments from government participants also included those of Dr. John B. Slaughter, excerpted as follows:

. . . I want to respond to that "Call to Action" now. I want to tell you about some of the ways we at the National Science Foundation are facing these challenges. . . .

The National Science Board, our policy-making body, has created a Commission on Precollege Education in Mathematics, Science, and Technology. This group will examine the quality of secondary-school education in terms of both general and preprofessional training in math and the sciences.

. . . as most of you know, the Foundation was reorganized a year ago so that it could focus more sharply on the support of engineering disciplines. We now have an entire directorate to do just that. In addition, our science database is set up so that we can pull out subsets of specific data on engineers when we need them.

And what about obsolete equipment? Well, last August, NSF convened an ad-hoc Interagency Working Group on University Research Instrumentation, chaired by our Deputy Director. This group began to review the problem and to explore possible Federal responses. One early result of this review was NSF's proposal, contained in its fiscal year 1983 budget, to increase major equipment and instrumentation support in our engineering research programs by 24 percent over last year.

For 1983, we also hope to increase funding for Research Initiation Grants in engineering by 7.4 percent and for engineering graduate fellowships by 10 percent. In addition, we are experimenting with a new program, called NEFRI, to encourage young engineers to enter faculty careers. . . .

At NSF, we're also working to open some doors of opportunity for engineering researchers. Two recent agreements we've made with other Federal agencies (the Department of Defense and the Army Corps of Engineers) should help do just that.

Dr. George A. Keyworth, Science Advisor to the President, was the luncheon speaker. An excerpt from Dr. Keyworth's remarks follows:

There are two overriding issues behind the administration's concern for engineering manpower shortages. One, of course, is the availability of qualified engineers and technical personnel for national security needs — in the Department of Defense, in other government laboratories, and on the staffs of industrial contractors. It is important to remember that the United States does not deploy large numbers of military personnel and material as some other nations do. We rely heavily on technological superiority to provide our defense. That basic defense philosophy is important to us as a free nation, but it cannot work without a healthy R&D enterprise.

The other Federal concern strongly dependent on engineering manpower is the priority the administration gives to strengthening the American economy — clearly the most important government goal today. In particular, the administration is determined to create the conditions that will permit and encourage a resurgence of international competitiveness by our industries.

This objective requires a strong fundamental science base — largely an academic responsibility — and an effective means to link that knowledge base to innovation and productivity — primarily a function of industry. The United States is the undisputed world leader in the generation of knowledge, but in recent years we have fallen down on the even more important job of making sure we were using that knowledge effectively. As a consequence, today many of our industries are staggering under the load of foreign competition. We no longer dominate the market for technology-dependent products — and that has well-recognized and far-reaching consequences on our domestic economy. Our goal must be to restore healthy productivity growth to American industry.

Dr. Keyworth also brought with him a message to NEAC from the President. President Reagan's message is included in Dr. Keyworth's text.

Many comments by other participants were made, both in the morning session and at a concluding press conference. While these are too numerous to summarize, there was general agreement on the Conference documents, and the participants plan to take the Conference materials back to the organizations which they represent, for consideration of the actions appropriate in each case.

NEAC National Engineering Action Conference · April 7, 1982 · New York City

Contact: Gene Nichols
George Hoover
(212) 245-0460

NATIONAL ENGINEERING ACTION CONFERENCE FOCUSES ON SOLUTIONS TO ENGINEERING FACULTY SHORTAGE

NEW YORK, April 7 -- More than 50 officials from higher education, industry, engineering professional societies and government attended the National Engineering Action Conference (NEAC) here today to endorse a "Call to Action" which urges concerned parties to work together to meet the shortage of engineering faculty and doctoral students preparing to enter the engineering teaching ranks.

Approximately 10 percent of all engineering faculty positions in the United States today are vacant -- and about one-half of these posts have been vacant for more than a year. This comes at a time when undergraduate engineering enrollments are reaching record levels and campus engineering laboratories are becoming obsolete.

If the current conditions continue, the "Call to Action" states, this shortage..."will inevitably bring a sharp deterioration in the quality of engineering education with serious consequences for the nation's key industries and defense."

- more -

NEAC: Suite 200 / 11 Dupont Circle / Washington, DC 20036

--2 NATIONAL ENGINEERING ACTION CONFERENCE xxx defense

According to NEAC chairman Dr. Edward E. David, Jr., president of Exxon Research and Engineering Company, the focus of NEAC is not on the question of the supply of young engineers, but on the threat to the quality of engineering education that these conditions imply.

"The real contribution of NEAC is in bringing together representatives of the four sectors with the greatest ability to act to solve the problem," Dr. David said. "We recognize it is the membership of these organizations who must devise and implement the special, often local solutions, that will bring what has been labeled the national 'crisis' in engineering education to an end."

In addition to the "Call to Action," the NEAC conference also generated a "Suggested Action Agenda" which delineates steps each of the four sectors could undertake to help remedy the situtation. Dr. David said, "These documents are not intended as exact blueprints for action, but rather act as directional signals for corrective action."

Among the actions suggested by NEAC were:

For Higher Education -- Increase incentives, rewards and recognition for undergraduate teaching of engineers. Set engineering faculty compensation at a level recognizing realistically the market for such talent in industry;

- more -

--3 NATIONAL ENGINEERING ACTION CONFERENCE xxx industry

For Industry -- Provide direct financial support to U.S. resident masters and doctoral candidates in the form of traineeships, scholarships and awards. Create opportunities for junior faculty to increase their income through consulting, summer employment, tutorials and grants;

For Academic and Professional Societies -- Using related educational foundations, expand scholarship and fellowship aid to engineering doctoral students and make direct grants to the schools. Encourage their memberships to make financial contributions in support of engineering education and, where possible, take advantage of corporate matching grant programs; and

For State and Federal Government -- Encourage re-examination of policies, especially at the state level, which may preclude making the pay of engineering faculty, and the educational environment, competitive. Assign priority to studies and hearings to determine the nature and scope of the engineering faculty shortage.

Dr. David said the economic and defensive strength of the United States depends critically upon the quality of the training received by the young engineers who will enter industry and government within the next few years.

- more -

--4 NATIONAL ENGINEERING ACTION CONFERENCE xxx years

"With the shortage of engineering faculty and the deteriorating academic environment for engineering, these young men and women will not receive the education they want, that they deserve, and that the times require. We at NEAC share the determination to galvanize action to meet the situation -- effective action by those with the knowledge, the power and the resources to act," Dr. David said.

# # #

NE AC *National Engineering Action Conference · April 7, 1982 · New York City*

BACKGROUNDER: THE ENGINEERING FACULTY SHORTAGE

More than 1,600 engineering faculty positions -- or some 10 percent of all engineering faculty positions in the U.S. -- are unfilled today, according to a study by the American Council on Education, and almost half of these positions have been open for more than a year. Even if all of the 1981 U.S. resident engineering doctoral candidates elected to enter faculty positions, the void would still not be filled.

Meanwhile, engineering enrollments have shot to record levels in response to rising demand and higher salaries for engineers in industry. The 1980 freshman engineering class was by far the largest engineering class ever recorded with 110,000 students. Some 365,000 full-time engineering undergraduates were enrolled in the fall of 1980. According to the American Association of Engineering Societies, this was up nearly 58 percent from the fall of 1975.

Quality of Education Threatened

A major result of these trends has been overcrowded classes and increasing restrictions on engineering enrollments. Some 20 of the 30 universities surveyed by the American Society of Engineering Education in February, 1981, had decided to limit

-more-

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enrollments in engineering. These include Cornell, UCLA, the New Jersey Institute of Technology, Notre Dame, Penn State and the University of Wisconsin, among others. These cutbacks were a result of the schools' concern about the quality of education that they can offer. Indeed, as a result of the difficulty in recruiting and retaining faculty, more than 80 percent of the engineering deans surveyed by the American Council on Education perceived a decline in the quality of instruction offered to engineering students.

The Accreditation Board for Engineering and Technology (ABET), which is charged with accrediting all the nation's engineering programs, reports further evidence of decline in the quality of engineering education. Last year, in visits to about one-third of the U.S. engineering institutions, ABET officials found a 30 percent decline in programs receiving a full-term accreditation. ABET also found a 45 percent increase in accreditations noting "improvement needed," and a 71 percent increase either in programs not accredited or in departments given notice to "show cause why accreditation should not be removed in three years."

The shortage of qualified faculty will be impossible to correct if current trends in <u>graduate</u> engineering education continue. Over the past decade the number of doctoral degrees awarded to U.S. residents has remained constant or fallen. It is

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likely that only one in four engineering faculty vacancies will be filled by new doctoral graduates. In addition, some engineering faculty are leaving for industrial positions.

Causes of the Faculty Shortage

The main causes of the faculty shortage problem are reasonably clear. Engineering faculty salaries lag badly behind their engineering counterparts in industry. In the past four years the differential between starting salaries in industry and the average salary of engineering faculty has widened from 22 to 33 percent. Even in these recessionary times, a young baccalaureate engineer can command a higher salary in industry than the average engineering assistant professor with a Ph.D. In fact, the American Council on Education study identified some 400 engineering faculty who had left academe for industry during the 1979-80 academic year.

Another major cause of the shortage is a marked decline in the quality of the environment for engineering faculty. The principal symptom of this decline is the deterioration of laboratory facilities and equipment. Much of the equipment and instrumentation in the engineering laboratories of our institutions of higher education dates from the 1950s -- before the computer era. Dean Daniel C. Drucker of the College of Engineering at the University of Illinois estimates that there is about a $1 billion dollar catch-up problem in the instructional

- more-laboratories alone. Many potential engineering faculty -- frustrated by teaching conditions and interested in pushing back the frontiers of engineering knowledge -- are choosing to go into industry where they have the opportunity to do their research using state-of-the-art technology.

Engineering Education Vital to U.S.

What is at stake if the nation fails to provide for the quality of engineering education? Nothing less than the health of the U.S. economy and the strength of its defense. We live in an increasingly technological world, a world in large part influenced by trained engineers. In the world market competition to produce high-quality products that consumers will want and can afford, leading edge technology is critical.

As an advanced industrial nation, the United States must depend heavily upon creating, applying and selling the products of such technology if it is to ensure higher living standards and a growing economy for its citizens. Engineers must turn in an equally high level of performance to ensure our national defense, which is based on technological supremacy. Furthermore, advancing technology will almost certainly require not just high-quality engineering education, but higher and higher levels of engineering education. In sum, one of the more important factors to the welfare of the nation in the 1980s and beyond will be the adequacy of our engineering faculty and the quality of our engineering education.

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National Engineering Action Conference

The goal of the National Engineering Action Conference (NEAC) is to identify and promote actions to meet the shortage of engineering faculty and the even worse shortage of doctoral students preparing to enter the engineering teaching ranks. The Conference brings together national leaders from every sector of American society directly concerned with engineering.

A premise of the Conference is that no single group or sector concerned with engineering possesses the resources or the insight necessary to prescribe solutions to the faculty problem. While the diversity of the American system of higher education represents one of its greatest strengths, it also renders the task of identifying and implementing appropriate actions highly complex. Solutions must be tailored to local circumstances by the universities, colleges, industrial firms, and engineering professionals concerned, in cooperation with state and federal governments. Thus, the principal work of the Conference will be to exchange views on appropriate actions.

Planning for the Conference began early in 1981, when a group of university administrators, acting through the National Association of State Universities and Land-Grant Colleges, agreed on the critical need for action. Joining with the Association of American Universities and the American Council on Education, they proposed a national conference be held in New York on April 7. Together these three organizations include as members all

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institutions of higher education in the United States.
Dr. Paul E. Gray, president of MIT, asked Dr. Edward E. David, Jr., president of Exxon Research and Engineering Company, to chair the conference.

A working group of more than 50 people, representing organizations in higher education, industry, the engineering professional societies and government, developed a "Call to Action" to be endorsed April 7 and an "Action Agenda,"

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A Call To Action

The state of engineering education in the United States is deteriorating severely — this at a time when young engineers have a vital role to play in assuring the future strength of our economy and national defense. We at the National Engineering Action Conference have taken heed. We pledge our utmost efforts to help find and apply the remedies. And we call upon our colleagues in each of the sectors most responsible — education, industry, the professional societies, and all levels of government — to join with us and do likewise.

Today, with undergraduate engineering enrollments at all-time highs, at least 1,600 engineering faculty positions stand empty. Further, only a fraction of the candidates necessary to fill such positions are actually pursuing advanced engineering degrees, and, of those receiving advanced degrees, an even smaller fraction are choosing academic careers. If not addressed, the faculty shortage will inevitably bring a sharp deterioration in the quality of engineering education, with serious consequences for the nation's key industries and defense in a competitive, dangerous world.

There is no single cure-all. Money, especially in times of austerity like these, cannot be expected to do the entire job. Organizations in the concerned sectors must cooperate to find solutions appropriate to local circumstances and institutions. Indeed, local initiatives, marked by *voluntary* participation and reliance on market signals, may prove the most innovative and effective.

We urge that all concerned focus their efforts on these two chief objectives:

1. To fill, with qualified personnel, the engineering faculty vacancies, and
2. To make engineering faculty careers more attractive by enhancing the academic environment.

The Conference "Action Agenda" suggests some actions that groups in each sector may take toward achieving these objectives. We recognize that every step suggested in the "Action Agenda" may not be appropriate in every setting. Yet clear awareness of the present danger and commitment to meet it are essential. We intend to do our part to arouse that awareness and inspire that commitment. But our individual efforts alone will not suffice. Again, we call upon our colleagues to act with us, on behalf of engineering students, faculty, their own institutions and the welfare of the Nation.

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Suggested Action Agenda

The following suggested actions can contribute directly to meeting the objectives set forth in the Call to Action. For convenience, the actions are listed by sector — higher education, industry, professional societies and government — but there is obviously a high interrelationship. All the actions listed may not be within the ability or resources of a given organization. However, every organization can undertake some portion of the initiatives. In fact, nearly every example listed has already been implemented in at least one instance.

For Higher Education

1. Increase incentives, rewards and recognition for undergraduate teaching of engineers.
2. Set engineering faculty compensation at a level recognizing realistically the market for such talent in industry.
3. Aggressively recruit promising undergraduate students to enter graduate programs, and strive to make the academic environment attractive to them.
4. Increase graduate student stipends to encourage a larger number of U.S. residents to become doctoral students.
5. Develop a flexible program of industrial residencies for graduate students, which builds on the success of undergraduate cooperative education.
6. Give high priority to modernizing instructional and research equipment and facilities in order to provide the capability for sustaining frontier research and instruction based on current technology.
7. Improve research and instructional productivity by providing adequate staff support.
8. Find creative ways for interested faculty and Ph.D. candidates to do research on subjects that might attract industry involvement.
9. Make greater use of part-time faculty and reconsider the Ph.D. requirement, placing greater reliance on practical skill and knowledge in filling faculty positions, including industry experience.
10. Expand collabrative, problem-focused research with industry and reward faculty for participation in such programs.
11. Enhance the financial autonomy of colleges and departments of engineering, using as a model such professional disciplines as law and medicine.
12. Win support among appropriate constituencies by publicizing the contribution of engineering institutions and the engineering profession.

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For Industry

1. Provide direct financial support to U.S. resident masters and doctoral candidates in the form of traineeships, scholarships and awards.

2. Create opportunities for junior faculty to increase their income through consulting, summer employment, tutorials and grants.

3. Enter into arrangements with specific universities to supplement engineering faculty salaries; for example, with grants or endowed professorships and chairs.

4. Assist engineering departments in modernizing their facilities and equipment, through financial grants, donation of new or surplus equipment and innovative debt instruments.

5. Actively pursue opportunities for purchasing research from universities instead of conducting it in-house when appropriate.

6. Enter into innovative programs with universities for cooperative research projects — sharing facilities/equipment/people.

7. Contribute to improving the quality and productivity of engineering education by accepting opportunities to serve on university advisory committees.

8. Encourage and provide incentives for qualified employees to teach in engineering as part-time, loaned or full-time faculty members.

9. Make clear in interactions with Congress, state legislatures, and boards of trustees that industry strongly supports initiatives for increasing engineering Ph.D.'s.

10. Enrich the faculty's experience by carrying on a continuing dialogue about modern engineering practice and emerging technology.

11. Help raise awareness among the general public regarding the importance of engineering to society and the serious problems in engineering education.

For Academic and Professional Societies

1. Using related educational foundations, expand scholarship and fellowship aid to engineering doctoral students and make direct grants to the schools.

2. Encourage their memberships to make financial contributions in support of engineering education and, where possible, take advantage of corporate matching grant programs.

3. Monitor manpower supply/demand in their respective areas of interest in order to help identify activities that will help maintain an adequately prepared supply of graduates and faculty.

4. Establish programs to facilitate engineering personnel exchanges between industry and academia, including a computerized data base that contains basic information on personnel and positions available and formal training programs to prepare industry engineers for teaching assignments.

5. Establish a forum of interested association and industry leaders in which the status of engineering education can be reviewed and discussed at least once each year and appropriate actions planned.

6. Conduct an intensive effort at the national level to encourage expanded graduate fellowship programs in engineering funded by the NSF and mission agencies.

7. Coordinate efforts at the state level, using state societies and local chapters, to increase state support to engineering education for faculty salaries, laboratory facilities and equipment, and financial aid for graduate study.

8. Plan and implement a campaign to alert the public to the state of engineering education nationwide and to the implications of the situation for jobs, productivity and future economic opportunities for themselves and their children.

For State and Federal Government

1. Encourage reexamination of policies, especially at the state level, which may preclude making the pay of engineering faculty, and the educational environment, competitive.

2. Assign priority to studies and hearings to determine the nature and scope of the engineering faculty shortage.

3. Support studies and hearings to identify and establish mechanisms to achieve the proper balance in support for equipment, manpower and other costs within the overall levels of academic research and education.

4. Encourage study for doctorates in engineering by providing fellowships, traineeships, internships and other aid to doctoral candidates under the aegis of the National Science Foundation, the mission agencies, Federal laboratories and other governmental organizations that employ engineers. These should carry adequate stipends to demonstrate the significance placed on higher degrees in engineering.

5. Expand "new investigator" and other programs in Federal agencies which are designed to encourage and support the research of new engineering faculty.

6. Further streamline regulatory and administrative procedures such that Federal and state monies directed toward engineering research and education will receive the most efficient and productive use possible.

7. Expand opportunities for university faculty to participate in government laboratory research.

8. Encourage joint research between industry and engineering faculty.

9. Lend the prestige of government to encourage private efforts to help solve the shortage of engineering faculty and emphasize the importance attached to engineering in our society.

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Action Examples

To illustrate possible concrete actions that could result from the NEAC Action Agenda, a compilation of examples or proposals for change is attached. The list is by no means complete, or in some cases, representative of a course of action preferred by a significant number of organizations represented at the meeting. Many actions have already been taken by organizations in higher education, industry, the professional societies or government. Other examples are unconventional, or represent major change from current practice or policies. Some have been introduced as a means of stimulating discussion or free-thinking about the problem. While the NEAC participants believe that many of the action examples are directly responsive to the concerns of the Conference, they are presented to illustrate the range of responses that have been considered, and the Conference endorsement of the general principles in the "Call to Action" does not imply an endorsement of all the specific examples cited.

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For Higher Education

Recommendations for academic institutions center around two major actions: faculty *compensation* and the engineering graduate school working *environment*.

- It is essential to confirm the causes of this engineering faculty problem. Intuitively, focus has been on salaries, etc., because the industry/university salary differential has been growing, but the real deterrents should be identified by surveying those who face or have made the industry/teaching choice. This should include graduate students at the M.S. level.
- It appears that the significant motivations for entering the teaching profession are far from clear. An informal in-house survey conducted at Exxon Research and Engineering Company of recent engineering graduates showed that higher pay was low on the list of reasons for choosing industry. First on the list was better opportunities to do research, including more responsibility, *better equipment and facilities*, and the chance to see concrete results.

HE-2 **Set engineering faculty compensation at a level recognizing realistically the market for such talent in industry.**

- Engineering faculty compensation needs to be raised to a more competitive level. Recognizing the need to work within the context of the university as whole, that regional differences exist, and that state legislatures must often be persuaded, there are nevertheless some useful ideas — most essential is leeway for differential salaries among faculties in various disciplines. Governor Babbitt in Arizona has addressed the problem by supporting the establishment of a separate engineering center at Arizona State University. In California, the Regents of the University of California recently approved a special salary scale for professors of engineering.
- Another way is by differential tuition, which could be "variable" to deal with the uncertainties about elasticity; the current surplus of applicants for undergraduate engineering school may mean that market forces would support a higher tuition for engineering, but it must be accompanied by assurance that the extra money will be used for upgrading engineering faculty salaries or equipment and not siphoned off for other uses. Likewise, lab fees and other supporting services charges would be increased, if coupled with the same assurances.
- The University of Minnesota has raised engineering tuition about $250 per semester this year. A similar increase has been made at the South Dakota School of Mines and Technology. The money is being used for faculty salaries.

HE-3 **Aggressively recruit promising undergraduate students to enter graduate programs, and strive to make the academic environment attractive to them.**

- Undergraduate engineering schools could encourage recruiters from graduate schools to talk to their seniors like industry does. Many department chairmen today personally interview promising undergraduates to encourage them to enter graduate school. Rose-Hulman is giving grad schools first crack before industry.
- Involve graduate students in course development and research discussions with industry.

HE-4 Increase graduate student stipends to encourage a larger number of U.S. residents to become doctoral students.

- An NSF study which identified 1,620 unfilled faculty vacancies in engineering also noted that nearly 25% of junior faculty positions are filled by foreign engineers holding bachelors degrees from outside the U.S., most ineligible to become U.S. faculty members. Increasing graduate student stipends and improving the working environment (and prestige) of graduate school may help the situation.
- At the recent Industry/Founder Societies Forum on engineering manpower, it was recommended that forgivable loans be provided for graduate study, with repayment through service as specified by the donor. Examples might include industry or government loans repaid by summer laboratory research, by government or foundations with service in minority or special programs.
- Another recommendation would allow faculty to extend 9-month contracts to 12 months with appropriate compensation.

HE-5 D 'elop a flexible program of industrial residencies for graduate students, which builds o the success of undergraduate cooperative education.

- *Co-op programs* for graduate students working in industry may be a financial enticement for some students to pursue graduate degrees, though it would stretch out the time for completing graduate work. The MIT co-op program for M.S.-level students could perhaps work at the Ph.D. level as well. The University of Cincinnati has a graduate student co-op program already in place. Stanford has a program for computer professionals. In some such programs, these are done in collaboration with industry, while the student is resident in the industrial setting. This creates one-on-one relationships between professor, grad student and industry researcher.
- Carnegie-Mellon has established a flexible new program to a) attract B.S. graduates who would normally go on to work in industry, and b) make it more feasible for the engineer employed full-time in industry, to study for the Ph.D. The latter is done by reducing the on-campus residency requirement, and modifying the thesis requirement. Three programs, known as the Intern Ph.D., Co-op Ph.D. and Co-op M.S., have been instituted recently at CMU.

HE-6 Give high priority to modernizing instructional and research equipment and facilities in order to provide the capability for sustaining frontier research and instruction based on current technology.

- Much has been made of the shortage and inadequacy of *engineering laboratory equipment and facilities*. Funding capital equipment is always difficult. The debt financing approach used at Colorado State University is an innovative and useful idea for the acquisition of high-cost scientific equipment and computers. *Multi-year capital acquisition* and financing programs are common in industry and rare in universities; ways need to be found to transfer this approach to the engineering schools, both graduate and undergraduate.

HE-7 Improve research and instructional productivity by providing adequate staff support.

- One recommendation of the recent Founder Societies Forum was to provide additional assistance for faculty to improve the grading of assignments and provision of tutorial aid for students through greater use of graduate teaching assistants and exceptionally qualified undergraduates.
- More use of modern techniques; video tape modules, computer aids.

HE-8 Find creative ways for interested faculty and Ph.D. candidates to do research on subjects that might attract industry involvement.

- The MIT Industrial Liaison Program, now involving 168 companies, is a well-known example of such a mechanism. For a flat fee, companies gain a window on the state of the art in academic laboratories while faculty, staff and students gain access to a variety of corporate R&D programs.
- Indiana University and the Texas A&M Research Foundation have both begun a series of conferences designed to bring faculty and industry together to explore mutually beneficial research projects.
- The State of Minnesota has provided a $6 million grant to the University of Minnesota to match funds raised for the Microelectronics and Information Sciences Center at the University.

HE-9 Reconsider the Ph.D. requirement and place greater reliance on practical skill and knowledge in filling faculty positions.

- Perhaps universities should challenge the current requirements for engineering faculty. The pendulum may have swung too far toward a research emphasis: if greater reliance is placed on experience, skill, and knowledge in filling faculty positions, a broader cohort of candidates incorporating, for example, design skills would become available.

HE-10 Expand collaborative, problem-focused research with industry and reward faculty for participation in such programs.

- At Carnegie-Mellon, $9 million of its $42 million research budget, will come from industry — up from $4 million out of $17 million, six years ago. Fifteen companies are supporting the CMU Robotics Institute.
- The University of Missouri has set up its own Office of Science and Technology to stimulate cooperative research.
- The Center for Integrated Systems at Stanford has attracted 17 industrial sponsors to date, as well as government support.
- Rensselaer Polythecnic Institute has established five means for effecting linkups with business, most involving business funding: a Center for Interactive Computer Graphics; a Center for Manufacturing Productivity and Technology Transfer; a Center for Integrated Electronics; an industrial park on land owned by RPI and an Incubator Space Project to help start new companies.

HE-11 Enhance the financial autonomy of colleges and departments of engineering, using as a model such professional disciplines as law and medicine.

- Medical school clinical practice plans for faculty are quite diverse in institutions across the country, and may provide a model for engineering faculty. The Association of American Medical Colleges has compiled detailed information on how these plans operate.
- At Dartmouth, the Thayer School of Engineering is financially independent of the rest of Dartmouth, with its own endowment.

For Industry

Industry is dependent on a continuing supply of high quality engineering graduates, and the problem of engineering faculty is clearly key. Companies, individually and collectively, could:

I-1 Provide direct financial support to U.S. resident masters and doctoral candidates in the form of traineeships, scholarships and awards.

- Many companies have already stepped up their aid to engineering education. A partial list would include Arco, Dow, Exxon, Union Carbide, Eastman Kodak, Champion International, RCA, Rockwell International, General Electric, Shell, Hughes Tool, Digital Equipment, Sun, and DuPont. Still, only a fraction of the firms that depend on the supply of engineers currently support engineering graduate schools. Formula approaches, such as that of the Council for Chemical Research, based on the number of engineers employed, or the American Electronics Association, based on a percentage (2%) of R&D budgets, offer a way for developing more industry participation. More companies must join in to do their part.
- The Massachusetts High Technology Council has proposed that its members allot 2% of their R&D expenditures to engineering education.
- Probably the largest single source of support is the widespread program of corporate *matching*, either equally or by some multiple, of an employee's financial gift to a university of his or her choice. Industries could consider increasing the matching formula for employee contributions earmarked for the support of engineering faculty.
- Increase support for doctoral candidates in disciplines important to each industry, but in a *new way* — tying support to the candidates' *willingness to teach*.
- The Foundry Education Foundation has established a specialized loan program to encourage assistant professors to complete the Ph.D., or associate professors to work for tenure. Targeted to the discipline of metal working, portions of the loans would be forgiven annually, after the candidate received tenure.

I-2 Create opportunities for junior faculty to increase their income through consulting, summer employment, tutorials and grants.

- Research grants specifically targeted for new and untenured faculty members would fill a specific need in the current faculty shortage. The Research Initiation Grants awarded by the Engineering Foundation are one example.
- Industry could increase supplements to faculty salaries (through faculty grants), again seeking to tie this to the willingness to *remain in the teaching ranks*.

I-3 Enter into arrangements with specific universities to suplement engineering faculty salaries; for example, with grants or endowed professorships and chairs.

- Some companies now endow professorships — an increasingly expensive proposition. The University of Texas has a program where companies can grant annual *supplements* when picking up the entire multi-year cost is not feasible. This concept has value in perhaps encouraging more companies to provide support.

I-4 Assist engineering departments in modernizing their facilities and equipment, through financial grants, donation of new or surplus equipment and innovative debt instruments.

- Industry should look for ways to assist university laboratories in providing analytical and other support services. It could increase the productivity of graduate students and would be a positive step in improving the *environment* for graduate school. There is a tradition that graduate students must do their own support work, including taking all experimental measurements. However, industrial labs cannot afford this approach, and universities may have reached the point where they can no longer afford it either.

I-5 Actively pursue opportunities for purchasing research from universities instead of conducting it in-house when appropriate.

- There is often an advantage to the engineering faculty when funding is made available in the form of general grants as opposed to contracts which must take into account the university overhead factor.

I-8 Encourage and provide incentives for qualified employees to teach in engineering as part-time, loaned or full-time faculty members.

- The Founder Societies Forum recently listed several ways to encourage adjunct and visiting professors from industry.
  - — Disseminate information on needs and benefits to companies.
  - — Encourage companies to establish formal means and policies for employee leaves and part-time teaching. Incentives for employees would be helpful.
  - — Encourage universities to establish short-term (2, 4, and 6-week) courses if visiting industrial professors are needed. Creative work to develop new schedules is necessary.
  - — Encourage universities to pursue adjunct and visiting professors more aggressively.
  - — Encourage experimentation with TV and/or conference-link modes of remote instruction by adjunct professors. Much previous non-acceptance of TV instruction would have to be overcome.
  - — Suggest that universities examine and experiment with pre-packaged-tape courses for credit.
  - — Ask ABET to review effects of increased use of adjunct and visiting professors from industry, use of TV instruction, and use of packaged courses on accreditation.
- New ways to utilize adjunct professors can be examined. They can be used to team-teach, or in modularized courses, or to enrich courses in partnership with existing faculty. Adjunct professors could be encouraged to teach during normal day-time courses by scheduling classes early or late in the day.

I-9 Make clear in interactions with Congress, state legislatures, and boards of trustees that industry strongly supports initiatives for increasing engineering Ph.D.'s.

- In the current environment, our state governments and legislatures exert ever more important influence over our universities. Together with the professional societies, industry should support universities to help explain the engineering faculty problem, by interacting with state legislatures, Boards of Regents, and other appropriate bodies.
- It has been proposed that defense contractors consider using part of their IR&D funding to support university research.

For Academic and Professional Societies

Educational and professional associations have an important role too. There are over one million members of engineering professional societies, a significant force if mobilized. The societies can:

A-4 Establish programs to facilitate engineering personnel exhanges between industry and academia, including a computerized data base that contains basic information on personnel and positions available and formal training programs to prepare industry engineers for teaching assignments.

- Identify where industry-developed course modules can be useful, and through coordination of its membership, encourage industry to develop them. (Eases teaching load, provides direct input of industry experience, and uses modern teaching aids.)

A-7 Coordinate efforts at the state level, using state societies and local chapters, to increase state support to engineering education for faculty salaries, laboratory equipment and financial aid for graduate study.

- It has been suggested that professional societies should develop and promulgate guidelines for salaries and employment conditions for engineering educators.
- Use state and local societies to ascertain the needs of engineering education in each state and territory and make those needs known and understood by state legislators and officials. The National Society of Professional Engineers, in cooperation with the American Association of Engineering Societies and the American Society for Engineering Education, has proposed a survey of state chapter and societies. The objective is to facilitate cooperative efforts among professional and technical societies and local industry to secure aid to engineering education at the state level.
- The Virginia Society of Professional Engineers has worked with Virginia Polytechnic Institute to support a proposal to the state legislature for improved facilities for the college of engineering.

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For State and Federal Government

Government's role in engineering education has traditionally been an important one. In the current environment, emphasis is shifting more toward the states, and they will presumably become more influential in this area.

G-1 **Encourage reexamination of policies, especially at the state level, which may preclude making the pay of engineering faculty, and the educational environment, competitive.**

- States should accept a high level of responsibility for the health of engineering education, since most engineering research and graduate study is at state universities.
- States should consider ways, including free-standing schools of engineering, to allow engineering to compete for personnel on a free-market basis. Examples have been already cited in the "University" section.
- Explore and authorize ways to raise incentives for industry to increase support for engineering through financial aid and equipment donation.

G-4 **Encourage study for doctorates in engineering by providing fellowships, traineeships, internships and other aid to doctoral candidates under the aegis of the National Science Foundation, the mission agencies, Federal laboratories and other governmental organizations that employ engineers. These should carry adequate stipends to demonstrate the significance placed on higher degrees in engineering.**

- The Defense Communications Agency has established a program to deal both with secondary education in science and math — working initially through high schools with ROTC units — as well as the engineering faculty issue. In the latter case, firms are approached, through local professional society chapters, to contribute support to university programs. One such program in computer science at George Mason University is already underway.
- The Office of Naval Research has instituted a graduate fellowship program under which as many as 45 three-year fellowships will be awarded to outstanding graduates in areas of science and engineering critical to the U.S. Navy. The American Society for Engineering Education is administering the program.
- The Department of Energy has established a program of engineering traineeships in key areas relating to energy.
- The National Science Foundation is continuing its fellowship program at approximately 500 new fellows per year and is planning to increase the percentage of awards going to engineering and the computer sciences.

G-6 **Further streamline regulatory and administrative procedures such that Federal and state monies directed toward engineering research and education will receive the most efficient and productive use possible.**

- Governments should consider permitting payment of full admininistrative and overhead costs involved in government-sponsored research at universities. This is not always the practice today.

NEAC PARTICIPANTS

CHAIRMAN — Dr. E. E. David, Jr., President, Exxon Research and Engineering Co.

ORGANIZER — Dr. Paul E. Gray, President, Massachusetts Institute of Technology

Participating Organizations	Elected or Principal Official and Affiliation	Appointed Executive or Associate, and Affiliation
American Council on Education	Dr. William G. Bowen, President, Princeton University	Dr. Jack W. Peltason, President, The American Council on Education
National Association of State Universities and Land-Grant Colleges	Dr. Robert Q. Marston, President, University of Florida	Dr. Robert Clodius, President, The National Association of State Universities and Land-Grant Colleges
Association of American Universities	Dr. Arthur G. Hansen, President, Purdue University	Dr. Thomas Bartlett, President, The Association of American Universities
American Society for Engineering Education	Dr. Daniel C. Drucker, Dean, College of Engineering, University of Illinois, Urbana-Champaign	Mr. Edward Lear, Executive Director, The American Society for Engineering Education
Association of Independent Engineering Colleges	Dr. D. Kenneth Baker, President, Harvey Mudd College	
The Business Roundtable	Dr. John D. Harper, Chief Executive Officer, Aluminum Company of America (retired)	Mr. G. Wallace Bates, President and Chief Oper. Officer, Business Roundtable

Participating Organizations	Elected or Principal Official and Affiliation	Appointed Executive or Associate, and Affiliation
Industrial Research Institute	Dr. Harry W. Coover, Executive Vice President, Tennessee Eastman Company	Mr. Charles F. Larson, Executive Director, Industrial Research Institute, Inc.
American Association of Small Research Companies	Dr. Samuel Cardon, Chairman, General Technology Services, Inc.	
Business-Higher Education Forum	Dr. Gerald D. Laubach*, President, Pfizer Inc.	Mr. Alan Magazine, Director, Business Higher Education Forum
National Association of Manufacturers	Dr. Gerald D. Laubach*, President, Pfizer, Inc.	Mr. Alexander Trowbridge, President, National Association of Manufacturers
American Electronics Association	Dr. C. Lester Hogan, Director, Fairchild Camera and Instrument Corp.	Mrs. Pat Hubbard Hill, Vice-President, Technology and Training, American Electronics Association
Committee for Economic Development	Mr. Franklin A. Lindsay, Chairman of the Executive Committee and former Chairman of the Board, ITEK Corporation	
The Conference Board	Mr. James W. McKee, Jr., Chairman, CPC International, Inc.	Mr. James Mills, President, The Conference Board; Dr. Ruth Shaeffer, Senior Research Associate, The Conference Board
National Action Council for Minorities in Engineering		Dr. Lloyd M. Cooke, President, The National Action Council for Minorities in Engineering
National Academy of Engineering	Dr. Courtland Perkins, President, National Academy of Engineering	Dr. Harold Liebowitz, Home Secretary, National Academy of Engineering

*Dual Membership

Participating Organizations	Elected or Principal Official and Affiliation	Appointed Executive or Associate, and Affiliation
American Association of Engineering Societies	Mr. Irvan F. Mendenhal, Chairman, Daniel, Mann, Johnson & Mendenhal	Mr. Eugene Zwoyer, President-elect, American Association of Engineering Societies
American Association for the Advancement of Science		Mr. William D. Carey, Executive Officer, American Association for the Advancement of Science
National Governors Association	TBN	TBN
Committee on Science and Technology, U.S. House of Representatives	The Honorable Don Fuqua, Chairman, Committee on Science and Technology, U.S. House of Representatives	Dr. Harold Hansen, Executive Director, Committee on Science and Technology; Dr. Paul Maxwell, Science Consultant, Subcommittee on Science, Research, and Technology
U. S. Office of Science and Technology Policy	Dr. George Keyworth, Science Advisor to the President and Director, Office of Science and Technology Policy	Dr. Douglas Pewitt, Assistant Director for General Science, Office of Science and Technology Policy
U.S. Department of Defense	The Honorable Frank C. Carlucci, III, Deputy Secretary of Defense	Dr. Leo Young, Director, Research and Technical Information, Department of Defense; Ms. Jean Carney, Staff Specialist, Research and Technical Information Office, Department of Defense
U.S. Department of Energy	The Honorable W. Kenneth Davis, Deputy Secretary, Department of Energy	

Participating Organizations	Elected or Principal Official and Affiliation	Appointed Executive or Associate, and Affiliation
National Science Foundation	Dr. John Slaughter, Director, The National Science Foundation	Dr. Jack Sanderson, Assistant Director, NSF
National Aeronautics and Space Administration	The Honorable James M. Beggs, Administrator, The National Aeronautics and Space Administration	
Licensing Executives Society	Mr. Lamar Washington, Director, Technology Transfer, Research Foundation, SUNY	
Accreditation Board for Engineering and Technology, Inc.	Mr. Leland Walker, Chairman, Northern Testing Laboratories	Mr. David Reyes-Guerra, Director, ABET
Council on Foundations	Mr. James O. Koerner, Vice President, Alfred P. Sloan Foundation	Mr. William R. Butler, President, Ecofunding, Inc.
Organizing Committee	Mr. Robert Stambaugh, Asst. Director, University Relations Department, Union Carbide Corporation (Chairman)	
Organizing Committee	Dr. Russell C. McGregor, Director of Government Relations, National Association of State Universities and Land-Grant Colleges	

Participating Organizations	Elected or Principal Official and Affiliation	Appointed Executive or Associate, and Affiliation
Organizing Committee	Mr. John W. Geils, Staff Executive, Faculty Shortage Problem, American Association for Engineering Education	
Organizing Committee	Mr. Jack Crowley, Director of Federal Relations for Science Research, Association of American Universities	

April 6, 1982
0336-X-PDF

NE AC National Engineering Action Conference · April 7, 1982 · New York City

PARTICIPATING ORGANIZATIONS AND PRINCIPAL ATTENDEES

Chairman -- Dr. Edward E. David, Jr., President, Exxon Research and Engineering Co.

Organizer -- Dr. Paul E. Gray, President, Massachusetts Institute of Technology

HIGHER EDUCATION

AMERICAN COUNCIL ON EDUCATION

Dr. William G. Bowen: Past ACE Chairman of the Board; President, Princeton University

The American Council on Education, founded in 1918 and composed of about 1,400 institutions of higher education and approximately 200 national and regional educational associations, is the nation's major coordinating body for post-secondary education. Through voluntary and cooperative action, the Council provides comprehensive leadership for improving education standards, policies, procedures and services.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Dr. Daniel C. Drucker: ASEE President; Dean, College of Engineering, University of Illinois, Urbana-Champaign

The American Society for Engineering Education is composed of more than 575 institutional members -- including engineering colleges, technical colleges, affiliates, industry, associations, and government -- as well as 11,500 individual members, interested in furthering engineering education. Formed in 1893, the Society works to improve and expand the education process that helps create competent engineers and engineering technologists. ASEE efforts play a major role in shaping the engineering curricula of colleges and universities throughout the U.S., and the society has long been involved in international activities as well.

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NEAC: Suite 200 / 11 Dupont Circle / Washington, DC 20036

ASSOCIATION OF AMERICAN UNIVERSITIES

Dr. Arthur G. Hansen: Chairman, AAU Committee on Science and Research; President, Purdue University

Founded in 1900 by the 14 American universities that then offered a Ph.D. degree, the Association of American Universities currently consists of 48 U.S. and two Canadian universities with preeminent programs of graduate and professional education and scholarly research. Reflecting the common elements of its member institutions, the activities of the AAU focus on issues of research and advanced training. Half of the members of AAU are public institutions, half are private.

ASSOCIATION OF INDEPENDENT ENGINEERING COLLEGES

Dr. D. Kenneth Baker: AIEC President; President, Harvey Mudd College

The Association of Independent Engineering Colleges is comprised of the presidents of 16 independent engineering colleges across the country who meet annually to share statistical information and discuss problems of mutual interest -- including faculty salaries, tuition, women in engineering, laboratory equipment, tenure and other aspects of engineering education.

NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES

Dr. Robert Q. Marston: NASULGC Chairman-elect; President, University of Florida

The National Association of State Universities and Land-Grant Colleges, the oldest higher education association in the United States, represents the nation's major public research universities and all of its land-grant universities, including 24 of the largest U.S. universities. Approximately 30 percent of all students enrolled in American institutions attend the 140 member universities in the Association for a total enrollment of more than 3.7 million students.

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INDUSTRY

AMERICAN ASSOCIATION OF SMALL RESEARCH COMPANIES

Dr. Samuel Cardon: AASRC President; Chairman, General Technology Services, Inc.

The American Association of Small Research Companies was founded in 1972 expressly to further the welfare of small R&D companies. Composed of almost 500 members, the association brings small and large research companies together to exchange ideas, processes, new inventions and services.

AMERICAN ELECTRONICS ASSOCIATION

Dr. C. Lester Hogan: Member, AEA Blue Ribbon Committee on Engineering Education; Director, Fairchild Camera and Instrument Corp.

The American Electronics Association, with more than 1,800 member companies, represents one of the fastest growing industries in the United States today. Since its founding in 1943, the American Electronics Association has grown to encompass all segments of the electronics industry -- including manufacturers and suppliers of computers, telecommunications equipment, semiconductors, and computer software and services. The core of AEA efforts is to develop a healthy business environment for the electronics industries.

BUSINESS-HIGHER EDUCATION FORUM

Dr. Gerald D. Laubach: Member, BHEF Executive Committee; President, Pfizer, Inc.

The Business-Higher Education Forum is the only nationally-based effort to merge the special talents of university presidents and Fortune 500 chief executive officers to examine and resolve issues of mutual concern. Among the most recent topics addressed are: cooperative research and development, federal regulatory reform, national energy research, corporate education and training, international education and engineering manpower.

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THE BUSINESS ROUNDTABLE

Dr. John D. Harper: Honorary Member of the Business Rountable; Chief Executive Officer of the Aluminum Company of America (retired)

Formed in 1972, the Business Roundtable is an association in which the chief executives of some 200 major companies focus and act on public issues.

COMMITTEE FOR ECONOMIC DEVELOPMENT

Mr. Franklin A. Lindsay: Chairman, CED Research and Policy Committee; Chairman of Executive Committee, ITEK Corp.

The Committee for Economic Development is an independent, non-partisan, non-profit research and education organization composed of approximately 200 trustees who develop specific recommendations for business and public policy. Most of the trustees are board chairman, presidents of major corporations or presidents of universities. Working with distinguished economists and social scientists, Committee for Economic Development trustees develop findings and make recommendations in the areas of the national economy; the international economy; the management of federal, state and local government; and education and urban development.

THE CONFERENCE BOARD

James W. McKee: Member, Conference Board Board of Directors; Chairman, CPC International, Inc.

Formed in 1916, The Conference Board is an independent, non-profit economic and management research company with facilities in the United States, Canada and Europe. The Conference Board has more than 4,000 industrial, educational, labor and governmental subscribers.

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INDUSTRIAL RESEARCH INSTITUTE

Dr. Harry W. Coover: IRI President; Executive Vice President, Tennessee Eastman Company

Founded in 1938 under the auspices of the National Research Council, the Industrial Research Institute is an association of some 278 companies representing more than 75 percent of the industrial research and development conducted in the United States. The Institute provides a means for the coordinating study of problems confronting managers of industrial research and development. The Institute's primary mission is to improve the climate for industrial research through understanding and cooperation between the academic and industrial research communities, and to stimulate an understanding of research as a force in economic, industrial and social activities.

NATIONAL ASSOCIATION OF MANUFACTURERS

Dr. Gerald D. Laubach: Member, NAM Board of Directors; member, Steering Group of NAM Policy Group on Innovation, Technology and Science Policy; President, Pfizer, Inc.

Founded in 1895, the National Association of Manufacturers is composed of approximately 12,000 manufacturing companies responsibile for 75 percent of all manufactured goods produced in the United States. The Association is organized to promote America's economic growth and productivity, particularly in the manufacturing sector, by developing and advocating sound industrial practices, as well as effective governmental policies at the national level.

ASSOCIATIONS

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Dr. E. Margaret Burbidge: AAAS President; Director, Center for Astrophysics and Space Sciences

The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objectives are to further the work of scientists, to facilitate cooperation among them, to foster scientific freedom and responsibility, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.

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AMERICAN ASSOCIATION OF ENGINEERING SOCIETIES

Irvin F. Mendenhal: AAES Chairman; Chairman,
Daniel, Mann, Johnson & Mendenhal

The American Association of Engineering Societies is a national organization comprised of 43 engineering organizations representing nearly one million engineers. As a central coordinating organization, the Association focuses the resources of the engineering societies on technical issues of national and international importance.

NATIONAL ACADEMY OF ENGINEERING

Dr. Courtland Perkins: NAE President

The National Academy of Engineering is a private organization established in 1964 to share in the responsibility given to the National Academy of Sciences, under its Congressional charter of 1863, to examine questions of science and technology at the request of the Federal Government. The National Academy of Engineering sponsors engineering programs aimed at meeting national needs, encouraging engineering research and recognizing distinguished engineers.

NATIONAL ACTION COUNCIL FOR MINORITIES IN ENGINEERING

Dr. Lloyd M. Cooke: NACME President

The National Action Council for Minorities in Engineering is an industry-supported effort to increase the number and quality of minority engineers. The Board of Directors of NACME consists of chief executive officers of major American corporations and leaders of the academic and minority communities.

GOVERNMENT

Committee on Science and Technology, U.S. House of Respresentatives	--	Rep. Don Fuqua (Fla.), Chairman
National Aeronautics and Space Administration	--	James M. Beggs, Administrator
National Governors Association	--	TO BE DETERMINED

- more -

National Science Foundation	-- Dr. John Slaughter, President
U.S. Department of Defense	-- Frank C. Carlucci, III, Deputy Secretary
U.S. Department of Energy	-- W. Kenneth Davis, Deputy Secretary
U.S. Office of Science and Technology Policy	-- Dr. George A. Keyworth, Presidential Science Advisor

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SECTORIAL COMMENTS BY:

EDUCATION

Dr. Arthur G. Hansen, Chairman, Association of American Universities Committee on Science and Research; President, Purdue University

INDUSTRY

Mr. Franklin A. Lindsay, Chairman, Committee for Economic Development Research and Policy Committee; Chairman of the Executive Committee, ITEK Corporation.

SOCIETIES

Dr. Daniel C. Drucker, President, American Society for Engineering Education and Dean, College of Engineering, University of Illinois, Urbana-Champaign

GOVERNMENT

Rep. Don Fuqua (Fla.), Chairman, U.S. House of Representatives Committee on Science and Technology.

Dr. Arthur G. Hansen

"The NEAC Conference has focused its attention on a number of important items confronting engineering education today. However, I believe three of the suggested items listed for higher education in the "Action Agenda" are essential to the future quality of engineering education in the United States. These items include number 2, dealing with competitive faculty compensation, number 4, increased graduate student stipends and number 6, modernization of equipment and facilities in university engineering laboratories.

Hansen (cont'd)

The time for action has indeed come and higher education institutions will do their share to help solve these and other important issues, but we can not do it alone. The key actions I have cited will require supplemental outside funding from industry, government or both. It is imperative that we in higher education work with representatives from these sectors to meet the challenges' threatening engineering education today."

Franklin A. Lindsay

"There are many ways in which an industry/university partnership can be created which can help materially in attracting and holding engineering faculties and in providing major financial support for university research.

One such scheme, in which I am involved, has given 30 percent of the equity of a new genetic engineering company to a special non-profit organization. By its charter, this organization can only use the proceeds from this equity to support future basic research at universities. In addition, the non-profit organization is now funding current research at three universities and has received in return options for limited exclusive licenses on patents developed by that funded research. This arrangement has the advantage that the universities are not direct shareholders in the genetic engineering company, yet will have a 30 percent participation in the future financial success of the company.

This scheme has been funded by six major corporations and is now in operation. It has been accepted by the university administrations and their faculties. We hope that it will become a prototype for other corporations working with other universities and in a broad range of technical disciplines."

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Dr. Daniel C. Drucker

"A high quality of education is essential for the practice of a demanding profession such as engineering. A greatly overloaded faculty working with inadequate equipment and facilities can be effective only for a limited time. Consequently, undergraduate enrollment and resource allocation must soon be brought into balance at most schools. This most likely will occur through significant reductions in undergraduate enrollment as some schools have already done, signficant increases in financial and other resources, or substantial steps in both directions.

Professional societies do have the capability, and welcome the challenge, to implement the manpower supply/demand and education actions suggested for them in items 3 and 5 which will help provide the basis for choice of the balance point for the school. Many societies are already actively pursuing several, or all, of the other action items listed for them along with others addressed to higher education, industry and government."

Rep. Don Fuqua

"In an effort to articulate the role the Federal Government has in this area, I have recently proposed legislation entitled the 'National Engineering and Science Manpower Act of 1982'. Federal initiative to enhance science and engineering education, such as the one I have proposed and others in existence, are important, however, they can reach only a small percentage of the population.

I believe a significant impact can come from the grassroots. Engineers as individuals and as a professional community can do a good deal. This will indeed require funds and guidance from various sectors, but of equal importance will be the influence of those who can clearly convey to the public the value of a technically literate population. The time, energy and concern of technical professionals such as yourselves can provide that influence."

NEAC *National Engineering Action Conference · April 7, 1982 · New York City*

UNIVERSITIES LIMITING ENGINEERING ENROLLMENT

One example of the serious shortage of engineering faculty is the number of major universities limiting engineering enrollment.

These are a few of them:

University of California, Berkeley

UCLA

University of Cincinnati

Cornell

Georgia Tech

University of Illinois

University of Maryland

Michigan State

University of Michigan

N.J.I.T

SUNY - Stony Brook

Notre Dame

Ohio State

University of Oklahoma

Penn State

Purdue

V.P.I.

Washington State

University Of Wisconsin

W.P.I.

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Mr. WALGREN. I would like to recongize Mrs. Heckler for an opening statement. We did reserve a place at the start of the hearing for that.

Mrs. HECKLER. I ask unanimous consent to have it inserted in the record.

Mr. WALGREN. Also, following that, a statement by Mr. Brown for the record.

The Chair would recognize Mr. Shamansky.

Mr. SHAMANSKY. Mr. David, I certainly welcome your testimony. I know that Exxon announced last year a $15 million program for engineering education, and the country in general is very grateful. I realize that money is for 66 universities to be spent over the next 5 years.

A classmate of mine at Harvard Law School whose name is John Haire, and he is president of the Council on Financial Aid to Education located in New York. I discussed with him, because of my concerns on this committee, the necessity of the private sector coming forth and trying to fill some of the gap now created. I believe it is a fair statement to say that he then discussed such programs as yours. You may know Mr. Haire, I don't know.

But in spite of the magnitude of the effort on the private sector, it seems to me—and I think he was inclined to agree—there is no reasonable prospect to expect the private sector to make up for what the Federal Government has been doing heretofore, and certainly cannot close the gap between the need and the ability, or at least the history with respect to the ability of the private sector to make up for that.

May we have your comments on that? Can the private sector close the gap?

Dr. DAVID. The private sector, Mr. Shamansky, can help to close the gap. But I think the gist of your remarks are correct. The total support for research and education by the Federal Government in the universities and colleges of the Nation amounts to in excess of $5 billion. In 1980, the contributions of the private sector—that is, of industry—to education was $290 million, around $300 million. I think that that contribution can be increased very substantially and will be increased over the years. However, it is not, in any way, going to replace the major role that the Government has had in higher education in this country.

So, the gist of your remarks, I think, is correct.

Mr. SHAMANSKY. Am I fair, then, in inferring from your remarks that you feel that the Federal Government must be doing more than it is now apparently going to do?

Dr. DAVID. I have not looked at the complete program of the Federal Government in higher education. I know that they already do a good deal. I would be hard pressed to recommend an increase or decrease in the actual appropriations for engineering education or the broader aspects of education at the present time.

Mr. SHAMANSKY. I hope you will forgive my saying I am getting different signals here. There is a pronounced gap, and now you are saying you don't know what we are supposed to be doing? What could we do to get an opinion from you? You are an expert in this area.

Dr. DAVID. I would not, Mr. Shamansky, agree that I am an expert in higher education. I think there are very few of those.

However, I think that there is no doubt that there is something to be done in engineering education in particular, which is the subject at hand.

Mr. SHAMANSKY. Let us talk about the National Engineering Action Conference.

Dr. DAVID. Yes.

Mr. SHAMANSKY. Now, is it the conclusion of the group of which you are now the head that there must be an increased role on the part of the Federal Government in funding this education in this area?

Dr. DAVID. Mr. Shamansky, the recommendations of the group included some additional funding by the Federal Government. But it also pointed out that the nature of engineering education requires activity by the industry and by State governments as well.

Mr. SHAMANSKY. I am not in any way slighting that. I just think it is important that if the private sector does believe that there has to be an increasing role by the Federal Government—and that seems to me to be the thrust of John Glenn's testimony and, frankly, of yours—to waffle at this point, for whatever reason, on this point is very unfortunate.

Now, I am trying to get you to say openly what I think is clearly implicit in what you just testified to, that the only way we are going to meet this challenge is to have a national approach.

Dr. DAVID. Well, Mr. Shamansky, I would prefer, rather than a large national program, a program in which there was a great deal of diversity in which the State governments and agencies all had an important role to play. And I think that the Federal Government has got to play its part.

Mr. SHAMANSKY. Yes.

Dr. DAVID. It is up to this committee, I think, and to the executive branch of the Federal Government to find exactly what that role should be.

However, it does seem to me that it is extremely important for the Federal Government to shoulder its responsibilities. However, I can't say at the moment whether that requires more money or a reprograming of money or different programs.

Mr. SHAMANSKY. So you really, at this point, have no opinion as to whether or not the Federal sector—the bill, of course, the Fuqua-Walgren bill, requires and emphasizes the collaboration between the public sector and the private sector. You have no opinion now as to the adequacy of the Federal effort as now contemplated?

Dr. DAVID. Let me comment on the bill just briefly, if that is admissible, at this point. I must say that the NEAC did not take the position on the bill itself. So these are my own opinions and not the opinions of NEAC.

Mr. SHAMANSKY. Sure. I said you were the expert, not NEAC as such.

Dr. DAVID. I think that the matching grant approach is a very good one, and it can help the situation materially because it provides the kind of diverse approach which I think will be most effective, because clearly what MIT needs and what Georgia Tech needs and what Rose-Hulman Institute needs can be quite different. So I think that a matching approach by the Federal Government would be quite constructive.

I would also say that I would like to see the bill include a provision so that individual contributions from within the Government could be matched. The Federal Government employs a large number of engineers and scientists. They contribute to the college or university of their choice. I think that the bill should include a provision so that the Federal Government could match those contributions as well.

I think this rather clearly shows that additional money flowing through these mechanisms to engineering education and to scientific education would be a good thing.

Mr. SHAMANSKY. So your testimony is that there should be additional money in some measure from the Federal Government?

Dr. DAVID. Yes.

Mr. SHAMANSKY. Thank you.

Mr. WALGREN. Thank you, Mr. Shamansky.

The Chair would recognize Mr. Dymally.

Mr. DYMALLY. Dr. David, the 66 universities which you plan to support in the next few years, have they already been selected, or are you in the process of selecting those universities?

Dr. DAVID. Mr. Dymally, they have been selected and announced, and the grants have, in large part, been made. The program is actually slightly larger than $15 million, which was mentioned by Mr. Shamansky and the chairman. It is actually $16.8 million. The additional $1.8 million is to go to black universities. It is a special program aimed at engineering education in the black universities.

Mr. DYMALLY. That was my next lead question. Is the book closed on that? Do you still have room for discussion?

Dr. DAVID. We would certainly be interested in any opinions that you have on that. The grants have already been made to those universities.

Mr. DYMALLY. I see. Thank you very much.

Mr. WALGREN. Thank you, Mr. Dymally.

Mrs. Heckler?

Mrs. HECKLER. Thank you, Mr. Chairman.

Dr. David, one of the areas of concern that I have heard expressed in the electronics industry, in regard to the need for engineers, is the increasing competition from the Government as a result of defense spending. It is very attractive for an engineer to go into defense industries rather than into commercial industries—further limiting the pool of talent available for our commercial sector.

Do you think that is a valid complaint, and did your conference address that?

Dr. DAVID. The conference didn't address that issue directly, Mrs. Heckler. However, from my own background, I know that selective Federal funding of certain sectors of industry has in the past distorted both educational efforts and employment in the United States. If one looks back at history, in the 1960's, for example, the case is very clear that really creative people were diverted to defense industries and into areas of great interest to the Federal Government—associated with the space program, for example. This left the traditional basic industries of the United States in a very poor position.

Mrs. HECKLER. How can we deal with that? How can we solve the problem, considering the emphasis that the Federal Government is now placing on defense spending?

Dr. DAVID. I think, Mrs. Heckler, that the problem today is not nearly as severe as it was in the 1960's. Many industries, including our own industry, believe that we pay competitive salaries and are able, therefore, to attract adequate people. So I don't think the situation is nearly as bad as it was.

However, I think that the Congress, in considering and passing programs in response to proposals by the executive branch, should seriously consider what the manpower base is and what effect these programs will have on manpower demands.

Mrs. HECKLER. Mr. Chairman, in that regard, I think it would be very useful for our committee to have joint hearings with the Armed Services Committee, and to investigate this question in terms of both the defense needs and the private commercial needs.

I am encouraged by your statement, Dr. David, but presidents of very large companies in Massachusetts have already experienced very severe problems in recruitment of engineers. They attribute it, in part, to the siphoning off of very capable talent by the defense industries. This is going to create a very serious problem down the line.

Dr. DAVID. Mrs. Heckler, I think the situation is uneven. It is certainly something to keep an eye on and to be certain that you understand what is happening as a result of larger defense programs with respect to manpower.

Mrs. HECKLER. On the question of faculty retention, which seems to be one of the major problems, I notice that one of the recommendations of your National Engineering Action Conference was to create more opportunities for recognition of faculty members and commensurate salaries.

What would this do to the university structure if the commensurate salary for a professor of engineering is enormously higher than other salaries at the university? Have you dealt with that issue?

Dr. DAVID. We have tried to deal with that issue, and I have talked privately with a large number of college presidents and university faculty on this subject. In many cases, I think the situation can be handled, and there already is a salary differential between engineering and scientific salaries in universities and, for example, the liberal arts and humanities. This is a difficult problem, but it is one that is now being faced and confronted in many places.

In some States—and I can quote chapter and verse on this—there are State laws, which prevent differential salaries. Those, we feel, should be changed to allow the marketplace to operate at least in a limited fashion in these situations.

Mrs. HECKLER. The emphasis of your conference, of course, is on engineering education, but it is quite apparent that there are similar problems at the pre-university level, in terms of preparatory training for engineering. For example, science and math teachers are often recruited from the academic environment to, again, the private sector. In Massachusetts, we already have a crisis in terms of shortages—serious shortages of truly competent math teachers.

Isn't it important for your industry, and others that depend on the quality of engineers, to look at not only the university level, but at secondary and primary levels of education too?

Dr. DAVID. I think it is, Mrs. Heckler. I would only say that most of the support, most industrial interest, as traditionally been in higher education. I think that from the industrial side we understand graduate education and undergraduate education much better than we do primary and secondary education.

However, a number of us have been involved over the years in getting more actively into these areas. At the moment, I am serving on the board of directors of the AAAS, the American Association for the Advancement of Science. You will hear later, I think, from Dr. Rutherford about the AAAS efforts to address the problem that you are concerned with. I have been actively involved with that effort of AAAS.

Some years ago, I was involved with the preparation of a curriculum for high schools for what we call technological literacy. It wasn't mathematics, physics, chemistry, or biology; it was a blend of those. The objective of the course was to try to provide material so that the student who was not going to be a scientist or engineer could feel more comfortable that he or she understood what was going on in the society around them. I think such contributions are to be recommended and pushed forward. On the other hand, I think industry is not extremely well suited to as active a role there than in higher education.

I might just add, however, that IBM, the Bell Telephone Labs and, to some degree, Exxon Research and many others do have materials which are used in primary and secondary schools these days. I think that this is one area where industry has been responding and can do more.

Mrs. HECKLER. It is encouraging to hear that.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mrs. Heckler.

I understand that there is interest among the committees involved with defense in the House to pursue a joint examination of these needs and their relationship, the impact particularly of the defense side.

We certainly now want to recognize the chairman of the full Committee on Science and Technology, Mr. Fuqua, who is the moving force behind the bill that we are considering. Mr. Fuqua.

Mr. FUQUA. Thank you very much, Mr. Walgren.

I, first of all, would like to insert this statement at the beginning of the hearing following that of the opening statement of Mr. Walgren.

Dr. David, I want to thank you for coming and testifying, and I express my appreciation for the leadership role that you have had in trying to bring this matter to the appropriate attention of I think not only of industry and academia, but also the American people.

One of the questions I really wanted to ask is: In the bill that we have presented, Congressman Walgren and I—and the purpose of the hearings is trying to perfect that bill and make it better—one of the things that we have is a Coordinating Council composed of people from industry and academia and the National Academy of

Engineering and the president of the National Academy of Sciences and others. Do you find that Coordinating Council to be an effective method of administering this program should this bill become law, or do you think there should be changes or improvements in the way that Council is established and functions?

Dr. DAVID. Mr. Fuqua, I am always wary of setting up statutory committees. I think that the same effect can be achieved by administering this program through by the current mechanisms in the National Science Foundation, perhaps with an advisory council in the usual mode which NSF uses to set up advisory activities.

I believe that the provision for a statutory committee will be a point of dispute with the administration, and I would think that some accommodation might be appropriate.

Mr. FUQUA. Well it was the purpose not to really tie their hands, but to try to give some direction. I think your point is well taken. Maybe in the report language on the bill, we might suggest that these were some people that would be good to serve on that coordinating council. Yes, I agree the whole bill could be done through administrative procedures right now. Unfortunately, funds for engineering education have been deleted from the NSF budget. We are attempting in that bill to restore some of those funds, $30 million.

Dr. DAVID. Yes.

Mr. FUQUA. So we thought it was a problem that was serious enough.

In response to one of of the questions that Mrs. Heckler asked about the military, we had some testimony from General Marsh who heads the Air Force Systems Command that they were more than 10 percent short of qualified personnel and technical expertise, just in the Air Force, and he anticipated that that would even accelerate in the coming years. So, yes, we do have a problem in the Defense Department, as expressed by General Marsh, particularly as it affected the Air Force and in his responsibilities, not only in manning complicated and sophisticated systems, but also in working contracts that the Air Force has when people were not eminently qualified in the service to be able to do that. So we have that.

In the other part, I think, when you look at the role and requirements of the Federal Government, not only the military, but also the Department of Energy, NASA, many of the others that require a lot of high technology, the Government—I don't have an answer, but I would say the Government uses probably a third to maybe half of the engineers in some facet doing work for the Government in some related fashion, either directly or indirectly. So there is a legitimate Federal role just for the Government's interest.

I think it has been pointed out, and you have been a very effective leader, that industry has responsibility. My observation has been that industry is very interested in trying to participate and help in this problem because they see it also as affecting their interests—their long-range interests. So I think it is very important that we try to move forward with some type of legislation so that we can try to correct a problem that I see blooming on the horizon and that is going to very adversely affect this country and its ability to compete in the world that we live in today.

I want to thank you again for coming and testifying here today.

Dr. DAVID. Thank you very much.

I would also like to thank you for the role you played at NEAC and for your leadership overall in the educational and science and technology areas. Thank you very much.

Mr. FUQUA. Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Chairman.

I have kind of high hopes for this bill because, in our view, it is a way to go forward or make a transition from programs that apparently this administration is unwilling to support, and yet go forward in an area that they believe we should go forward with. I sympathize with the frustrations that, perhaps, Mr. Shamansky was indicating in his question because, on the one hand, we have expressions from the administration that they recognize those needs and, on the other hand, they don't support any of the programs in the area.

I couldn't help but look at Dr. Keyworth's statement to the NEAC where he says that the administration will be highly amenable to appropriate new programs. In particular, he is in support of programs that impact many students over time—examples might be instructional equipment, research instrumentation, or improving the skills of secondary teachers—while the programs that they zeroed out of the National Science Foundation were specifically these programs that they certainly recognize the need for.

One of the things that seems so proper about this particular bill is that it would provide a way to go forward in an area where they certainly recognize the need for, and perhaps in a form that would be acceptable and supportable by the administration.

Do you feel this bill would have the support of the administration?

Dr. DAVID. Mr. Walgren, I can't speak for the administration. I do think the principle of matching grants should fall within the area that the administration would support.

I would just make a couple of comments about your remarks. While I am generally supportive of what you say, I think the principal effect of this bill, if it is passed approximately in the form that we see, will be on higher education, not on primary and secondary education. I think that when you look back at the National Science Foundation programs aimed at secondary schools and, to some degree, primary schools, over the past 20 or 25 years—and I am familiar to some degree with them—you have to ask, since those programs have been funded for over 25 years, how did we get to the situation we are today with all those programs in place?

I think that the answer—although it is a complicated question and a simple answer perhaps doesn't do justice to it—the reason, basically, is because the requirements of today are really quite different from the requirements of the 1960's and the early 1970's. If you look back at such curriculum developments as the Physical Science Study Committee, the engineering concepts curriculum project and others that were funded by NSF, they have had a major impact on primary and secondary education. But they have not attracted the students that they intended to. There has been very definitely a falling off in the number of physics students and the number of students who are aimed at engineering and scientific careers. The situation has already been described here this morning.

I think a complete reexamination of what kinds of programs should be put into place should be made. I think merely trying to reinstate the same kinds of programs that we had in the 1960's and the early 1970's is not going to solve the problem which you are so quite correctly concerned about.

Mr. WALGREN. I hope that we do go through that kind of reexamination because, clearly, something is not working properly. I hope, as part of that reexamination, those looking at it will take into account, as I understand, the tremendous reduction in effort in education by the National Science Foundation since 1960. As I understand it, at that time, the National Science Foundation's education budget was 49 percent of the Science Foundation's effort. And it is on a direct fall through 1980 when they are down to around 2 percent of the National Science Foundation's effort.

So, I just hope we can find some kind of a solution. Of course, that is why this bill was conceived, trying to find some range of common ground that could benefit this area that seems to be suffering so completely.

Do you have any views on what the best role of the Coordinating Council would be? As I understand, the Senate side has them quite interested in taking assessment of human resource needs and the like, and making policy recommendations. Do you have a strong feeling of the role that Coordinating Council should play?

Dr. DAVID. Mr. Walgren, I can make a few comments. I wouldn't presume to try to mastermind the functions of that Coordinating Committee. But there are a few points that can be made.

Certainly one of them is that in a pluralistic society of the kind we have, projecting manpower needs many years into the future is extremely difficult and hazardous. It is clearly tied to the economic situation of the country, and one thing you can say about economic projections is that they are almost always wrong. Going with that uncertainty are some of the projections of manpower that we have seen. So I distrust manpower projections. I don't think any Coordinating Council can do a reasonable and credible job of laying out the requirements many years into the future for manpower in this country.

I think the Coordinating Council, or some existing group to which the responsibility could be assigned, could lay out a program to establish educational mechanisms which can respond on a timely basis to the demand situation with which we are confronted at any given time. That is what NEAC was trying to do for engineering education. It wasn't saying that we need more engineers, we need fewer engineers, or we need more computer scientists or fewer chemical engineers. It was saying, we should should put into place the mechanisms, the educational mechanisms, if you will, so that whatever is needed can be produced with high quality. I think that function is the one the Coordinating Council or some existing group ought to take on.

Now, I will say that the National Academy of Sciences is very concerned about this problem, and you might consider, since there is a question of whether the Coordinating Committee is a proper thing to be established, to place the responsibility for doing the studies into the Academy of Sciences or conceivably into the AAAS to get the kind of perspective that you want, the kind of guidance that you want from outside the Federal Government.

Mr. WALGREN. Dr. David, you indicate in your testimony that one of the recommendations of this conference was that the policies on the State level which preclude making the pay of engineering faculty competitive be certainly directly addressed. I think that is certainly very sound, particularly where they preclude making pay competitive.

How did the representatives at the conference see that ability of the industry to directly contribute to making the pay of engineering—providing the resources to make the pay of engineering faculty either competitive, or how did they see their role in helping to keep that faculty in place?

Dr. DAVID. I think the NEAC people all agreed that the effort should not be one to necessarily equalize salaries between the private sector and the universities and colleges. That wasn't the intention. The intention was to make the situation competitive. That does not say that salaries have to be equal.

But trying to answer your question more directly, we think there are many mechanisms that can be used. One is direct grants for salary supplements to young faculty, who are the faculty that you really want to keep in place. That was an element in the Exxon program, and it is an element in several other programs that have been announced.

Second, industry should be hiring the faculty members selectively for consulting jobs, provide opportunities for joint activities in the universities, and do a number of things of this sort which will provide opportunities for engineering professors to participate in industry and to gain some additional income through that mechanism.

Mr. WALGREN. Has industry made any assessment of whether it has the resources to cover that field?

Dr. DAVID. Yes, sir.

Mr. WALGREN. Perhaps this is not a good analogy, but it strikes me that if you have a problem and there is one element that is draining the ability to solve the problem and this drain of graduate students immediately into industry before they receive maximum training is one, and certainly the pull from industry away from teaching positions is another, wouldn't you look in some disciplined way to stop that from happening and look to the agent that is causing it and ask them whether they have the ability to do that? Has industry looked at that carefully and made an assessment of the dimensions of that problem as to whether or not they can stop doing that?

Dr. DAVID. Well, industry is not a monolith, Mr. Walgren, as you well know, so various elements of industry have looked at the problem differently. I would say this: It is not wise, I think, for industry or government to put restrictions on the hiring of university people by industry. It wouldn't be fair or acceptable, I think, for us to say we have certain openings, but university people are not eligible to fill them.

However, we have looked at the question of what are the financial resources that university and colleges need in order to retain their young faculty and to make the situation somewhat competitive. And it is not a very large financial problem, interestingly enough. If you do the calculation, it comes out that annual supplements for salary between $100 million and $200 million would be adequate.

Now, the universities and industries in many places have also looked at the question of quality of life for engineering professors in universities, and science professors as well. One of the problems, as you well know, is the availability of top-flight, first-class equipment to do their research. And some industries have already seen their way clear to allow faculty to come and use the equipment in the industrial area. This turns out to be a very substantial contribution where, really, no money passes at all.

So there are various ways of doing this. I think, rather than a fiat that we won't hire any more university people, which I don't think is feasible, the techniques of the kind that I have just been talking about are what we should look to.

Mr. WALGREN. Who should try to put that coverage in place? Could this Council under this bill address that problem, do you feel? Or would that probably be better addressed by some other mechanism?

Dr. DAVID. I think we should go to the kinds of institutions that we had at NEAC. For example, the Committee on Economic Development, the AAU, the Business Roundtable, the Business Higher Education Forum. We should get those people involved in this problem and get them to convince their members, whether it is universities and colleges or industry, to look at this mechanism and take advantage of it to the degree that they can. I think that would be the most effective.

However, alerting the industries and universities to these possibilities is certainly something the Academy of Sciences, the AAAS, this committee could do and do very well.

Mr. WALGREN. Perhaps we ought to consider putting representatives of those groups on the Council or incorporating them in the Council in some form.

Thank you very much, Dr. David. We certainly appreciate your contribution to the hearing, and we look forward to other thoughts that you might have on this from time to time as it develops.

Dr. DAVID. Thank you, Mr. Walgren, for the opportunity.

Mr. WALGREN. Thank you.

Mr. FUQUA. Mr. Chairman?

Mr. WALGREN. Mr. Fuqua.

Mr. FUQUA. Before you call the next witness—I unfortunately have a couple of other meetings I have to run to—but I wanted to acknowledge one of the witnesses, my good friend, Dr. Delbert Tesar from the University of Florida who will be testifying later. I hope you will treat him very kindly. He is very interested in the subject. It is one he and I have discussed many times. I appreciate very much your being here, Del. I apologize for not being able to be here when you testify, and also to the other witnesses.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Fuqua.

Mr. WALGREN. The next panel will be made up of Dr. James Rutherford from the American Association for the Advancement of

Science; and Dr. Eugene Zwoyer, president of the American Association of Engineering Societies.

Gentlemen, if you will come forward. We want to welcome you to the committee. Your written statements will be made a part of the record as a matter of course, but please feel free to make your presentations as you feel most effective.

STATEMENTS OF JAMES RUTHERFORD, CHIEF EDUCATION OFFICER, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE; AND EUGENE ZWOYER, PRESIDENT, AMERICAN ASSOCIATION OF ENGINEERING SOCIETIES

Mr. RUTHERFORD. Thank you, Mr. Chairman. I appreciate the opportunity to present my views on this bill. I think it is a terribly important one when we look at it in the light of the serious national needs we have for technical, scientific, and engineering manpower.

Indeed, the first point I would like to make about the bill concerns its major strengths. It is implicit in everything about this bill that there is an urgent national question at hand. The decisions may be made in separate universities in this State and the other States, but the fact of the matter is that the economic strength of the Nation and our security depend upon our having the capacity for producing the kinds of technical, scientific, and engineering workers that we need now and will need for the foreseeable future.

Being a national problem, it is clearly not the sort of thing that the Federal Government ought to leave to chance. I would like to make that point first.

The bill also implies—has drafted in it—the claim that we now have nothing approximating a national policy or a Federal policy with regard to the technical and scientific manpower of the Nation. Individual Federal organizations have policies—NSF has policies and DOD has policies—but collectively, these policies don't constitute a coherent and rational attempt, not to control the U.S. production of scientific workers, but rather to base production on Federal response to the best information on needs.

This is shown in the fluctuations, the shortfalls, the gluts. The Wall Street Journal today tells us that the chemical engineering graduates are having a little more trouble in getting jobs this year than they were having last year. Things go up and down. What the bill is saying is not that we must predict future needs, but that we must prevent wild and extreme oscillations.

The bill recognizes the main dimensions of the problem, except in one respect: the short title leaves out the word "technical" and, therefore, might underplay an important issue. The bill is dealing with technical, scientific, and engineering manpower, but doesn't say "technical" in the short title. Good scientific and first-rate engineering output of the Nation depends upon the quality of the large number of technical workers. The bill has to acknowledge that capable technicians, as well as scientists and engineers, have to be produced.

In summary, I believe that the purposes of the bill are sound, it is based on a well-documented need. I would like, however, to comment on a couple of points about the bill itself that have come to my attention.

Under the section on "Findings and Purposes," section 2, there are two parts that need more emphasis. One, raised by Mrs. Heckler earlier this morning, is that our ability to produce good scientists, engineers, and technical workers depends upon strengthening our elementary and secondary schools. In the long run, it is missing the whole point of the structure of the educational process in our Nation to believe that technicians, scientists, and engineers can be produced without a system that, from top to bottom, is strong. This bill mentions elementary and secondary education. Perhaps there are some ways of strengthening that.

Incidentally, Dr. David did mention that AAAS was undertaking some initiatives. I will leave for your information or for the record a document called "Education in the Sciences, a Developing Crisis," which is the AAAS view of the precollege aspects of the problem and what the scientific societies might do about it.

The other item in that section of the bill that needs to be emphasized is that, in the long run, we need a larger pool, an effective pool, from which to draw engineering and scientific talent. That means that we cannot continue to miss bringing women and minorities into scientific fields. That is something that starts down in the early grades. It is not a problem that is solved by some number of fellowships given at the graduate level. We have to be serious about the problem from the very beginning. That is the long-term aspect in the bill, and it needs to be kept and emphasized.

Section 3, dealing with policy, is a strong statement that we need a policy based on analysis of the best information we have. The section indicates that departments and agencies other than NSF must be involved. I urge you to keep that in. NSF cannot deal with the problem alone. It must involve other agencies of the Federal Government. That is why the section calls for coordination, and in principle, coordination is an important aspect of the bill. But my experience in the Federal Government proved that it is a very difficult thing to achieve, that efforts to set up an umbrella Federal group to coordinate lots of other groups rarely works, although the need is there.

In principle, OSTP could do this job of coordination. After all, in some real sense, it has purview over the Foundation; it deals with OMB, it deals with other Federal agencies that are involved in science. The bill might require OSTP to do this as one of its functions. There may be other ways of doing it.

In this section, there is a requirement that manpower programs ultimately be funded through normal processes. I concur that that is the only way the provisions of the bill will work in the long run. Funding through the authorization/appropriation process assures periodic examination and precludes the Council's becoming a separate agency that will go in its own direction. That is a strong part of the bill that needs to be kept. After all, this problem is going to be with us a long time, so we should set in process something that can work for a long time.

In section 5, the Council is being asked to do lots of things. I have indicated some concern about the ability of coordinating councils to be effective. An example is the one called Federal Interagency Commission on Education, and it is infamous in Washington. We were not able to get all the agencies that deal with education to move together. Maybe this Council would do better.

Two provisions in the bill give me some concern. One is the makeup of the Council itself. Institutions and people who are already interrelated have independent tasks and, yet, this Council might put them together in a way that suggests a line of authority. For example, the two academy presidents. It seems to me a delicate thing to get the academies connected too closely into the Federal enterprise when, in fact, they are supposed to be in a different sense external and available to conduct studies and analyses and not get into policymaking to the extent that the Council is also a policymaking device.

The bill mentions 10 people and specifies all 10. What the bill doesn't make clear is, if the chairman wanted a larger committee, what kinds of people they would be. I think there is a vagueness there that can be repaired.

Mr. SHAMANSKY [presiding]. Dr. Rutherford, if I might interject something. On the typing that I have here, it says, "Also the bill is vague about the numbers on the Council and who the others might be since the '10' are already proscribed." Do we mean proscribed or prescribed.

Dr. RUTHERFORD. I mean prescribed.

Mr. SHAMANSKY. OK. I just wanted to make sure what the editorial comment was.

Dr. RUTHERFORD. Yes, prescribed.

The other concern is it calls for the Chairman of the National Science Board to be chairman of this Council also. That may very well mix up the roles of that office. I am not sure whether the Council would be working for the Board, or the Board for the Council, or the Council for OSTP. I think that might be better dealt with in some other way.

The section on responsibilities of the Council, it is very comprehensive, there are a lot of functions there. Certainly analysis belongs there, systematic review of government programs belongs there, and coordination, as difficult as it is, probably belongs in such a Council, whether it is embedded in OSTP or in the National Science Foundation.

However, action also seems to be proposed at least there are references to encouraging some general outcomes, increasing opportunities, increasing access for minorities and others. It sounds to me as though the Council now is out of the policymaking and coordinating business and into action. Then there is the fund which it has authority over, so it becomes not only a policymaker, but a funder. When you put those two things together, you have created another agency.

You might want to consider having the Council put more emphasis on coordination, review and reporting, than on programmatic activities. There are also some problems with the Council's relation to the Scientific Manpower Commission, the Engineering Manpower Commission, and the like.

Mr. WALGREN. Dr. Rutherford, who would then become the funder? Apparently choices must be made at some point, I would gather, in which of these matching proposals to accept.

Dr. RUTHERFORD. The funding function could very well be lodged in the National Science Foundation. It seems to me that the bill can say to NSF, "On this aspect of the science education program, Congress has determined that we want these kinds of activities funded at certain levels and in a certain way. You set up the mechanism to do it and keep us informed. And in the process of doing it, you will be informed by the policy that might very well come out of the Council attached either to the Board or OSTP."

But I see nothing in current circumstances that would prevent Congress from requiring the NSF to be the manager of this fund by whatever rules are set up.

Mr. SHAMANSKY. Excuse me. Manager in—is that purely an administrative function or a policy function? Because the Council, it seems to me from what you are saying, should be the policy formulator, and worry about the use of the word "manager" as implying policy as distinguished from administration.

Dr. RUTHERFORD. I am talking about administration. I think the size of the fund and the purposes for which it is designated would come from the policy determinations of the Council. NSF then would administer the fund at whatever level has been decided. Otherwise, if you ask the NSF what size it should be and for what purposes, you will get the same answer you get in your annual authorization process.

Mr. SHAMANSKY. Is it possible that perhaps a closer reading or another reading of the Walgren-Fuqua bill would suggest that that is what was intended?

Dr. RUTHERFORD. Quite possibly, Mr. Shamansky. I am only suggesting that I see some confusion about where the difference is between the Council, the fund, and the connection.

Mr. SHAMANSKY. It is certainly staff's opinion, if I may cite the staff, that that is the intention. I am sure we will look to see if we can't clarify the language to achieve the purpose you are mentioning.

Dr. RUTHERFORD. Well, sir, I think that will suffice, having submitted my other remarks. Thank you.

[The prepared statement of Dr. Rutherford follows:]

Prepared Testimony of F. James Rutherford

I thank you Mr. Chairman for the opportunity to comment on H.R. 5254. My remarks today are based on my own reading of the Bill in the light of what I believe are serious national needs for technical, scientific, and engineering manpower. My comments are not, however, a result of a formal AAAS study nor do they represent a position statement of the Association. I hope that my comments will be of some use in dealing with this serious issue.

Before commenting directly on the substance of the Bill, I would like to support the notion strongly that the Bill is addressing an urgent <u>national</u> question. While it is true that individual institutions and states make most of the decisions that count with regard to higher education and indeed have control over resources allocation, the fact remains that the problem far exceeds the boundaries of local interest. The security of our nation and its economic strength depends upon technical and scientific manpower continuing to be produced in sufficient numbers and of a high enough quality so that we can operate in a technologically-based society. The federal government similarly cannot leave to chance matters of such urgency.

The Bill is not only on solid ground in claiming that there is a national issue to be addressed, but also in the claim inherent in the Bill that a federal policy does not now exist. The National Science Foundation, the Department of Defense, and other agencies have programs and activities relating to scientific manpower, but these individual policies are not mutually reinforcing, coordinated, or complementary. Individual federal organizations may have policies, but the federal government does not.

Our failures in this regard are shown in the wide fluctuations that occur in the output of technical, scientific, and engineering mampower in relation to national needs. Shortfalls are followed by gluts and then they get back to shortfalls again. A national policy, a coordinated effort, could at least operate to dampen the magnitude of these oscillations.

The Bill itself recognizes a very important aspect of this total problem, though the short title of the Bill does not emphasize it. This is that the need for a large cadre of highly trained technicians is every bit as important as having sufficient numbers of well-trained scientists and engineers. These people upon whom our technological effort depends are trained in technical schools and two-year colleges and could thus be overlooked in efforts that focus most of their attention on classical university training. If anything, the Bill might emphasize even more the need to make sure that there will be an adequate supply of technicians for the foreseeable future.

In sum, I believe that the purposes of the Bill are sound and that it is based upon a well-documented need. Let me then turn to a few comments on the substance of the Bill and its efforts to devise ways and means for achieving the purposes put forth.

Section 2. Findings and Purposes. This section identifies very well issues and problems and why action is needed. There are two parts of it that need to be kept no matter what other changes may be made for they are frequently overlooked in manpower discussions. The first is in Section 2 (4) where the decline in quality of scientific and mathematics education in the elementary and secondary schools is referred to. Any long term effort to deal with our technical manpower needs must recognize the necessity to have appropriate pre-college education. If our youngsters continue to move away from education in science and mathematics and the teaching continues to decline, then we simply will not have enough people prepared to respond to whatever technical training and higher education opportunities which may exist.

Section 2 [illegible] also recognizes the importance of having a larger pool of prepared young people from which to draw trainees given the decline in the total number of students in school. We must increase the number of women and minorities entering scientific fields or we will simply run short. I am not referring here to equity, but to the need to stop losing the human resources that are so necessary to our future.

Section 3. Policy. This section presents a clear statement with strong emphasis on analysis as a basis for policy. It is also sound in encouraging departments and agencies other than just NSF to support policies established at the federal level. NSF must surely have a major role in developing and serving a federal scientific manpower policy, but it cannot do this alone because of the magnitude and complexity of the national need.

This section calls for coordination of the policy by the Office of Science Technology Policy and this makes good sense for in principle OSTP is in a position to mediate across all departments and agencies, and through the Administration to influence OMB. I am not sure, however, but that this coordinating function could be assigned to and carried out by OSTP without the establishment of a separate council. That is, the Bill might require OSTP to serve the coordinating function and provide staff and financial resources in order to carry it out. The coordination by them might, or might not, involve the establishment of a separate council or panel but the responsibility would be clearly lodged in one place.

The requirement in Section 3 (b)(2) is important because it is the only place that emphasizes that the funding for technical, scientific, and engineering manpower programs ultimately needs to be obtained through the normal process of authorization and appropriation.

The scientific manpower problem will remain with us for a long time and must be dealt with systematically. Even though this presents some coordination problems, it is important that the relevant agencies build into their own budgets appropriate funding and that this is periodically reviewed by Congress. The problem of coordination is precisely one of the things that this Bill adresses so that once it is in place each of the agencies who are involved should be expected to not only have requests for their own programs, but should be required to show how these relate to the total federal effort.

Section 4. Coordinating Council on Engineering and Scientific Manpower. The idea of having a council or ongoing panel to coordinate federal efforts is attractive in principle. In practice such councils often turn out to be weak and ineffective. An example of this, for which I have some responsibility and blame, is the Federal Interagency Commission on Education. However, it seems likely that a council or panel lodged in and being a part of OSTP is more likely to have the kind of authority it takes to command the attention and cooperation of the various agencies.

In the Bill there are two provisions which give me some concern. One of these is in part (b) dealing with the makeup of the council. Some of the proposed members come from agencies or organizations that have their own independence that could be jeopardized by having their heads serve together on a council that has policymaking authority. In particular I refer to the academy presidents, directors of OSTP and NSF and the Chairman of the National Science Board. There is something to be said for close exchange of ideas and information among these, but the lines should not get too tangled. Also the Bill is vague about the numbers on the council and who the others might be since the "10" are already proscribed.

The other concern has to do with subsection (c) which calls for the chairman of the National Science Board to serve as chairman of the council. This could appear very much to confuse the authorities invested in the chairman of the NSB with duties related to an organization established by a separate law and having different purposes and authorities. If the function of such a council were to be entirely with NSF then the council could be made invaluable to the Board and its chairman, but that is quite different from the way the Bill has it. If the council is located in OSTP as I have suggested be considered than the chairman should clearly not be that proposed.

As I may have indicated, there are two possibilities that could avoid some of the entanglements I referred to. One would be to require the NSB to set up a continuous panel or council or a certain categorical composition with the requirement that annual reports from the panel or council be made to Congress and OSTP via NSB. This would allow NSB to add its own comments to the report and OSTP to do the same, thereby presenting Congress with a document independently designed but in which there is an analysis by NSB and OSTP.

Another possibility would be to have the council or panel simply be a function of OSTP. It could do this job by enlarging its own staff or by establishing panelists for the purpose.

Section 5. Responsibilities and Authorities of Council. This section is very comprehensive and in fact includes functions of quite different kinds. Analysis of current manpower data leading to policy recommendations along with systematic reviewing of the government's various programs in the area of scientific manpower, ought to have the highest priority. Coordination of the efforts of various departments is called for and as I have indicated, to the extent that this can be accomplished it is worth doing. Possibility of being effective depends a great deal upon the authority associated with the council and to that end locating it in OSTP seems preferable. The section also, however, calls for the operation of program activities to "encourage" general outcomes such as increasing opportunities for young people and increasing access for minorities and others. The goals are important but it is not clear how such a council could contribute in active ways to their assessment. Perhaps it is simply a matter of changing the language in a way that makes it clear that in considering the scientific manpower problem the council must deal with the important questions of human resources and how to reach those human resources that are being missed.

It may be that the Bill should put more emphasis on the coordination, review, and reporting functions than on programmatic activities. Even there care must be taken to see that the council is not charged with duplicating the efforts of the Science Manpower Commission, the Engineering Manpower Commission, the Science Resources Studies Division of NSF, or the National Science and Technology Policy, Organization, and Priorities Act of 1976.

Section 6. Establishment of Engineering and Science Manpower Fund. If the federal government is going to play its role in strengthening the system that produces our future scientists and engineers, than it is going to have to invest some funds. Currently the government's approach is mostly to award graduate fellowships. This is important but not nearly sufficient. Programs that can reach bypassed youngsters or that can help with counselling at the precollege level have to be in addition to our investment in graduate study as it now stands. But the Bill as it stands does lead to some confusion of roles by virtue of establishing the council as a policy formulating body on the one hand and as a grant giving concern on the other. While there should be a relationship between policy and funding, putting them together in this way really risks the possibility of creating an independent agency within an independent agency

One way of dealing with this might be to have the council or panel concern itself with policy and coordination and be located in OSTP. A fund might then be set up as a separate designated experimental program within the NSF. The council would then be free to oversee the NSF performance in the light of programs being conducted in other agencies.

The suggestions I have made should not be taken as criticisms of the thrust of H.R. 5254. They are intended to suggest that there are some areas of possible structural confusion and that there may be acceptable ways of strengthening the Bill.

Mr. SHAMANSKY. I thank you, Dr. Rutherford, for your testimony, and we will have questions subsequent to Dr. Zwoyer's testimony.

Dr. Zwoyer.

Dr. ZWOYER. Thank you, Mr. Chairman. I am very pleased to appear before you today to testify on various aspects of H.R. 5254. The American Association of Engineering Societies recognizes the need for such legislation which deals with the national engineering, technical, and scientific manpower, and we are pleased to be able to endorse this bill. The bill addresses the problem that we have long recognized, and you have long recognized, as being vital to the well-being of this Nation.

In our written testimony, we make a few suggestions that we hope will assist you in addressing this area, and we very much appreciate the opportunity to discuss with you some of these items.

First, I would like to address the scope and thrust of H.R. 5254. We see the task of the Council that it provides for, as being twofold. We consider of the highest priority the coordination of data collection and the analysis of that data to produce credible demand forecasts on an annual basis. This reliable data is urgently needed to facilitate the channeling of secondary school graduates into apprenticeship programs, engineering education, or science education. It is also needed to facilitate planning of facilities for vocational and academic technical education.

Second, we think the Council should produce an annual plan to identify the strategy by which it will recommend the allocation of resources available under this legislation in the following areas: support of engineering faculty income; replacement of laboratory teaching equipment in engineering schools; and support of school stipends to increase the participation of U.S. nationals in graduate engineering study.

The legislation provides that the Council assure an adequate supply of engineers and scientists. We think that this should be expanded to include the training requirements of technologists and technicians that work with and enhance the productive efforts of scientists and engineers. Here we are referring to the technician that usually receives 2 years of formal training and the technologist who receives a 4-year degree in some field of technology.

As far as an adequate supply of technical manpower is concerned, we suggest also that we need an appropriate supply. We want supply to equal demand. Senator Glenn spoke to the issue this morning; there is a danger of creating an oversupply.

In the written testimony, we point out the need for valid short-term demand forecasts for skilled technical manpower and the difficulties in obtaining this type of information. We need this information by subdisciplines within the engineering profession, and by geographical regions.

Regarding the funding, we recognize, and we know that you do, too, that the proposed funding of $50 million per year is not intended to solve all of the issues covered in the legislation: namely fellowships, laboratory teaching equipment, and teaching salaries. We have made some rough estimates that the solutions to the problems that are addressed by this legislation would require almost $1 billion in the first year, and about $500 million per year thereafter.

Just to update the equipment in our teaching laboratories would require an initial investment of about $500 million, and an annual maintenance expense of another $50 million thereafter. This is just for engineering schools; it does not include the requirements of our other scientific colleagues. We estimate that up to another $200 million per year is needed to improve engineering faculty salaries, and at least $40 million for graduate fellowships in engineering.

We all recognize that this is not a problem for the Federal Government alone; it is also the problem of State and local government and of industry and of academia, all of whom must work together.

With regard to the makeup of the Council, we have made some suggestions in the written testimony. We recognize that the practicing engineers and scientists will be affected by the actions of the Council. With this in mind, we have recommended that the membership of the Council must be carefully balanced to include representation from the professional engineering and scientific societies and from industry and from academia. We think that the Council should consist of both voting and nonvoting members, and that the voting members should have representation from our high technology industries, from our schools and universities.

I think that the voting members of the Council should represent the United States engineering societies and the United States scientific societies to assure that the needs of most of the engineering and scientific communities are met. We propose that the Council should include the president of the American Association for the Advancement of Science, and the chairman of the American Association of Engineering Societies. Their presence would assure all engineers and scientists, whether they are associated with large or small professional societies, of their representation on this very important body.

We have made other recommendations in the written testimony concerning the types of people that could be included as voting members.

With regard to the nonvoting members of the Council, we would suggest that the executive directors of the Scientific Manpower Commission and the Engineering Manpower Commission, as well as the director of the Science Resources Studies Division of the National Science Foundation, would be appropriate because of their knowledge and background in manpower requirements.

In summary, we feel that the Council established in H.R. 5254 will provide a useful function, in that it will develop and support a data base which will document shortages and surpluses of engineers and scientists by specialty and by geographical region. We feel that individual practicing technical persons should have representation in the Council through their professional and technical societies, and that the Council should be expanded to include the training requirements of technicians and technologists.

We feel that the funding for research, fellowships, laboratory equipment, salaries, and instrumentation demonstrates a recognition of the problems that exist in engineering education, but this funding must be supplemented to a very large extent by State and local government, academia and industry before the problem is solved.

Thank you, Mr. Chairman, for the opportunity to present our views.

[The prepared statement of Dr. Zwoyer follows:]

PREPARED TESTIMONY OF DR. EUGENE ZWOYER

Mr. Chairman and members of the Committee:

It is a pleasure to appear before you to testify on various aspects of H.R. 5254, the National Engineering and Manpower Act of 1982. My name is Eugene Zwoyer, I am president of the American Association of Engineering Societies (AAES), a federation comprised of 43 engineering organizations representing nearly one million engineers.

The AAES recognizes the need for such legislation as H.R. 5254, which deals with national engineering, technical and scientific manpower, and we endorse the bill in principle. We thank Congressman Fuqua, Congressman Walgren and this sub-committee for being sensitive to this situation. It is a problem we have long recognized and you have long recognized as being vital to the well being of this nation.

We have a few suggestions that we hope will assist you in addressing this area and we very much appreciate the opportunity to discuss with you some of these items.

First, we wish to address the scope and thrust of H.R. 5254. In its present format the bill establishes a Council whose goal is to assure an adequate supply of engineering and scientific manpower for the nation's needs.

We see the task of the Council as twofold:

Firstly, we consider the highest priority to be the coordination of data collection and analysis of data to produce credible demand forecasts on an annual basis.

Secondly, the Council should produce an annual plan to identify the strategy by which it will recommend the allocation of resources available under this legislation in the following areas: support of engineering faculty income; replacement of laboratory teaching equipment in engineering schools; and support of school stipends to increase the participation of U.S. nationals in graduate engineering study.

The Council is presently tasked to assure there is an "adequate" supply of engineers and scientists. This should be expanded to include the training requirements of skilled workers and technicians. We feel that the manpower requirements for skilled workers and technicians must be included in the Council's charter in order to improve the utilization of practicing engineers and scientists. We ask that the Council established in H.R. 5254 be tasked to assure that there is an appropriate supply of technical manpower.

We do not expect the Council to dictate the supply of technical manpower by controlling admissions to colleges and universities or by controling the entrance requirements to professions. Instead, we feel that the Council should act as a clearing house to make reliable data available to the public regarding the demand for technical manpower. This would be an important positive step which would be immediately useful to persons contemplating a technical career.

Further, this reliable data is urgently needed to facilitate the channeling of secondary school graduates into apprenticeship programs, engineering education or science education. It is also needed to facilitate planning of facilities for vocational and academic technical education.

Presently, there is no valid short-term (one-year) demand forecast for skilled technical manpower. Both the Scientific Manpower Commission associated with the AAAS and the Engineering Manpower Commission of the AAES are doing a good job of reporting on enrollment and graduation data. The Bureau of Labor Statistics performs a macro-demand forecast on a rolling ten-year basis which lacks sufficient definition of occupational as well as geographic requirements. We require data-gathering which has, on a voluntary basis, a sufficiently high participation by employers to be statistically significant, and has satisfactory detail in both occupations and geography. For instance, in engineering there may be a surplus of mechanical automotive engineers in Michigan and a shortage of aerospace engineers in California. There must be protection for this sensitive information using the force of law, in order to encourage voluntary participation without disclosing the source of the information. Judgment must be used in utilizing the information where the geographic requirement may readily point to a specific employer.

In addition, experience has shown that engineering employers cannot, or will not, make realistic disclosures of future needs. In part, this is because employers will not risk demoralizing their staff by revealing possible layoff plans. More importantly, the Federal government typically requires identification of current staff that will be applied to major procurements in aerospace and defense a year or more before work will begin. Since several companies are vying for the same contract, this results in stock-piling and redundant projections of manpower needs in excess of that which will actually be needed to staff the single contract.

Securing reliable forecast information will require satisfactory legal protection of sensitive employer information. Such data must be based upon the employer's realistic analysis of the effect of foreign competition, domestic competition and/or the probability of the employer receiving major contract awards.

The solutions to the problems addressed by this legislation have been estimated to require one billion dollars in the first year alone. We realise this is not a Federal Government problem alone, it is a problem of the state and local governments, of industry and of academia who must work together. What the Federal Government can do, and we hope will do, is provide meaningful data annually for one-year demand forecasts, and as is outlined in your bill, supply matching grants.

In line with the new Federalism, please note that some universities are already reallocating their resources to provide increased salaries to engineering faculties. Other universities are increasing tuition so that they can make their engineering faculty salaries more competitive with industrial salaries. Graduate study will become more attractive to U.S. students as faculty salaries become competitive with those of industry.

Engineering universities must emphasize the sound teaching of fundamentals. To do so it is necessary to maintain state-of-the-art teaching equipment to the extent possible. In areas of rapidly changing technology, equipment becomes obsolete in a short time making it difficult and expensive to maintain laboratory teaching equipment that is at the leading edge of the state-of-the-art. However, through cooperation with industry, such as summer work and industrial research by faculty, both students and faculty can stay abreast of some of the new, advanced equipment. In some fields industry must acquaint the new engineering graduate with the latest state-of-the-art equipment. Even so, maintaining adequate modern teaching equipment is a serious and expensive matter in our engineering and technology schools in the United States.

The Council established under this legislation will, through its actions, affect the practicing engineers and scientists. With this in mind we wish to submit to this sub-committee our suggestions as to the membership of the Council, which must be carefully balanced to reflect the professional engineering and scientific societies, industry and academia.

We recommend that the Council consist of both voting and non-voting (or ex-officio) members. The voting members should represent high-technology industries; our nation's vocational schools; our two-year technical training schools; and the nation's four-year colleges and universities having engineering and scientific degree programs.

Other voting members of the Council should represent the U.S. engineering societies and the U.S. scientific societies to assure that the needs of most of the engineering and scientific community are met. In addition, we propose that besides these professional society representatives, the Council include the President of the American Association for the Advancement of Science and the Chairman of the American Association of Engineering Societies. Their presence will assure all engineers and scientists, whether associated with a large or small professional society or an active or more passive professional society, of their representation on this most important body. We also feel the Council should include the Department of Defense Under Secretary for Research and Engineering.

Ex-offico (non-voting) members of the Council should include the Executive Directors of both the Engineering Manpower Commission and the Scientific Manpower Commission; as well as the Director of the Science Resources Studies Division of the National Science Foundation.

These advisors to the Council should also include the Commissioner of the Bureau of Labor Statistics, Department of Labor; the Administrator of the National Center of Education Statistics, Department of Education; the Assistant Secretary for Employment and Training Administration, Department of Labor; and the Assistant Secretary for Vocational and Adult Education, Department of Education.

In summary, we feel that the Council established in H.R. 5254 could provide a useful function in that it could develop and support a data base which would document shortages and surpluses of engineers and scientists by specialty and region. We feel that individual practicing technical persons should have representation in the Council through their professional and technical societies, and that the Council should be expanded to include the training requirements of skilled workers and technicians. We feel that the funding for research, fellowships, capital equipment, salaries, and instrumentation demonstrates a recognition of the problems that exist in engineering education, but that this funding must be supplemented, to a very large extent, by state and local government, academia, and industry before the problem is solved.

As President of the American Association of Engineering Societies, I wish to give credit to work performed in connection with the H.R. 5254 by the Engineering Affairs Council of AAES and several of AAES's constituent societies, especially the IEEE Manpower Task Force.

Mr. Chairman, thank you for the opportunity to present our views to the sub-committee. I will gladly answer any questions which you, or the members of this sub-committee, may have.

Mr. SHAMANSKY. Thank you very much, Dr. Zwoyer, for your testimony.

If I may, I would like to call upon myself, since I seem to be the only member here at the moment. I hope you are aware of the very nature of this work, we have multiple committee meetings. I have already appeared at my other committee as the phantom Congressman. We show up, and then you run back here.

Dr. Rutherford, you did raise, according to my notes, some very important points that I think this bill does begin to address. First of all, the idea that this country has a lot of policies from the various entities involved in the general field, but we don't have a national policy collectively. This raises the question: Do you think that our type of society can have a national policy, and should it have a national policy?

Dr. RUTHERFORD. I believe we can have a policy. In some sense, we always have a policy. It may be that the Federal Government should not engage in certain activities but let others take care of. I think we can.

What probably will not work in our kind of society is a rigid policy based upon trying to control the numbers of this or that that are produced across the Nation. But a policy that frames national goals and purposes clearly, makes clear what the national interest is, and says, for example, that the Federal Government will work with States and the private sector in the following ways, is a form of policy that says that the Federal Government, because it runs institutions and organizations that have their own enormous demand for certain kinds of technical and engineering manpower, will make what investment is necessary to retain the capacity to produce those as needed.

What I am trying to say is I think one can frame in the American context a policy that addresses a national need without imagining it to be the 5-year plan that regulates everybody's life, which no one wants.

Mr. SHAMANSKY. I wrote here as you were using these words "rational" and "coherent." I think they are marvelous words. I try to be a rationalist myself. It is very difficult sometimes. But I love your spirit in approaching the thing.

With respect to the fluctuations in financing which in our system, it seems to me, is inherent, do you see that the Council could help avoid such fluctuations?

Dr. RUTHERFORD. No. It could dampen them. It could cut out the highs and lows in some way. But we are still going to have our ups and downs. That is all right. We are a resilient Nation and we are a mobile people, so we move around where the opportunities are. Still, we shouldn't have such extremes, and I think that there are policies that could do some of that—particularly by having better data for all of us to see, whatever the arrangements are.

Mr. SHAMANSKY. I would like both of you gentlemen to respond to this, assuming you have an opinion: Where should the Council focus its attention? Frankly, I thought a valid point was made about children, literally children. Joan Gance Cooney came before this committee last year and pointed out—she was talking about one of her programs, I think it is "three, two, one, contact," that unless we attract children at 8- to 12-year-old ages, they are not going to take the necessary courses in high school that will even permit them to take the courses in college. You have got to plan ahead.

Do you think emphasis should be placed early on, high school? You know, there is the precollege classification, undergraduate, graduate, all or none of the above.

Dr. RUTHERFORD. Perhaps we each have an answer that may be different. We are talking about people who start at birth and go through a long process. And to believe that there is some one point at which we can inject ourselves into that system and make much of a difference, it seems to me is wrong headed in the first place.

Like it or not, we have to deal at a variety of levels, maybe with different intensities. If we have to choose a place to put emphasis, special emphasis, it should be in the years of adolescence, grades 6, 7, 8, and 9. We are losing the battle right then and there. The kids won't take any more math, they won't take science, and then all the rest of it falls away and we are into expensive programs trying to attract people with money or something when the pool has shrunken.

We also are losing our girls to science at that age, and we are losing the minorities.

Mr. SHAMANSKY. Dr. Zwoyer?

Dr. ZWOYER. Well, education should be a lifelong experience, I think. That is becoming more and more recognized all of the time. Undoubtedly, emphasis needs to be placed on our counseling and guidance at the elementary and secondary levels. And there are some attempts at this by bringing the young people into what we have called summer camps that are being offered at various universities across the country. The instruction at these camps merely acquaint them with what science and engineering is all about, with the hope that they might decide to enter that kind of education.

Mr. SHAMANSKY. Dr. Zwoyer, if I might interject the observation that those camps you are talking about have been zeroed out, as we say around here, as to the Federal participation. I hate to be the one to bring that to your attention. It is an administration idea, not ours.

Dr. ZWOYER. The private sector has continued to support them in a very, very small way.

Mr. SHAMANSKY. In a small way. How about in an adequate way?

Dr. ZWOYER. It is inadequate.

Mr. SHAMANSKY. OK.

Dr. ZWOYER. Associations don't have enough money—we haven't found enough money to do it adequately. But I think that is an important part of the education system and one that should be emphasized because, if we lose them at that age, we are not going to have them later on.

Mr. SHAMANSKY. Dr. Rutherford and Dr. Zwoyer, what degree of awareness is there on the part of your colleagues—and I just don't mean in your particular organizations, but in the whole scientific and engineering field—as to what is happening with respect to the young people's interest in here. We get the figures all the time with the percentage of the Japanese and Russian and Western European children who get multiple math courses, mathematic relat-

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ed courses, and those lines are significantly going up at a very high level, and ours are going down.

Dr. RUTHERFORD. Gradually the community of scientists and engineers is beginning to be aware of this. For a long time, it was easy in the scientific world to believe that the problems were due to the schools being inadequate or to teachers' disinterest. I think many of them now are becoming alarmed and looking at it and seeing it as a very difficult and complicated problem.

But we still have a long way to go. It is surprising how few people understand how little science and mathematics is required of an American student today. I visited recently a State that I regard as the State having one of the grandest histories in America, Minnesota, and discovered, to my shock, that one can graduate from that State, as far as the State is concerned—they make up the rules—with no high school science. None is required.

Mr. SHAMANSKY. Is that a recent thing, or is that historically the case?

Dr. RUTHERFORD. I don't know. I happened to be there just by accident on a day when the State legislature was voting on whether or not to increase the junior high school science requirement—in the 3 years of junior high school—from three semesters to four. That was voted down by the legislature, for some reasons that escape me.

But the point I want to make is that there is beginning to be an understanding among scientists and engineers, in the larger community, that in this Nation we are simply failing to ask enough of our children, to make clear to them why they need to study science, and to get their parents to understand.

Mr. SHAMANSKY. Let me ask you a question. Now we are talking, and I think properly, about asking enough of our children. Are we asking enough of the end users of the people that we believe should be trained, mainly the laboratories, private and public and nonprofit, mainly the corporations and the universities, and so on, and so forth? I don't hear their voice. I am beginning to hear something from you. I thought it was very reassuring that Dr. David was here. I worry a little bit that he wasn't quite sure whether the numbers were OK. What is the private sector doing here? They are the ones who need the personnel.

Dr. RUTHERFORD. They need the personnel. If industry can do something in education, it is easy to do it in the realm of graduate education, maybe undergraduate, providing instrumentation, providing chairs, providing research money. That they know how to do.

However, dealing with elementary and secondary education is a much more complex matter. It isn't certain at all in my mind what role, if any, American private enterprise should have in the American public schools. Public education in America is a public matter.

Mr. SHAMANSKY. That is not my question. I am asking if there is an awareness on their part that they, as they look into the job market, that they are looking at a 12-year pipeline.

Dr. RUTHERFORD. Right.

Mr. SHAMANSKY. Do you mean to say they are only looking at the end of the pipe and not looking as to what goes in at the beginning? That is beyond their imagination?

Dr. RUTHERFORD. My sample isn't very good. Perhaps you had better——

Dr. ZWOYER. Mr. Chairman, I think that at the present time, there probably is an adequate supply of engineers, and certainly an adequate supply of scientists.

There is a shortage of graduate students in the pipeline, and there is a shortage of engineering faculty. There are vacancies across the country on engineering faculties. Because of the shortage of engineering faculties and other reasons, the enrollment at the engineering schools is beginning to be limited. If we don't produce enough Ph. D.'s to enter the teaching market, there will be further curtailments and, somewhere down the line, we probably will have a shortage of engineers. At the present time, overall, I would say there is not a shortage of engineers entering the job market.

We made a survey not long ago, having written to 240 chief executive officers of large industries, and asked them what they thought were the kinds of things that the engineering profession should be doing jointly with industry. The largest single reply that we received was to do something about the crisis in engineering education. So I think they are aware—I know they are aware of what could happen.

As far as I know, none of us has defined just exactly what role industry should play, just exactly what role the Federal Government should play, just exactly what role the State and local governments would play.

Mr. SHAMANSKY. Of course, this bill would have to address that.

Dr. ZWOYER. That is right. The Council could probably define that.

Mr. SHAMANSKY. If I may, I invite some questions from the distinguished minority counsel.

Mr. RHEEM. Thank you, Mr. Chairman.

I would like to follow up on the question of what role the Federal Government has, if any, to get local school districts and school boards to increase science curriculum requirements? I know the National Science Foundation has done some good work in curriculum development. We can now provide the school districts with good science curriculum and other science and math related materials.

How do you raise the consciousness of the parent teachers associations, et cetera, to increase science standards? What kinds of things are being done; what kinds of things can we do?

Dr. RUTHERFORD. I am not sure what the Federal Government can do to really influence the local school board. That is pretty distant, and that is the realm at which it becomes stickiest in the Federal-local relationship. One must be very careful.

There are things to be done, however. Let me mention one because I know about it. Our own association is working now with the National School Boards Association to see, in the case of mathematics, if we can find resources to produce a film and a workshop kit so that during the next academic year in each of the 50 States at the meeting of the school boards associations—which is very well attended, I understand—there will be a half-day workshop on the mathematics situation in the schools, directed and designed to catch the attention and understanding of school board members. That is an example of where the scientific societies, working together with the school boards, can help build some sort of understanding.

Your reference to the curriculum is very well taken. In spite of what happened in 1968 and 1969, the fact is that this Nation invented a new way of producing scientific course and mathematics courses, and it is copied all over the world. But we did only half the job. Those courses that were created are still not as widely used as they should be, for a variety of reasons. But we never really did get around to the job of creating new programs for all those other youngsters who don't ordinarily elect science at all. They are citizens, they are workers, and they have been neglected.

So the schools would pay more attention, in my judgment, to the need to upgrade science and mathematics if they were being provided with some well thought out and developed options relating to the scientific-mathematical instructions of reluctant students. And I think only the Federal Government is likely to do that, but it hasn't shown much inclination in recent years.

Dr. ZWOYER. Well, I agree with Dr. Rutherford's comments. But also one of the big problems is the shortage of highly qualified teachers at the secondary level in the field of mathematics. We need to get more people entering that profession. I assume it has something to do with salaries that are offered, and some of the ideas expressed by Dr. Rutherford could influence the school boards to develop a salary program that would attract people into the teaching of mathematics. It might be that there would have to be a differential salary, such as we have suggested, at the college level, where it is necessary to pay higher salaries for engineering faculty than for other sectors within the university.

Mr. RHEEM. The difficulty I see is that we have two parallel efforts or needs that are occurring: one is the need you just mentioned of more teachers, including the retention of teachers, that can provide the proper classroom setting for the students; and on the other hand, we need the parallel effort of school districts requiring additional science courses. All of the data, especially that which Senator Glenn presented to us this morning and other data previously presented before this committee, indicates a slipping in terms of the science and math requirements of school districts all across the United States. But nothing in this bill, or in the work that this committee has been involved with to date, involves getting school districts to increase those requirements.

I am just trying to get a handle on this. Is it our fault we are not entering that area, or is that someone else's job and, if so, whose, and who is doing it?

Dr. RUTHERFORD. The constitutional authority resides with the States and the States, in turn, generally dole it out to the local school boards. Because that is so, it is hard for the Federal Government to deal with it, except by preaching. The practical ways to get there are indirectly to influence school boards. One is by the introduction of new kinds of curricula.

Let me suggest another. School board members—the ones I have talked to—are aware of the need because it is painful when they have to assign unprepared teachers to teach science or mathematics. When the pressure is on them, the real pressure, the board and the superintendent would rather assign, say, a history teacher to a chemistry class than to fire that history teacher. On the other hand, if that is going to be done in some places because there is not an adequate supply, for whatever reasons, then, it seems to me, there ought to be a mechanism to provide resources to school districts to enable a misassigned teacher to get up to date in the field by being retrained, but that the Federal investment help for that purpose comes with the understanding that that school district, as a consequence, will have graduation requirements that make it sensible to have such teachers.

There are some ways, short of telling school boards what they ought to have as graduation requirements, that could make upgrading them attractive.

I should also point out that the universities and colleges of the land are culpable. Schools pay a lot of attention to admission requirements of the nearby colleges and universities. The kids are pretty clever these days. Grade point average is what counts. They will avoid fourth-year math and physics in order not to get a low grade if the college they want to enter doesn't require those courses. Our colleges and universities ought to once again say, "Our place provides the kind of education that, in order to learn from us, you must come in with certain kinds of knowledge."

Mr. RHEEM. Are they likely to upgrade those requirements at a time when the student population is declining?

Dr. RUTHERFORD. There is a little bit of it going on. Some of the clever ones have found that, in the competition, the higher standards help rather than hinder. The public universities, particularly in cities, have a special problem. But there are ways, even there, for admission with lesser requirements, but withholding credit until deficits are made up.

If colleges and universities will raise their standards and some of their faculty members will work with nearby school districts in raising the school standards, part of the cost could be defrayed by a Federal program.

Mr. RHEEM. Thank you.

Thank you, Mr. Chairman.

Mr. SHAMANSKY. Thank you.

I think we must be aware of the reality of our present system of operating our government, certainly the executive branch, namely the role that the Office of Management and Budget has assumed. It has almost become what I might refer to in the military sense as a "chief of staff organization"; regardless of what the departments are doing, it seems that they have a veto over almost everything.

I have expressed previously my belief that the Office of Management and Budget, looking at the size of the deficits, simply makes cuts without regard to what the consequences are. They feel that they don't have any leeway.

The difficulty there is that it OMB then hides behind a mask of so-called executive privilege because they set the policy, and then they say that you can't ask us how we did that. That is a classic catch 22 brought up to date.

Perhaps they should be placed on the Council and be required to answer to the Congress for their decisions because, in effect, when I find Dr. Slaughter testifying with respect to the needs of the National Science Foundation, I have no doubt in my mind that he is responding to the constraints placed upon him by the numbers he is given by the administration, and that gets back to, in this case, the OMB.

In your testimony, Dr. Rutherford, you did refer to the question of financing and getting that number factor in there. Would you comment on the need of establishing just where the money comes from and how much and the people who have that responsibility?

Dr. RUTHERFORD. From my own personal experience, I understand just what you are saying about the incredible and increasing power of OMB. It is not BOB anymore. The "M" looms very large in that OMB is able to make decisions that the other agencies are bound to, and they go into a very deep level of the enterprise. If it were a matter, for example, in the case of NSF, of simply saying to the Foundation, "Here is your bottom number. You set your priorities"——

Mr. SHAMANSKY. But they don't do it that way.

Dr. RUTHERFORD [continuing].—that would be all right. But that is not the way it is done any longer.

Mr. SHAMANSKY. They prescribe the various areas which, it seems to me, is well beyond their financial expertise, and gets into a matter of theory as to what the country should be.

Dr. RUTHERFORD. But I must say that under recent administrations, including the last one, the power increased. For example, OMB was given authority over forms and data collection. Now you can't send out and collect data anymore for any program without their approval, which means if they are not likely to like the data, they can simply stop its collection.

Mr. SHAMANSKY. I am glad you made the point that it is not strictly a matter of bureaucracy under this administration. I think that is a fair comment. I am talking about the role in general of that particular organ of government.

Dr. RUTHERFORD. How to deal with it is a reality. It is like the gravitational constant for the moment. There it is. How does one cope?

I hadn't thought about your idea. It is certainly worth thinking about that the Council would have the required presence of a senior officer of OMB, who would then be in a position to have to discuss reasons for budgetary decisions. Whereas currently the public can argue with Congress and can argue with agencies, it cannot make opinions known to OMB, for better or for worse——

Mr. SHAMANSKY. They don't let us know what they have in mind until they derail the train.

Dr. RUTHERFORD. That might be a way of beginning to open up dialog between such an important agency and the others.

Mr. SHAMANSKY. Before we conclude your particular testimony, I want to make one thing clear: I have persistently been trying to evoke testimony as to the necessity of a role of the Federal Government, if that is what the witnesses believe. I don't want that to be misconstrued, however, to my believing that the Federal Government is the answer. I really don't. I just don't want to pretend that there is no role for the Federal Government.

What really scares me is the fact that the private sector has been so ineffective in formulating and then articulating the problem. The Congress is only going to respond, it seems to me, to the public. If those groups who are most affected directly and, it seems to me, that is the end users of the educational product, the engineers and scientists, as long as they go their merry way and we don't hear from them, there is no basis for a role of the Federal Government. We have an assisting and coordinating and a cooperating leadership. But if there is no felt need on the part of the public, then the Federal Government, I don't think, can, just in the nature of our system—and I accept that—make up the difference.

Dr. RUTHERFORD. One of the things that the AAAS and some of the other scientific and engineering societies are exploring now is how to help scientists and engineers become better citizens, not only at the Federal level, but at the local level. If you go to school board meetings, you rarely find scientists and engineers either on the board or in attendance. They are displeased with the quality of the decisions made by the boards, but they themselves won't participate in the numbers they ought to.

Mr. SHAMANSKY. Is it that they don't want to get their hands dirty?

Dr. RUTHERFORD. They just don't think of it much. They are very busy people, and it hasn't occurred to them.

Mr. SHAMANSKY. Why not?

Dr. RUTHERFORD. One reason is that the societies haven't helped educate them enough. Their own education, incidentally, is all too often narrow and not sufficiently based upon an understanding of the history and the structure of their own culture. Just as there is a deficiency in the scientific training of most people, among many scientists and engineers there is the reverse problem. But our society should feel responsible for the continuing education of its members, including their need to participate in the only system we have, which is a political, open, participatory one. But people have to participate or nothing else happens.

There is a better and better response. I am finding that the scientists and engineers are beginning to say, "Yes, how do we go about this?"

Mr. SHAMANSKY. I want to encourage you in those efforts. Dr. Rutherford and Dr. Zwoyer, thank you for your testimony.

Dr. RUTHERFORD. Thank you.

Dr. ZWOYER. Thank you.

Mr. SHAMANSKY. Our next witness—and his presence has already been acknowledged by Chairman Fuqua—is Dr. Delbert Tesar. Dr. Tesar is professor of mechanical engineering and director of the Center for Intelligent Machines and Robotics. I love that name. I would like to meet an unintelligent machine.

STATEMENT OF DELBERT TESAR, PROFESSOR OF MECHANICAL ENGINEERING AND DIRECTOR OF THE CENTER FOR INTELLIGENT MACHINES AND ROBOTICS, UNIVERSITY OF FLORIDA

Dr. TESAR. I appreciate your comments.

I am very pleased to again be before this committee to discuss some of the issues having to do with innovation and our ability to respond to some of the economic realities that we face, as well as some of the threats we face from outside. The fact is, I think my testimony will try to look at that larger envelope, and then look at the particulars to respond to that.

First of all, I would like to indicate that I am a teacher. I have been involved in teaching engineering and research for about 25 years. As you have mentioned, I am the director of a center dealing with robotics, which is a leading edge technology. But I must mention that this technology grows out of a very old technology. The existence of machines has been available for hundreds or thousands of years.

I have also been involved in assessment activities, not only economic assessment and technical assessment, but also assessment, for example, in nuclear reactor maintenance, questions dealing with this sort of thing. I also strive to establish university-industry cooperation. I constantly interact with people from industry and I try to integrate their priorities into my views.

Finally, I would like to say that I have traveled extensively in Europe, behind the Iron Curtain, in each of those countries.

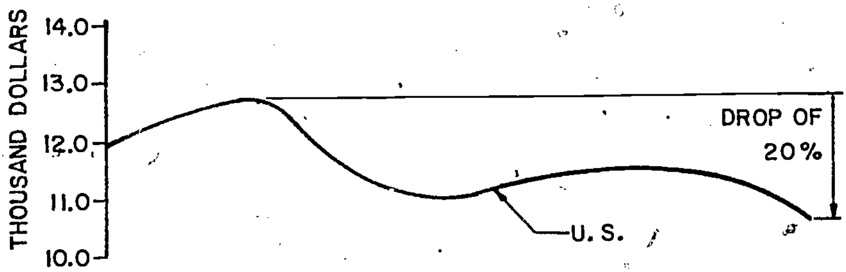
My testimony will essentially show few contradictions from those that have been presented before me today. There is some variance with regard to what I would like to suggest needs to be done. There certainly is some emphasis that I would like to change.

I would like to compliment you, Mr. Shamansky, with regard to your awareness of the details of this problem. I believe that you are conscious of the problem that we face, the realities that we face, in manpower. I would like to say that I also agree with your sense of urgency. I think there is a serious problem facing this country and, because it takes so long to correct our present condition, the urgency is much higher than if we could turn the spigot and have a response.

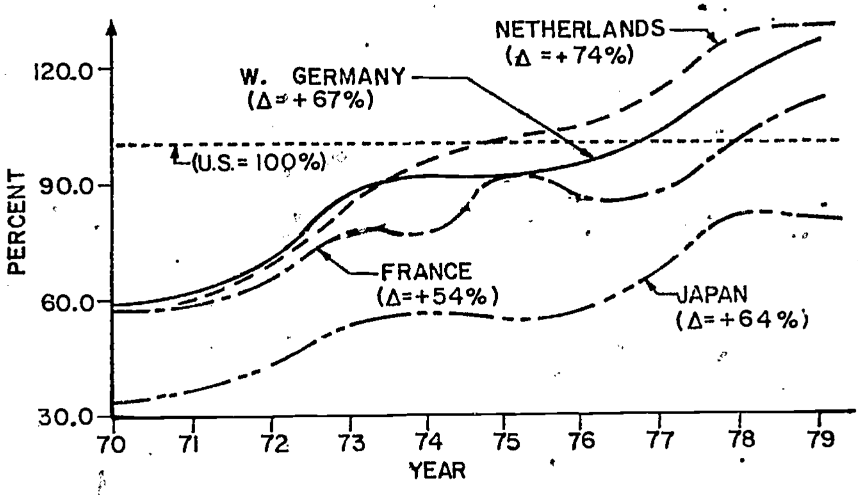
So, if I might begin my testimony in terms of some documented slides, I think it will make my communication with you much more efficient.

What I would like to do with this few minutes is to give you some background as to why there is this problem that we face.

GROSS DOMESTIC PRODUCT
PER EMPLOYED PERSONS
RELATIVE TO U.S., 1970-1979



RELATIVE TO U.S.:

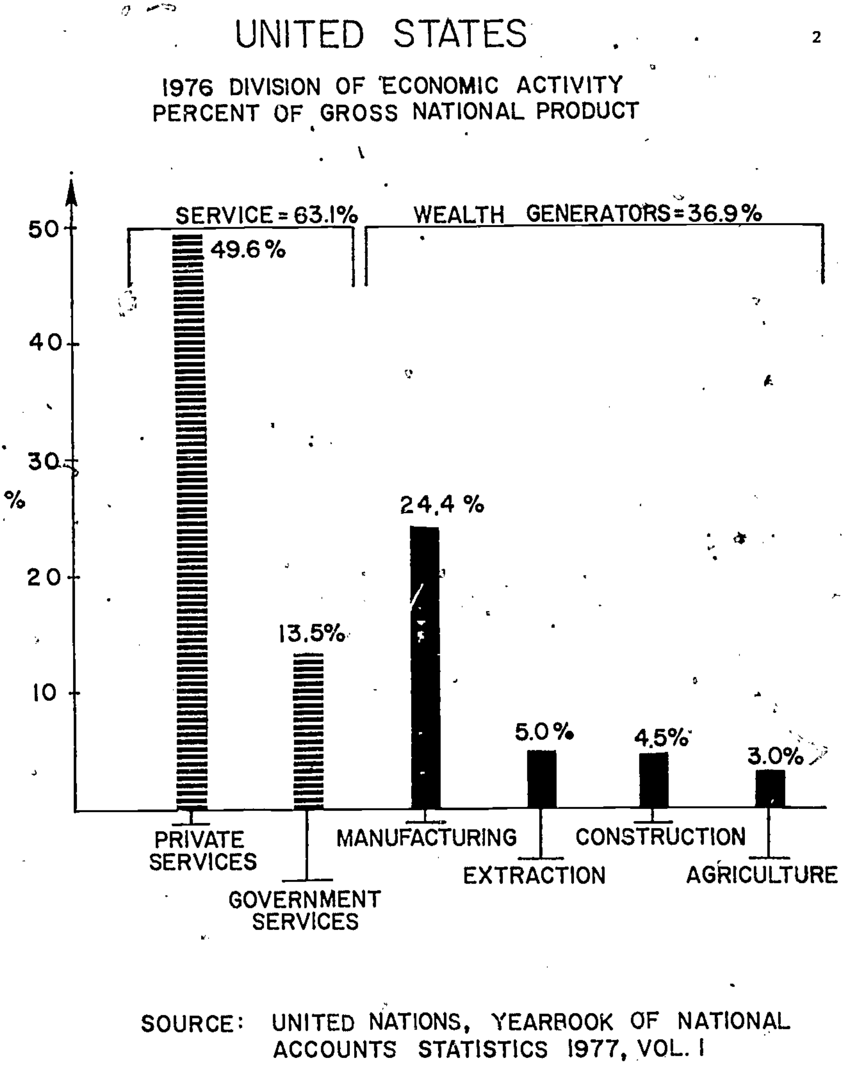


SOURCE: ART NEEF
OFFICE OF PRODUCTIVITY AND TECHNOLOGY
SEPT., 1980

SLIDE 1

Dr. TESAR. The first slide [slide 1] that you see indicates that we have lost over the last 10 years about 20 percent of our take-home pay in this country per worker. That is a crucial issue, because it means our wealth has diminished. It also means our ability to integrate our society and make it more homogenous as opposed to heterogeneous is weakened. Our rising expectations are not being satisfied.

But if you look at our competing nations, you will see that many of our competing nations are doing much better in this particular indicator than we are. In fact, they have had growth (relative to the United States) up to 75 percent in their take-home pay per worker in the last decade. This is indicative of our competition.



SLIDE 2

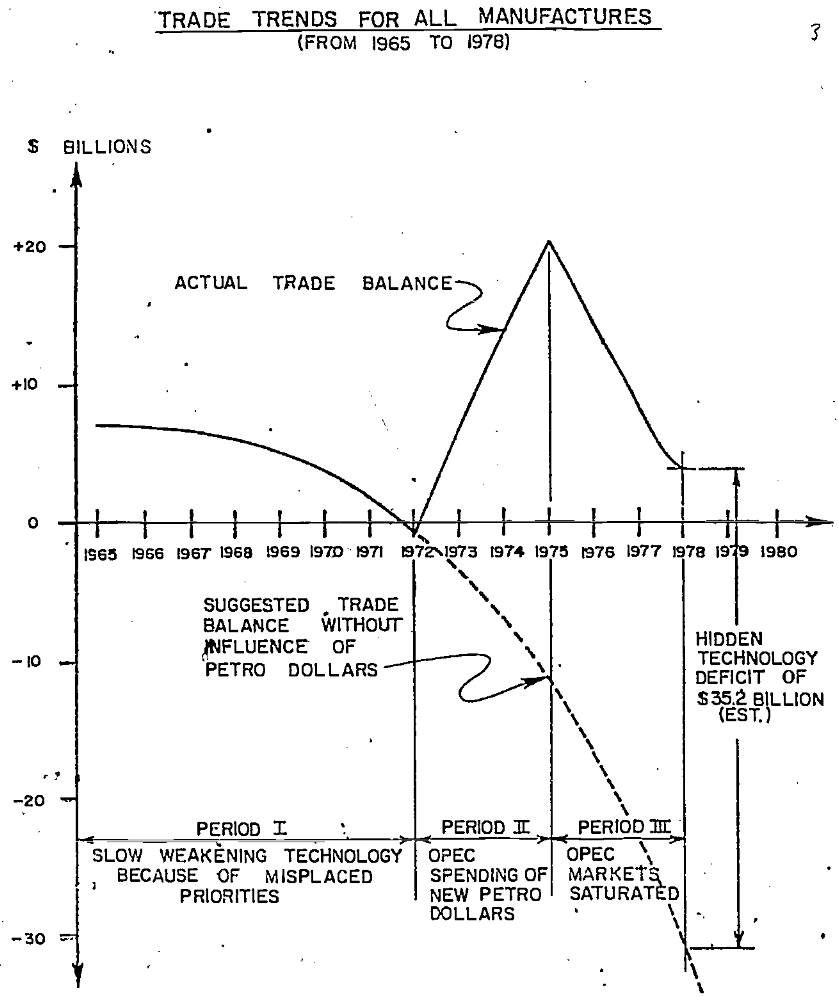
Dr. TESAR. In addition, I think it is also necessary to see the sense of priorities, how the economic realities, for the United States are divided up. [slide 2]

First of all, private service in this country represents about 50 percent of our gross national product, government services represents about 13 percent, and those are the service realities that help us have a better standard of life and organize ourselves to respond to threats from outside.

But the generation of wealth is the undergirding of the United States. Its economic well-being is associated with the generation of wealth. There are four primary components:

Manufacturing is 24.4 percent of our gross national product, and dominates all the other wealth generators; extraction is only 5 percent, everything that comes out of the ground, oil, gas, minerals, everything, is only 5 percent; construction is 4.5 percent; and agriculture is 3 percent.

This should give you an idea of the relative balance of priorities we need at the national level for policy. Policy should be in proportion to these economic realities.

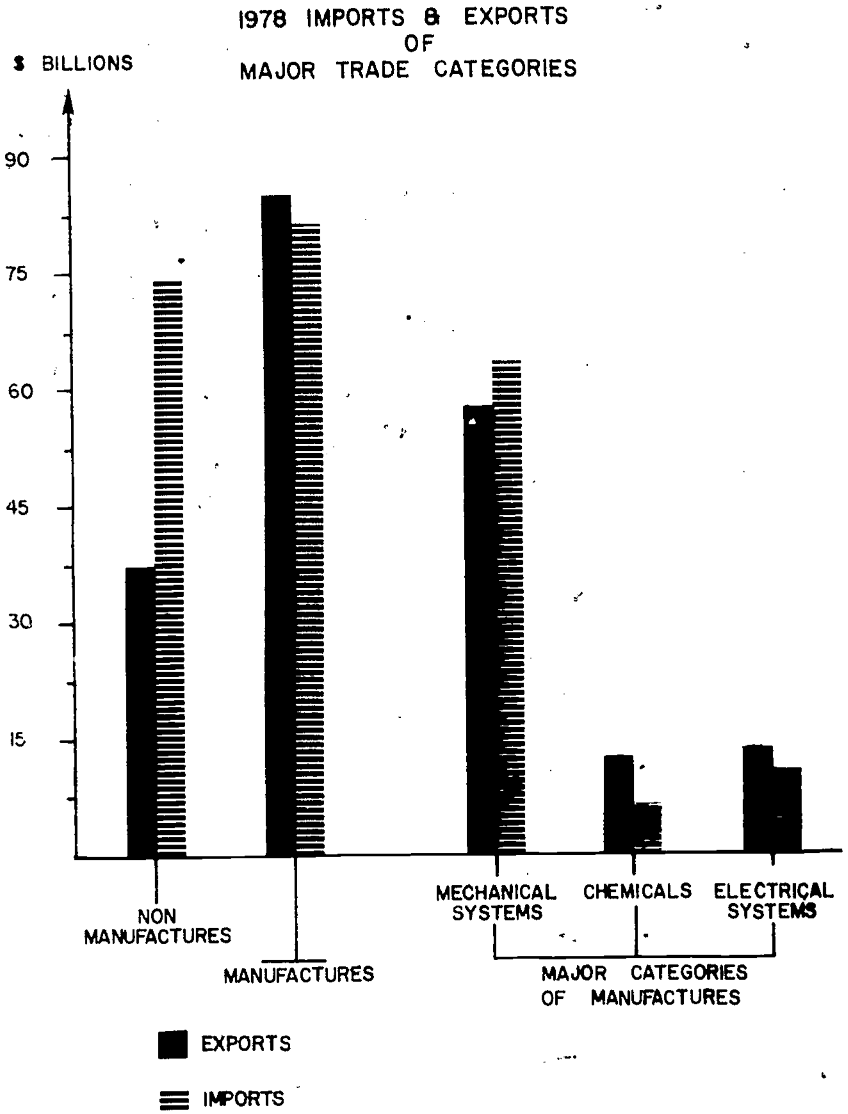


SLIDE 3

Dr. TESAR. If you wish to look at our trade as an indicator of our difficulty [slide 3], you can see that, over the last 15 years, we have had an undulation in our trade balance in manufactures. Manufactures is greatly related to our ability to generate wealth.

You can see that, in 1972, we had a slight loss in our total trade in manufactures, we had about a $20 billion shock due to the infusion of OPEC dollars back into this country. This has been going down since 1975 for various reasons. There was a worldwide recession in 1975 when the OPEC countries decided not to send their money here to buy large technological items.

But if you had not had that shock, then the suggestion is that the fundamental continuum of the U.S. economy, as far as technology is concerned, would have gone on down. We cannot completely confirm that, but that is something that we need to be aware of, that there is an implicit difficulty greater than the simple numbers themselves represent.

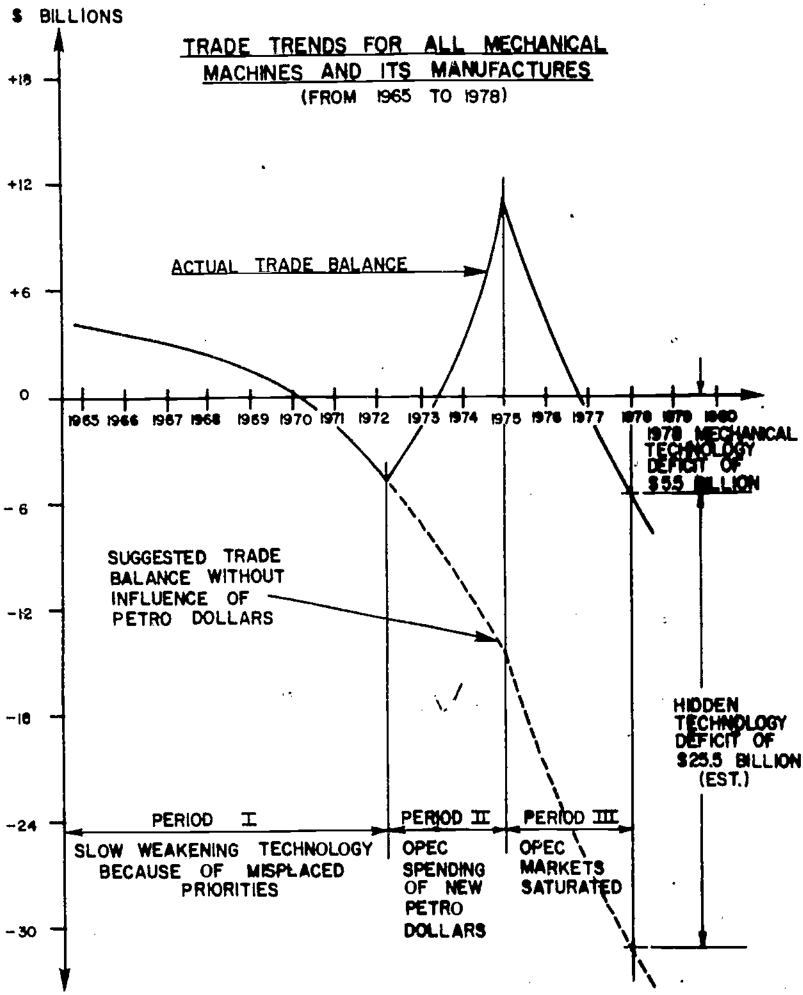

1978 IMPORTS & EXPORTS
OF
MAJOR TRADE CATEGORIES
$ BILLIONS
90
75
60
45
30
15
NON
MANUFACTURES
MANUFACTURES
MECHANICAL
SYSTEMS
CHEMICALS
ELECTRICAL
SYSTEMS
MAJOR CATEGORIES
OF MANUFACTURES
EXPORTS
IMPORTS

SLIDE 4

Dr. TESAR. Now, if you look at manufacturing [slide 4], you will see that manufacturing competes very well in total dollars with nonmanufactures in trade. In our nonmanufactures represents about 40 percent of our trade, and manufacturing represents about 60 percent. Our manufacturing trade is marginal, and our nonmanufacturing trade loses about $40 billion per year. In our nonmanufacturing trade we know there are certain things that are very obvious, like oil, which exhibits a $40 billion loss. But there are also things like $5 billion worth of coffee, which we continue to buy all the time. We have to find some way to compensate for that.

Now, the Japanese have figured that out a long time ago. They knew they had to do this in terms of manufacturing. We have not quite bought that sense of urgency. We have got the luxury of choice, and we seem not to respond to this pressure.

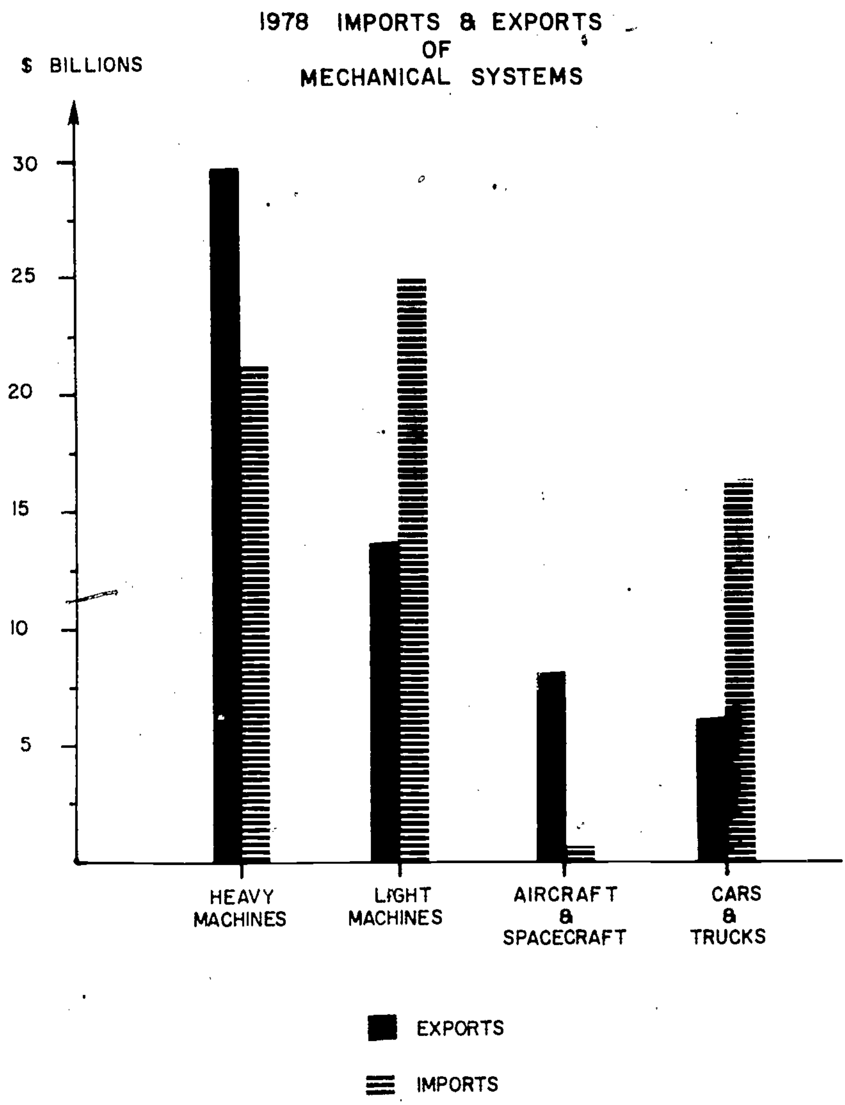
But if you look at the manufacturing area, you will see that there are three primary components in manufacturing: mechanical, chemicals, and electricals. When it comes to magnitude, the mechanicals are 75 percent—in fact, up to 85 percent of the problem. So if you are going to target, you need to target the ability to make things, to be able to make sewing machines, cameras, shoes, textiles, and what have you. A balanced policy has to be target in proportion to the magnitude to these realities.



SLIDE 5

Dr. TESAR. Now, if you look at the mechanicals' trade over the last 15 years [slide 5], you will see, again, that by 1965, the trade was already degrading, it was already on the downturn. By 1972, it showed a $3 billion to $5 billion deficit, it had a $14 billion positive shock, and on the way down as of 1978 and 1980.

So we do see that the mechanicals are a dominant part of our trade, that they are sensitive to outside infusion of dollars, and that they are not, by any means, strong.



SLIDE 6

Dr. TESAR. Now, if you look at the field of mechanicals [slide 6], you can break it up into four primary parts: Heavy machinery is one of the best protected technologies in this country; light machinery is one of the worst protected technologies. The ultimate light machine is a robot. Aircraft is also one of the best protected technologies. We have gained—as I have been told recently in the newspapers—that we gained now a $30 billion surplus in military hardware sales. I think that is a big positive, but it does not show up in this particular presentation. Cars and trucks, however, is a disaster. I believe this year we are going to lose about $20 billion in

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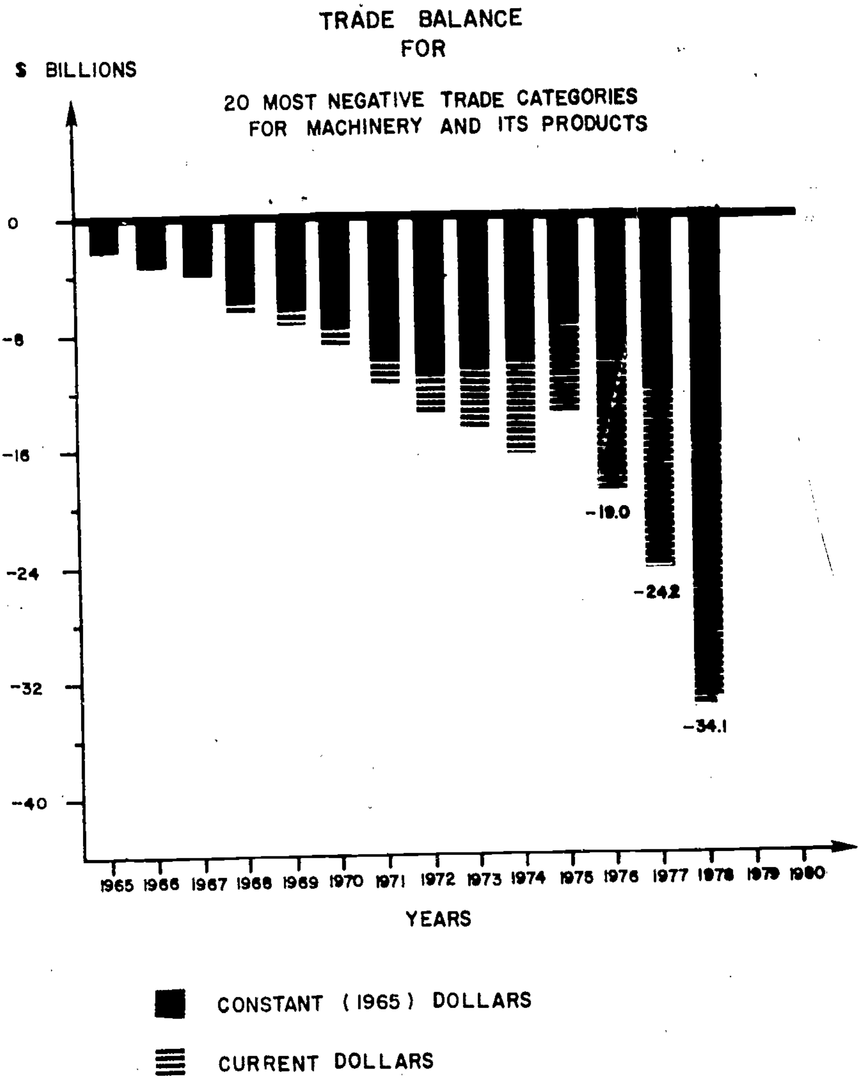
the trade of automobiles, and that is pure manufacturing technology. It is an industry that we could not possibly afford to not target as a major initiative in this country, and we have failed to do that.

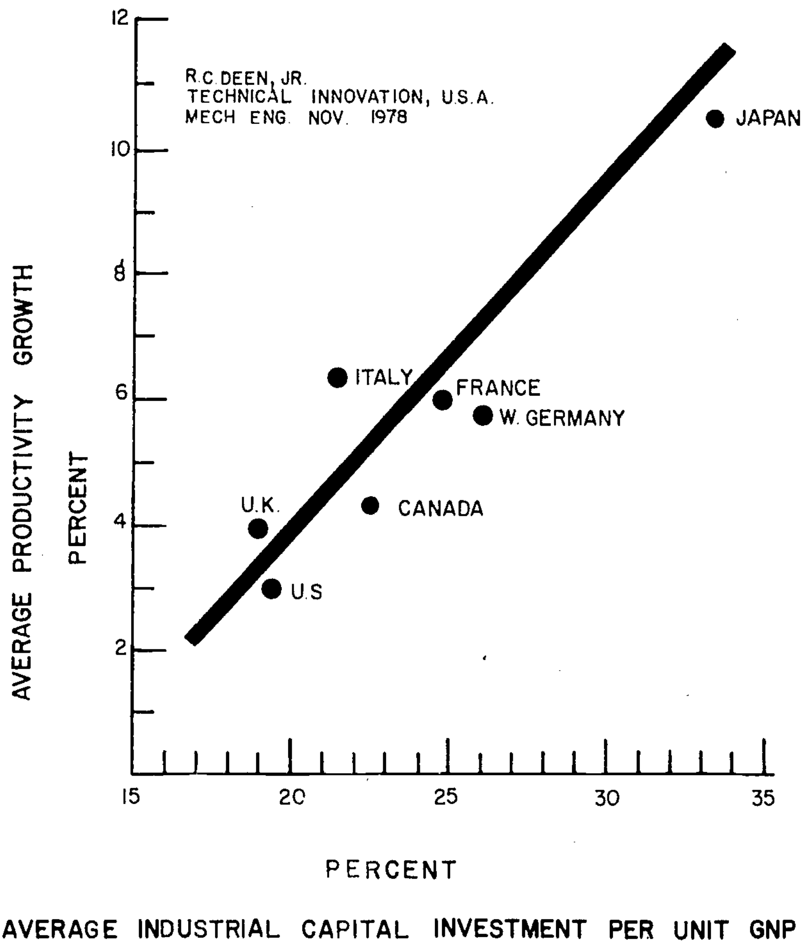


SLIDE 7

Dr. TESAR. If we look at the aggregate of 20 of the worst trade categories in mechanicals [slide 7] take the 20 worst trade categories and put them together and look at the history of this over the last 15 years, you will see that we have lost $35 billion in 1978 in this category, and it is on the way down. So the aggregate of mechanical technology in manufacturing is not being protected, and there is no resistance. In other words, it is going down rapidly.

So if you are going to ask for a turn-around, it is going to take years and years to get the people on board and get the organizations structured and get a lot more vitality than we have right now.

CORRELATION BETWEEN PRODUCTIVITY GROWTH AND INDUSTRIAL CAPITAL INVESTMENT (1960 — 1973)



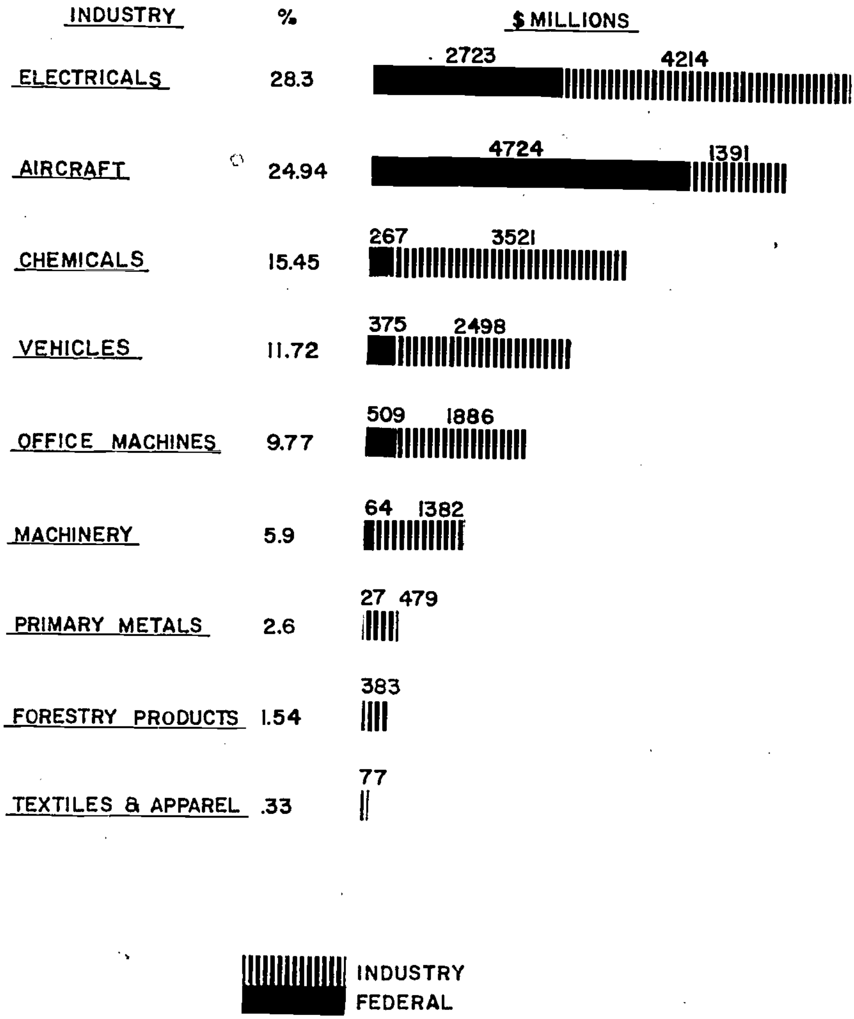
SLIDE 8

Dr. TESAR. In addition, the question always comes up: Is there a response to technology [slide 8]? If you invest in technology, plants, equipment, people, R. & D., the whole question is: Is there a response to that particular investment?

Well, if you look at our competing nations, there is a perfect response correlation. For example, the Japanese over the last 15 or 20 years have an 8 to 10 percent productivity growth, and they have been investing at a rate of about 30 percent of their output back into the system to keep it alive. We have been investing at a much lower rate and, of course, we have a much lower productivity. In fact, we are lowest of this whole spectrum of competing nations.

So, without a doubt, if you don't have policy, you are not going to have a cohesive investment strategy and you are not going to have a response appropriate to the need.

FUNDS FOR TOTAL R & D FOR MANUFACTURERS
BY INDUSTRY AND SOURCE 1976



FROM: (NSF 78-314) R & D IN INDUSTRY

SLIDE 9

Dr. TESAR. Let us look at the R. & D. at the national level [slide 9]. First of all, it is very important to see where our money is going. How do you feed the system so it responds the way it does? It turns out that the electricals have about 28 percent of the Nation's R. & D., both Federal and industrial. Of that, 40 percent of it comes directly from the Federal Government, and that is policy.

Where you put your money is where the policy is. Without a doubt, we have a policy to protect electrical technical technologies.

Now, in the area of aircraft, we have an even stronger policy, we have 24 percent or 25 percent of the Nation's R. & D., both industrial and Federal, of which 77 percent comes from the Federal Government. That is pure policy. We have a sense of direction in those two areas.

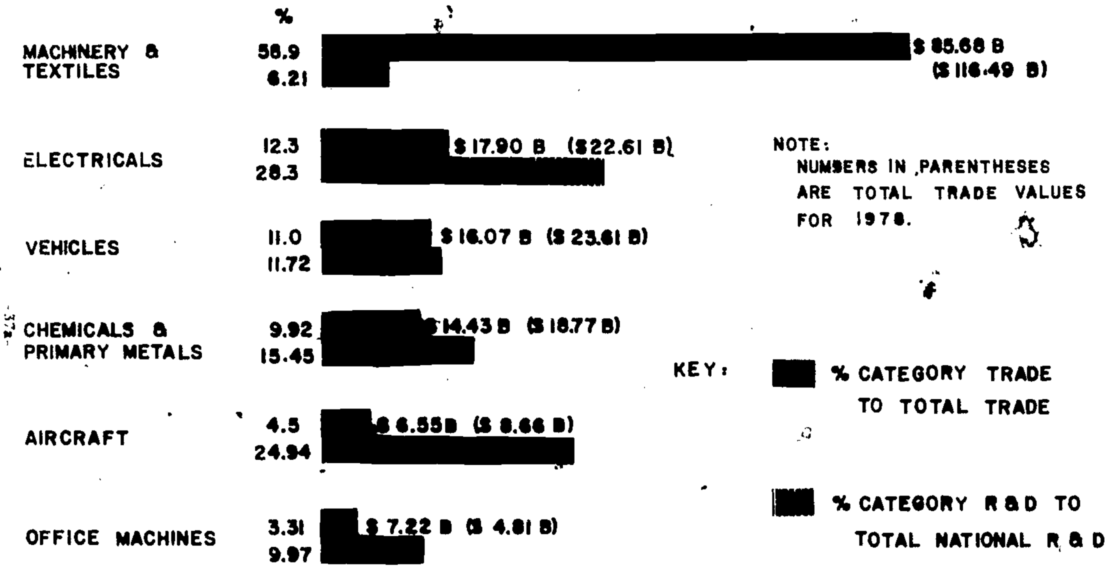
If we look at these other areas, like chemicals, you will find an unusual situation. You have 15 percent of your Nation's R. & D., but only about 10 percent of it comes from the Federal Government. Why that is, I can't possibly determine. It is, in fact, an autonomous industry.

Vehicles, by comparison, have about 12 percent of the Nation's R. & D., and about 20 percent of it comes from the Federal Government, primarily, as I understand it, to satisfy Government regulations.

Now, office machinery has about 10 percent—and that includes computers—of which about 30 percent comes from the Federal Government. In machinery, the thing that I am concerned about, the ability to make products, to compete with the Japanese and the Germans, gets only about 6 percent and almost no involvement by the Federal Government.

So we have a dilemma. We have got an imbalance, you might say.

PERCENTAGES OF PRIMARY TRADE CATEGORIES FOR 1976
COMPARED WITH PERCENTAGES OF TOTAL NATIONAL R & D



SLIDE 10

Dr. TESAR. I want to show you now on the next two slides what this imbalance is [slide 10].

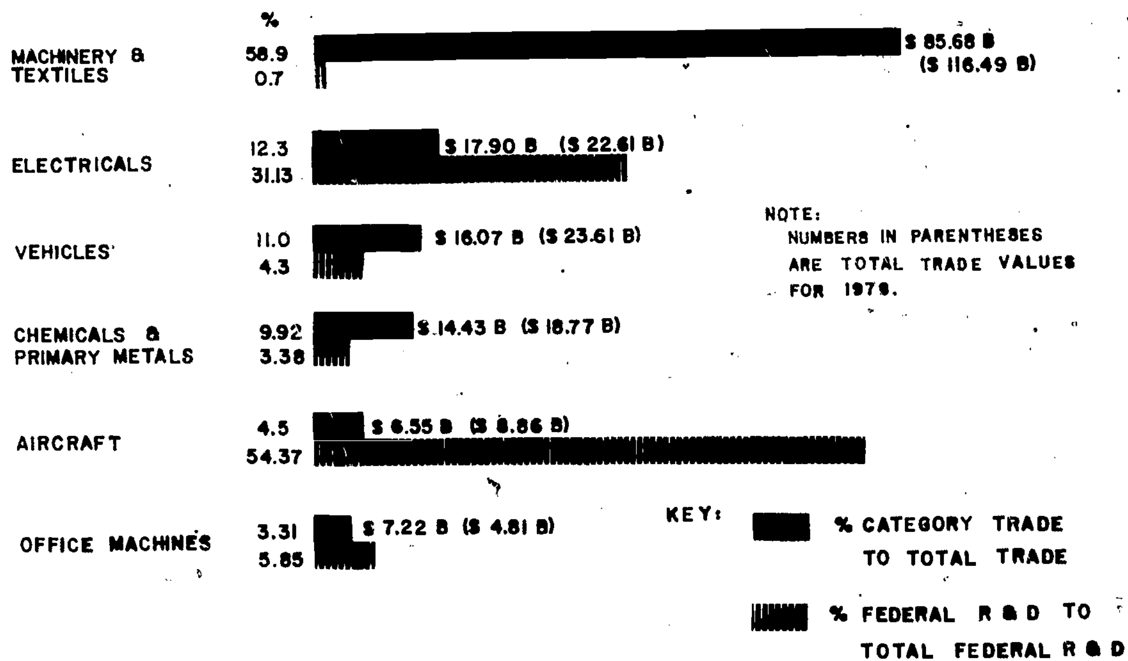
If you look at trade as an indicator—that is, the black bar in these charts are—represent total trade, 60 percent of the trade is in machinery, its products, and textiles.

Now, as you look at the R. & D. that you put in to protect that, both Federal and industrial combined, you see only about 6 percent of your Federal and industrial R. & D. to protect it. So there is a 10-to-1 imbalance right there in that particular indicator.

Now, if you look at other categories like aircraft, you have 4.5 percent of your trade and 25 percent of your industrial and Federal R. & D. If you look at the field of electricals, you have 12 percent of your trade and 28 percent of Federal and industrial R. & D. So there are imbalances.

We know that there is a very good reason for some of these imbalances. There is a defense, for example. But the economic reality of the United States, if you are weakening—as I tried to show you at the very beginning—if you are weakening and have a heterogenous society, that is an internal threat. That is an internal threat we cannot afford to allow to continue for a long period of time because rising expectations means you start pulling apart a society that is not cohesive.

PERCENTAGES OF PRIMARY TRADE CATEGORIES FOR 1976
COMPARED WITH PERCENTAGES OF FEDERAL R & D



SLIDE 11

Dr. TESAR. Now, if you look at what the Federal Government thinks of these same trade categories, this is what you get [slide 11]: Machinery and textiles represents 60 percent of your trade. That is everything we make from machines with machines, that is everything you take off the food shelves and the drug store shelves and things like that, the machines to make civil sector products. This trade gets only 0.7 percent of all of the Federal R. & D. dollars. So that there is a 100-to-1 imbalance in this particular area.

If you look at electricals, you get 31 percent of the Federal R. & D. dollar to protect 12 percent of your trade; and in aircraft, we have 4.5 percent of your trade protected by 55 percent of the Federal R. & D. dollar for manufacturing.

Now, your question might be, why do we have such a big imbalance, one way versus another way. Well, the civil sector has not been protected and the defense sector has. Let us recognize that. Do we want to change it? We may not want to change it. But let us recognize it as fact that this is the condition that we now face.

THE PRIMARY PROBLEM IS THE
EFFICIENT CONVERSION OF ENERGY
AND NATURAL RESOURCES INTO
CONSUMER GOODS

SLIDE 12

Dr. TESAR. We say, then, that the primary problem is the inefficient conversion of energy and natural resources into consumer goods [slide 12].

OUR MAJOR TECHNOLOGICAL OPPORTUNITY
IS TO PUT MORE R. & D. INTO MECHANICAL MANUFACTURING

SLIDE 13

Dr. TESAR. Therefore, the opportunity is to put more R. & D., if you wish, into mechanical technology [slide 13]. But by no means do I mean stupid machines. In other words, my center would not be labeled the Center for Intelligent Machines and Robotics if I didn't mean integration. I don't mean separation of disciplines by any means whatsoever.

WEAKNESS IN U.S. MANUFACTURING - MECHANICAL TECHNOLOGY

1. IMPORTANCE OF MANUFACTURING

WEALTH GENERATORS	% GNP
MANUFACTURING	24.4%
EXTRACTION	5.0%
CONSTRUCTION	4.5%
AGRICULTURE	3.0%

2. MECHANICALS REPRESENT 75% OF OUR MANUFACTURES TRADE

3. 20 MOST NEGATIVE DEFICITS IN
1978 MECHANICALS TRADE --- $34 BILLION LOSS

SLIDE 14

Dr. TESAR. Now, if we look back to summarize the picture just a little bit, we have a weakness in manufacturing [slide 14]. That is a crucial thing that most people seem to want to avoid recognizing because there are big dollars behind correcting it.

We have a deficiency in the civil sector in particular. Manufacturing, as I pointed out to you, is about 24.4 percent of the gross national product. Mechanicals represent about 75 percent of our manufactures trade, and 20 of the most negative deficits in the mechanicals produced a $34 billion deficit in 1978.

WEAKNESS IN U.S. MANUFACTURING - POLICY AND MANPOWER

1. EXCLUDING AUTOMOBILES AND AIRCRAFT

- – MECHANICALS – 60% OF OUR MANUFACTURING TRADE
- – SUPPORTED BY 6% OF NATIONS R&D

  IMBALANCE 10 TO 1
- – SUPPORTED BY 0.7% OF FEDERAL R&D

  IMBALANCE 100 TO 1
- – IMBALANCES IN MANPOWER IDENTICAL TO THOSE IN R&D

2. EMERGING THREAT TO CIVIL SECTOR

- – MAJOR MANUFACTURING R&D DEVELOPED IN DEFENSE SECTOR
- – U.S. MANPOWER VERY WEAK IN CIVIL SECTOR
- – FOREIGN CIVIL SECTORS MAY BE PRIMARY BENEFICIARIES

SLIDE 15

Dr. TESAR. Excluding automobiles [slide 15], you have mechanicals representing 60 percent of your trade supported by 6 percent of the Nation's R. & D., so there is a 10-to-1 imbalance there, as I have said, supported by only 0.7 percent of the Federal R. & D., so there is a 100-to-1 imbalance there.

Now, if you look at what is happening as an emerging threat to the civil sector, I think you have a crucial question, one which I don't know exactly how to deal with, but it has got to be met—Mrs. Heckler mentioned it this morning. The fact is that we have a major push for manufacturing in the Department of Defense. There is going to be $500 million set aside per year by 1985 in Mantech programs, which I completely support. But the fact is that that technology tends to become available in the public domain. If it is available in the public domain, that means other civil——

Mr. SHAMANSKY. Excuse me, Doctor.

Dr. TESAR. Yes, sir.

Mr. SHAMANSKY. You said $500 million available——

Dr. TESAR. In the Mantech program.

Mr. SHAMANSKY. From what? Would you explain what that is?

Dr. TESAR. Manufacturing technology program in the Department of Defense to help industry to bring in higher-level technology in manufacturing.

Right now, industry in the Department of Defense has no immediate incentive to bring in new machines and new technology because it is high risk. So the Government, in particular the Department of Defense, enhances this incentive by putting money on the line.

Mr. SHAMANSKY. But we only approach it from the military.

Dr. TESAR. In this case, it is pure military.

Mr. SHAMANSKY. Wouldn't it be helpful to put the rest in there?

Dr. TESAR. I think there would be considerable justification to look at the civil sector in the same way.

Mr. SHAMANSKY. I gather from the thrust of your testimony here that—certainly the figures would show that—the noninvestment in this area is having very bad consequences.

Dr. TESAR. Absolutely. The first consequence that you have if you don't have good technology in the civil sector is the loss of jobs. That is what everybody is concerned about. Why don't we have more jobs for our people?

The fact is we have allowed our technology to diminish so we can't compete.

Mr. SHAMANSKY. Are you suggesting, then, that somehow the market hasn't been sufficient to have the most up-to-date manufacturing technology?

Dr. TESAR. If you have very low level of risk capital, which is true of a lot of industries which are labled "dying industries" in this country, you cannot respond to the outside threat.

Mr. SHAMANSKY. Why can't you respond?

Dr. TESAR. Because you don't have enough, let us say, commitment and new dollars to new equipment and new people and new R. & D. to stay in competition with your foreign competitors.

Mr. SHAMANSKY. But it seems to me that that is a self-fulfilling prophecy. If there is technology for continuous casting in steel mills but the chief executive chooses not to do it, that is his decision.

Dr. TESAR. Every industry does this one thing, they want to survive. They want to survive as long as possible.

Mr. SHAMANSKY. But this isn't surviving.

Dr. TESAR. No, it is not surviving in the long term by any means. That is right. I agree with that, of course.

Mr. SHAMANSKY. I am sorry to interrupt, but I didn't know what Mantech was.

Dr. TESAR. Fair enough. It is $500 million involved by 1985, which I strongly support, by the way. But I think there is one dilemma, which is this one: If you have a new major thrust in manufacturing in the Department of Defense—which I say there is—then where is this technology going to go? Certainly the military industry will benefit, but we want the civil industry to also benefit.

The dilemma I have recognized is that all of this information goes into the public domain. Consequently, within my intuitive understanding—other civil sectors that have high manpower density in manufacturing will be much more capable of absorbing this technology than our own civil sector, and that is a dilemma that I want to leave with you as a concern that I have.

Mr. SHAMANSKY. Would you elaborate? The dilemma eluded me as you were talking about it.

Dr. TESAR. Yes, let me try to say it again. It is my perception that if you have—as you remember, we have a 10-to-1 imbalance in real dollars being spent for R. & D. in this country for civil sector, and we have about 100-to-1 as far as Federal dollars imbalance, that means that you don't have enough technologists. That is what it absolutely means. If you don't spend R. & D. money, you don't have people. So we don't have enough people to absorb this technology.

Mr. SHAMANSKY. Is it that they don't exist at all?

Dr. TESAR. They don't exist at all.

Mr. SHAMANSKY. Is there a demand for their existing in the first place?

Dr. TESAR. I am saying that internal to the United States, if you have a perfect steel wall around the United States, there would not be a need to create a demand. The system would constantly go forward in its own way. But since we have this fantastic external threat of organized societies to compete in our home markets and, therefore, take away our jobs, then there is a need. The question is: How do we meet it and create policy so that we know what to do to respond to that need?

Mr. SHAMANSKY. Is it that they take away our jobs, or we don't know how to keep our jobs?

Dr. TESAR. I think we know how, but we don't have the sense of urgency of purpose and direction.

Mr. SHAMANSKY. But that is our fault.

Dr. TESAR. That is our fault.

Mr. SHAMANSKY. So, in a sense, there our foreign competition is not taking anything away as much as we are leaving the field free to them.

Dr. TESAR. Thank you very much. That is a good point, of course. I do not, in fact, fault our competition; I fault ourselves in this.

Mr. SHAMANSKY. OK. I just want to know where you think the responsibility lies?

Dr. TESAR. It is with us and the national policy and the universities. I would like to point out some of this as I go through this presentation.

Mr. SHAMANSKY. Please continue.

EMPHASIS ON ENGINEERING MANPOWER IN COMPETING NATIONS

1. RELATIVE STRENGTH

COUNTRY	% B. SC. WITH ENG. DEGREE
U.S.	5%
JAPAN	.15 -. 20%
N. EUROPE	20%
EASTERN BLOCK	40%
RUSSIA	40%

2. JAPANESE MANPOWER REL. TO U.S.

CATEGORY	NO. OF PROFESSIONALS/ 10,000 POPULATION	
	U.S.	JAPAN
ENGINEERS/SCIENTISTS	70	400
LAWYERS	20	1
ACCOUNTANTS	40	3

3. RUSSIAN DEFENSE PRIORITIES (12 TO 1)

	NO. ENG./YR.	% OF ALL B. SC.	% ENGINEERS IN DEFENSE
U.S.	60,000	5%	25%
RUSSIA	300,000	40%	60%

SLIDE 16

Dr. TESAR. Now let us look at the engineering manpower problem by means of looking at competing nations [slide 16]. The United States has 5 percent of its bachelor degrees generated in engineering versus all bachelor degrees that it generates. Japan has 20 percent, northern Europe 20 percent, and Eastern bloc countries have 40 percent. This information is fairly well known.

But let us consider the Japanese, in regard to their professionals per 10,000 people. The engineer and scientist level of the United States is 70 while in Japan it is 400. That is about a six times difference in that category. But in lawyers, they have 20 to 1.

Mr. SHAMANSKY. Doctor, that is a pretty sensitive area there.

Dr. TESAR. I appreciate that.

Mr. SHAMANSKY. I just want you to watch that.

Dr. TESAR. I think that Senator Schmitt said something about this in his testimony last time about dividing up the pie, who creates the pie and who divides it.

Mr. SHAMANSKY. I suggest that we may have a more just society than Japan. There is also a correlation there.

Dr. TESAR. That is a possibility, yes.

I think, however, No. 3 is pretty important. The United States is generating about 60,000 engineers per year, Russia is generating 300,000—most people are aware of this. But one thing they probably are not sufficiently aware of is that 25 percent of the U.S. engineers get into defense-related industries, and 60 percent of the Russian engineers get involved in defense-related industries per year. That means they have a growth differential on us in defense-related or security-related industries of 12 to 1. That is a major threat, 10 years from now we will not have the luxury of saying we have the best defense technology.

RUSSIAN MANPOWER DEVELOPMENT

1. MAJOR NATIONAL PROGRAM IN PLACE FOR SECONDARY EDUCATION

2. NUMBER OF STUDENT-YEARS OF CALCULUS IS 100 TO 1 RUSSIAN VS. U.S.

3. COMPARATIVE COMPULSORY H.S. SCIENCE PROGRAM

	YEARS OF STUDY		
TOPIC	RUSSIAN	U.S.	RUSSIAN ADVANTAGE
ALGEBRA	5	3	2
GEOMETRY	10	2	8
CALCULUS	2	?	~2
PHYSICS	5	1	4
CHEMISTRY	4	1	3
ASTRONOMY	1	0	1
BIOLOGY	5.5	2	3.5
GEOGRAPHY	5	2	~3
DRAFTING	3	0	3
WORKSHOP	10	4(?)	6 - 10
	50	15	~38

4. 5,000,000 GRADUATE EACH YEAR

   % COMPLETE IN U.S.S.R. - 98%

   % COMPLETE IN U.S.A. - 75%

SLIDE 17

Dr. TESAR. In fact, if you look at what the Russians are doing in the high schools [slide 17], you will see a much more significant threat than that. It has been very documented and alluded to earlier this morning.

The fact is that they have a national program in place for the last 10 years in secondary education. Just one indicator, in the field of calculus, they have a 100-to-1 higher level of activity in the high schools in calculus than we do. If you look at all of the science subjects of interest that you could offer in the high schools, they do 3½ times more student years per student than we do. That is major technological activity and major national programing.

Now, they produce about 5 million graduates each year, of which 98 percent of all of their relevant age group actually finished, and only 75 percent of ours do. So I think we have got a crucial problem here indicated by this.

THREAT IN TECHNOLOGY
JAPAN - ROBOTICS

- • - JAPAN MAKES 45% OF WORLD'S ROBOTS
- • - JAPAN PROVIDES TAX BREAKS TO USE ROBOTS
- • - DEVELOPMENT PROGRAM FOR SENSING INTELLIGENT ROBOTS
  - STARTS IN 1983 FOR SEVEN YEARS FOR $140,000,000
- • - HITACHI HAS 500 MAN ROBOT TASK FORCE
- • - NIPPON ROBOT ACCURACY - 40 MILLIONTHS OF AN INCH
- • - SALE OF ROBOTS IN JAPAN

  1980 - $ 400,000,000

  1985 - $2,200,000,000

  1990 - $4,500,000,000

PAUL ARON, BUSINESS WEEK
DEC. 14, 1981

SLIDE 18

Dr. TESAR. If we look at Japan in just one technology [slide 18], by no means a dominant technology—I don't want to overemphasize the significance of robotics—but it is indicative of a leading-edge technology. Japan now makes 45 percent of the world's robots. They are not 45 percent of the world in size, as a country but they make 45 percent of the world's robots. Japan provides tax breaks for robots being used. They have now a $140 million program set aside just for the next generation of robots, not today's robots, but the next generation of robots. We have nothing of that significance going on in this country.

Hatachi has a 500-man robot work force. Nippon has a robot they say has 40 millionths of an inch of positional accuracy. Now, you know and I know that that is impossible, but the fact that they are able to say it indicates a high level of confidence that we have to be aware of. By 1990, they are going to produce $4.5 billion worth of robots per year. Now $4.5 billion is a loss which I prefer not to have. But what they are going to do with the robots is what I am concerned about. They are going to make more and more quality products to satisfy markets much more rapidly than we are, just like the South Koreans are now making shoes in a 6-week turn-around period and it takes us 6 months.

That sort of indicates our responsiveness to market, which we don't have by comparison to this particular society.

STATUS OF U.S. ENGINEERING EDUCATION

1. LACK OF EMPHASIS ON MANUFACTURING IN U.S. WHILE OTHERS (JAPAN AND GERMANY) DO.

   (DR. LEWIS BRANSCOMB - OCT. 1981)

2. SHORTFALL IN EQUIPMENT IN ENGINEERING COLLEGES
   - $750,000,000 DURING LAST DECADE
     (DR. RAY BISPLINGHOFF - APRIL, 1981)
   - EQUIPMENT SUPPORT BY U.S. GOV. CUT SEVERELY

3. ENGINEERING STUDENT POPULATION UP BY 50%
   FACULTY DOWN BY 10%
   - 1800 FACULTY POSITIONS OPEN

4. NUMBER OF U.S. NATIONALS OBTAINING ENG. PH. D.'S DROPPED 50% SINCE 1968
   - FELLOWSHIP SUPPORT BY U.S. GOV. CUT BY FACTOR OF 5

5. ONLY 13% OF HIGH SCHOOL STUDENTS PREPARED FOR ENGINEERING
   - DOWN FROM 28% IN 1972

SLIDE 19

Dr. TESAR. Status of the U.S. engineering education [slide 19]. First of all, for example, Dr. Branscomb has indicated we don't have enough emphasis on manufacturing. I 100 percent agree with that.

Shortfall in equipment in engineering colleges, Dr. Bisplinghoff has confirmed that there is about a $750 million shortfall of equipment in engineering colleges alone. That has already been alluded to several times this morning.

Engineering student population is up by 50 percent and faculty is down by 10 percent. That means your quality of product, that is the engineer, is going to be poorer than it was in the past. The number of U.S. nationals obtaining Ph. D.'s dropped by a factor of 2 in the last decade. Certainly we have to recognize that is an unbelievable loss. Fellowship support by the U.S. Government was cut by a factor of 5. That is a serious error, I think. Only 13 percent of the high school students are prepared now to go into engineering, where it used to be 28 percent only 10 years ago.

So we have lost in every way when it comes to better engineering education in this country.

RECOMMENDATIONS

IN ORDER OF RESPONSE TIME

1. INCREASE FELLOWSHIPS SUPPORT FOR ENGINEERING GRADUATE STUDENTS
   - – FROM GOV. SOURCES
   - – FROM IND. SOURCES

2. INCREASE EQUIPMENT TO U.S. COLLEGES
   - – ENHANCE FURTHER TAX INCENTIVES TO INDUSTRY

3. INCREASE INCENTIVES TO INDUSTRY
   TO COUPLE WITH UNIVERSITY R&D
   - – LAST TAX LAW GAVE NO NEW INCENTIVES

4. DIVERT 1% OF DEFICIT TRADE CATEGORIES FROM IMPORT DUTIES
   TO SUPPORT FEDERAL DIRECTED RESEARCH IN MANUFACTURES
   - – AUTOMATIC PROPORTIONAL FUNDING TO NEED

5. STRENGTHEN MANDATE FOR SCIENCE SUBJECTS IN THE HIGH SCHOOLS
   - – MORE FEDERAL SCIENCE EDUCATION FUNDING
   - – HIGHER COLLEGE ENTRANCE STANDARDS

SLIDE 20

Dr. TESAR. Now, what are the recommendations I make [slide 20]? In addition to something else I am going to present here, increased fellowship support for engineering graduate students. What would I like to have? I would like to have 5 percent of all engineering graduate students—I am going to put a quota on that—I would like to have 5 percent of all engineering graduate students continue on to a Ph. D. under Government support. I would like to have 5 percent continue on to a Ph. D. under industrial support. We can mesh this particular opportunity together in a national fund.

What I would like to have in addition to that is national competition. Let us get this into a real positive national competition for these funds.

I would like to increase the equipment to U.S. colleges. We do have a tax law that is beautiful. Let us not change it. Let us keep what we have when it comes to equipment to universities. It is working.

Increased incentives to industry coupling with university R. & D. Let me point out that of all of the money spent in universities in this country for education, only 2 to 3 percent of it comes from industry directly. And if you look at all of the R. & D. money that is spent in universities in this country, only 2 or 3 percent of it comes from industry directly. So there is almost no coupling between universities and industry. So if you want to have a change, it is going to take an unbelievable change from industry to make up for what we have, this lack of coupling. So this indication is that we need new incentives. In other words, the Government has to do something. Industry is not going to respond to something unless something major happens to change its present condition.

The last one I would like to mention, No. 5, strengthen the mandate for science subjects in the high schools, more Federal science education funding perhaps. But one thing that will do the trick is accreditation. All engineering schools have to go through accreditation every 5 or 6 years. They have to satisfy a certain set of criteria. Why cannot we get the high schools to satisfy a certain set of criteria in the State?

Now, it turns out that in my State, the chancellor of the university system has now improved the standards of entry level students into universities. This is going to take effect 1 year from now, and it is going to be constantly built up. This is a step in the right direction. It can be done.

Now, what I would like to do then is go to some slides I have on transparencies here.

RELATIVE STRENGTH OF U.S. TECHNOLOGY

1. COMMENT:

    - WE WERE STRONG IN 50'S AND 60'S
    - WE WEAKENED IN THE 70'S
    - WHY?

2. RESPONSE:

    - WE WERE NEVER SUPERIOR TO OTHER VITAL TECHNOLOGICAL SOCIETIES
    - POSTWARE REFUGEES FUELED OUR MANPOWER POOL AND DRAINED THAT OF OUR COMPETITION

3. CONDITION:

    - INSTITUTIONS FAILED TO COMPENSATE FOR THIS INFLUX ESPECIALLY IN MANUFACTURING TECHNOLOGIES

SLIDE 21

Dr. TESAR. On the relative strength of U.S. technology [slide 21], I would like to mention that there have been a lot of statements recently that during the 1950's and 1960's we had the strongest nation in the world, why in the 1970's did we weaken? Recently, there was an attractive article in Science Magazine discussing this issue. J. D. Lewis said that maybe we weren't really that strong. Maybe, in fact, we were not superior to other vital countries, especially in Europe.

Post-war refugees fueled our manpower base in this country and drained that of our competition. This is a crucial issue pointed out in not only that particular article, but others.

The condition of our present institutions was wherever there were voids, those refugees, those people who were brought into this country by immigration filled those voids and institutions did not, therefore, have to respond, particularly the universities.

FACTS ABOUT ENGINEERING MANPOWER

1. TECHNOLOGISTS (B. Sc.)
   - Scientists - 900,000 or 43%
   - Engineers - 1,200,000 or 57%
2. DOCTORATES (Ph. D.)
   - Scientists - 254,500 or 84%
   - Engineers - 48,500 or 16%
3. PERCENT B. Sc. Get Ph. D.
   - Scientists - 28%
   - Engineers - 4%
4. CONCLUSION
   - 7 to 1 Enhancement of Engineering Graduate Education is Feasible
   - Reverse The "Eating Our Seed Corn" Syndrome

Slide 22

Dr. TESAR. Facts about engineering manpower [slide 22]. It is very important to see what the magnitudes are. Scientists represent 900,000 in this country, about 43 percent; engineers represent 1,200,000, about 57 percent of our engineering manpower.

Now, those that go on for their Ph. D.'s in the scientist spectrum, 28 percent go on to get Ph. D's; in engineering, only 4 percent do. This is an imbalance, if you wish. You might say let us keep the scientist level up, but let us bring the engineers up, let us say up to a level of 14 percent, which is again going back to my recommendation of 5 percent Federal funding, 5 percent industrial funding to get up to a level of 14 percent.

Now this idea shows that there is a 7-to-1 enhancement in engineering education that is feasible. Let us go halfway. This goes back to this classic "eating of the seedcorn" dilemma that we have.

ENGINEERS ARE TARGETED

1. PERCENT WORKING OUTSIDE DISCIPLINE

   ENGINEERS - 20%

   CHEMISTRY - 35%

   PHYSICS - 50%

   MATHEMATICS - 83%

   PSYCHOLOGY (M. SC.) - 85%

   SOCIAL SCIENCE (M. SC.) - 88%

2. PERCENT WHO TEACH

   SCIENTISTS - 17%

   ENGINEERS - 2%

3. CONCLUSION

   ENGINEERING DOCTORATES ARE A RELIABLE INVESTMENT IN FUTURE TECHNOLOGY

SLIDE 23

Dr. TESAR. Engineers are targeted: It is very important to see that engineers stay on the [slide 23] job. Of all engineers that exist today, only 20 percent are not directly involved in engineering technology, and most of those that are not are involved in management and R. & D.

By comparison, in the fields of chemistry, physics, mathematics, psychology, and social science, you see a reduced targeting of those scientists to the task. Now, by comparison, those that teach, scientists that teach, 17 percent of them teach; engineers, only 2 percent of them teach. So if you want to have them respond to industry, then you put more engineers on board.

Finally, engineering doctorates are a reliable investment in future technology because they go to work and stay on the job. So, if you want a return on investment, this is the place to put it.

Mr. SHAMANSKY. Doctor, I have to interject something here.

Dr. TESAR. Of course.

Mr. SHAMANSKY. If a bachelor degree in engineering can get more than the Ph. D. graduate can in a university, it is irrational to think that they are going to do otherwise.

Dr. TESAR. Yes, I agree.

Mr. SHAMANSKY. So what do you do about that?

Dr. TESAR. I think the fellowship supports are crucial to get a new kind of urgency in the student to stay in school longer, to continue through. There is more than money involved. There is a certain satisfaction of raising yourself up technologically.

Mr. SHAMANSKY. Yes, but having said that, you still have to pay the bills, you have your family, and so on, and so forth. There are the mortgage payments, assuming anyone buys a house again.

Dr. TESAR. We will discuss that shortly here. It has to do with the ways the graduate student normally reacts to financial support.

ENGINEERING MANPOWER FORECASTS

1. BLS AND NCES

DISCIPLINE (IN THOUSANDS)	JOB OPENINGS	DEGREES GRANTED
ELECTRICAL	128	172
MECHANICAL	95	171
INDUSTRIAL	98	48
COMPUTER SCIENCE	500	100

2. FALLACY IN FORECASTS

   - USE SIMPLE EXTENSION OF PRESENT DISCIPLINE ACTIVITY

3. FUTURE INTEGRATION OF COMPUTERS

   - INTELLIGENT PROCESSES
   - INTELLIGENT MACHINES
   - ALL DISCIPLINES WILL HAVE EXPANDED ROLE
   - INDUSTRIAL ENGINEERING AND COMPUTER SCIENCE GIVEN TOO LARGE A ROLE IN FORECAST

4. OVERALL FORECAST

   Decade Will Show An Under Production of 200,000 Technologists

SLIDE 24

Mr. TESAR. Now, engineering manpower [slide 24]. If you look at this particular forecast, I think it is very important that you do so, job openings in the electricals for the next decade are supposed to be 128,000; in degrees granted, we are supposed to exceed that by 50,000.

If you go down to industrials, you will see 98,000 job openings and 48,000 going to be produced.

Down here at computer science, the recommendation is 500,000 job openings and 100,000 that are going to be produced.

I think this is a very unfortunate forecast. It was alluded to this morning that it is very difficult to make forecasts, and I think this particular forecast is very unfortunate. But if you take the sum of all these, you will find that we need about 950,000 new technologists during this decade, and we are going to generate about 750,000. So we do have a deficit of about 200,000.

I suggest that the fallacy in the forecast is because we use a simple extension of what we mean by a given discipline. We don't think that the discipline is going to respond to the need. The need will be in intelligent processes and intelligent machines. All disciplines will have expanded roles. It is not necessary to think that computer scientists are the only ones that can make a machine intelligent. So I think that this is an issue that we need to deal with.

So industrial engineering and computer science have been given too large a role in this forecast, and I say that there is about a 200,000 total need.

Mr. SHAMANSKY. I would like to get to a question that Dr. Zwoyer's testimony raised in my mind.

Dr. TESAR. Yes.

Mr. SHAMANSKY. He said that we have enough engineers now and, yet—that kind of statement mixes me up. Does that mean our industry is so limited that we only need the number of engineers, or if we had more engineers we would have a greater need for them? Which comes first? What does he mean—I am not going to have him as a witness—but he did say that we had enough engineers now, yet we have obviously fewer engineers than Japan, which has half our population.

Dr. TESAR. That is right.

Mr. SHAMANSKY. What is meant by that?

Dr. TESAR. First of all, relative to international competition, we don't have enough engineers. That is the No. 1 issue. No. 2, when it comes to an internal situation, we use other people besides engineers to do engineering jobs and, therefore, it gets very mushy in this respect.

So I don't have a perfect answer for you, but I believe there are a couple additional answers as I go along in this particular testimony.

FOREIGN DOCTORATE CONSORT

1. FOREIGN STUDENTS IN ENGINEERING

   - M. Sc. - 40%
   - Ph. D. - 47%

2. FOREIGN STUDENTS BY DISCIPLINE

   - Aerospace ----------- 64.6%
   - Civil/Environmental - 55.0%
   - Chemical ------------ 53.3%
   - Materials/Mining ---- 52.6%
   - Mechanical ---------- 50.6%
   - Petroleum ----------- 50.0%

3. U.S. Ph. D. GRADUATES IN ENGINEERING

   - Dropped from 3020 in 1972
     by 50% to 1485 in 1980

4. FOREIGN IMMIGRATION

   - Foreign Engineers
     1976 ----- 1,555

     1980 ----- 3,390

Slide 25

Dr. Tesar. If I may, foreign students in engineering (slide 25). Right now it has been alluded to that about half of our Ph. D. graduating class is of foreign nationals, and we have a large population in the major technology disciplines, like aerospace, civil, chemical, materials, and so on.

As I mentioned already, the drop in the Ph. D. production of U.S. nationals is a factor of 2 over the last 10 years. We have, in addition, a very high growth of immigrants in this country in engineering, about a factor of 2 over the last 4 years in immigration into this country. So there is very high pressure to bring people into this country in the engineering technology spectrum.

ENGINEERING GRADUATE STUDENTS

- ALMOST 90% REQUIRE FINANCIAL SUPPORT
- ALL PERFORM USEFUL FUNCTIONS FOR ASSISTANTSHIPS
- REQUIRE LONG LEAD TIMES TO MAKE COMMITMENT TO GRADUATE PROGRAM
- FEDERAL FUNDING IS UNCERTAIN MAKING LONG LEAD TIMES UNLIKELY
- FOREIGN STUDENTS WILLING TO DEAL WITH THIS UNCERTAINTY

Slide 26

Dr. Tesar. Now if we look at engineering graduate students [slide 26], going back to this financial need that you mentioned, I think it is imperative that we recognize that almost all graduate students who want to stay in the engineering program require financial support, otherwise they won't stay in, about 90 percent in my own experience. All perform useful functions or assistanceships, they are not there on a gravy train. They are actually performing and meet a task.

They require long lead times to make a commitment. This is our biggest dilemma right now in the universities. If you want a very high quality senior to stay on, you have to make the commitment to him 6 months to 12 months in advance. Now the difficulty with that is the Federal funding at the university level is extremely uncertain. It goes on and off and, therefore, you can't make commitments. You would be very foolhardy to make a commitment to a young person if you can't meet it. So that is one of our big problems.

Foreign students, are willing to deal with this uncertainty. That is one of the reasons why we have so many foreign students now involved in our research program.

MAGNITUDE OF PROBLEM

1. NUMBER OF ENGINEERING DEPARTMENTS
   - 250 ENGINEERING SCHOOLS
   - 10 DEPARTMENTS PER SCHOOL
   - 2500 TOTAL DEPARTMENTS

2. FUNDING TO IMPACT
   - $100,000/YR PER DEPARTMENT
   - $.25 BILLION/YR FOR THE NATION TO IMPACT

3. REALITY
   - ALL BENEFICIARIES MUST PROVIDE FUNDING

4. MATCHING FUNDS FOR GRADUATE FELLOWSHIPS
   - SUPPORT 5% OF B. SC. BY GOVERNMENT
   - SUPPORT 5% OF B. SC. BY INDUSTRY
   - PROGRAM TO BRING PH. D.'S TO 14% OF B. SC. POPULATION

SLIDE 27

Dr. TESAR. I would like to now address the question that was raised earlier this morning. That is the magnitude of the problem [slide 27].

The number of engineering departments, if you think of 250 engineering schools in this country, there are usually 10 departments in each school, that means you have a total of 2,500 departments. If you are going to have impact, it means about $100,000 per department. That means in a distributed geographic sense, not to favor a few major schools, but to make sure that all schools that are producing young people also get help. So if you put $100,000 per department in, you have a $250 million effort to have impact. It should be arranged so that all beneficiaries would provide funding, as you have suggested. In other words, all those sectors, industry, government, universities, whoever benefits, should play a role.

I am suggesting that these matching funds be established 5 percent goes from government, 5 percent from industry, sufficient to increase our level of Ph. D. generation by a factor of 10 percent up to 14 percent.

INITIAL STEPS TOWARD IMPACT

1. FEDERAL

- 1982 NATIONAL ENGINEERING AND SCIENCE MANPOWER ACT
- EXISTING PROGRAMS AT NSF, DOE, AND DOD

2. INDUSTRY

- STANFORD UNIVERSITY - $750,000 FROM 14 CORPORATIONS
- UNIVERSITY OF MINNESOTA - $6,000,000 FROM 4 MAJOR LOCAL COMPANIES
- $15,000,000 EXXON GRADUATE EDUCATION PROGRAM

3. CONCERN

- ACTIVITY MUST HAVE MAGNITUDE OR WE WILL BE LULLED INTO FALSE SENSE OF ACCOMPLISHMENT.

SLIDE 28

Dr. TESAR. Initial steps towards impact by the Federal level: Of course [slide 28], we have the present bill that is under consideration—which I highly recommend. We have existing programs in NSF, DOE and DOD. We have industry putting in money specifically to meet this problem. For example, as I have suggested here, Stanford was able to garner $750,000 from 14 different corporations. The University of Minnesota was able to receive $6 million from four local companies. Of course, we have just heard $15 million has been set aside by Exxon for the next 5 years to do something about this.

Now these generally are one-shot efforts. Therefore, they are not a continuing program. I think it is very important that we recognize the activity must have magnitude and we must not, therefore, be lulled into a sense of accomplishment when it has not been done. This is the point that you raised earlier this morning.

INTERNATIONAL ENGINEERING MANPOWER

1. COMPETING NATION'S MANPOWER

- SIGNIFICANT COMPETITIVE PRESSURES
- WHY DO THEY DO WELL?
- WHY DO THEY FAIL?
- WHAT CORRELATIONS ARE USEFUL FOR OUR NATIONAL POLICY?

2. MANPOWER IS A NATION'S BEST INDICATOR OF A LONG TERM POLICY.

3. MANPOWER DISTRIBUTION LEADS TO PROPORTIONAL ADVOCACY.

SLIDE 29

Dr. TESAR. Now to my last point, I think it is necessary, if you are going to talk about engineering manpower, that you look at your international competition. Universities, industries, everybody, (if they want to know how they survive) they always look at their competition to see how they are going to match the competition to survive.

When it comes to engineering manpower, I think we need, as was mentioned earlier this morning, an international engineering manpower study to find out where the significant pressures are, competitive pressures from other countries, why do they do well, why do they fail, what are the correlations. That information is immediately available if we just go get it. Manpower in a nation is the best indicator of long-term policy. It is 40 years down the road. If you have good people on board, then this will develop a policy, as a matter of fact, because of advocacy. Advocacy means competitive ideas in front of everybody at the same time.

ELEMENTS OF INTERNATIONAL STUDY

1. DATA FROM SEVERAL COUNTRIES

   U.S.A., RUSSIA, W. GERMANY, JAPAN

   POLAND, ROMANIA, U.K., FRANCE, ITALY

2. LEVEL OF EXISTING MANPOWER

3. BREAKDOWN OF EXISTING MANPOWER

   ELECTRICAL, MECHANICAL, AERONAUTICAL, CHEMICAL,

   CIVIL, MATERIALS, INDUSTRIAL, OTHER

4. NEW GRADUATES BY DISCIPLINE

5. COMPARATIVE ANALYSIS RELATIVE TO

   G.N.P., POPULATION, R&D, ETC.

6. LEVEL OF EXISTING ENGINEERING TO ALL TRAINED MANPOWER IN EACH COUNTRY

7. QUALITATIVE JUDGEMENT ABOUT UTILIZATION

SLIDE 30

Dr. TESAR. Finally, the elements of this international study (slide 30). Data from several countries, in particular from the United States, Russia, West Germany, Japan, Poland, Rumania, United Kingdom, France, Italy, that would be representative of most of our competition. The level of existing manpower in each of these countries, (breakdown of existing manpower) will be necessary so that we have enough sharpness in our data, that is, electrical, mechanical, technologies, and so on.

New graduates by discipline, comparative analysis with GNP of each of these countries, population R. & D., et cetera, level of existing technology of all trained manpower in those countries and, finally, utilization. We know that, by comparison to utilization in the United States for engineers, utilization in other countries like Russia is much poorer. We need to somehow try to attempt to quantify the quality of this utilization.

So, with those remarks, I would like to indicate I fully support this bill, and I am very concerned about the urgency to respond to the bill.

[The prepared statement of Dr. Tesar follows:]

Testimony On

National Engineering and Science Manpower Act of 1982

(H. R. 5254)

by

D. Tesar

Professor of Mechanical Engineering
and Director of the Center for
Intelligent Machines and Robotics

College of Engineering
University of Florida
Gainesville, Florida 32611

April 27, 1982

I. Premise

The competitive position of the United States in both civil sector and defense sector technologies for manufacturing are threatened by a weakening engineering manpower base. The vitality to the nation's technological manpower is perhaps the best indicator of our long-term commitment as a society to innovation and strength in all technological endeavors.

This analyst believes that the National Engineering and Science Manpower Act of 1982 (H.R. 5254) is a proper and meaningful step towards corrective action to improve our manpower capacity.

II. Relative Strength of U.S. Technology

A frequent comment among many analysts trying to perceive the reason for our present weakened competitive international position is that the U.S. was strong during the 50's and 60's; what happened during the 70's? A recent comment* by J. D. Lewis very likely is the best response:

> What tends to be forgotten is that we were not superior to other nations in many fields before World War II. Then, for example, German chemical engineering was pre-eminent and European science excelled. In fact, many of the scientists who built America's postwar technology base were refugees. We are not likely to benefit from a European brain drain again. Since the end of World War II, the former combatants have rebuilt their industries, and the United States is watching other nations pass it by. The strength of the European and Japanese economies can no longer be attributed to lower wage rates or to these countries skimming off the cream off our technology base. Much of it is due to greater technological vitality.

Not only does the present writer agree with Lewis intuitively, he feels that in the field of manufacturing** this comment is particularly

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*J. D. Lewis, "Technology, Enterprise, and American Economic Growth," Science, Vol.215, March 5, 1982.

**D. Tesar, "Mission Oriented Research in Light Machinery", Science, Vol.201, Sept. 8, 1978, pp. 880-887.

relevant. Because a large cadre of well-trained manufacturing specialists came to the U.S., the U.S. universities did not find it necessary to maintain or enhance their manufacturing related disciplines. Hence, today exceedingly few universities in the U.S. offer in-depth programs dealing with manufacturing technology. This is especially evident in terms of the equipment available for teaching and research which either doesn't exist or has long been obsolete.

Bruno Weinschel,* who has been active over the past few years in urging better policy for technology, recently provided these supporting comments:

> In the last 25 years, due to Sputnik and our space effort, the financial support of basic research in academia has emphasized <u>engineering science</u> in the U.S. at the expense of <u>engineering design</u> (for manufacuring).
>
> The Labor Department estimates that there will be an average annual opening for 31,000 skilled machinists and machine operators alone, compared to a supply of 2,300 new qualified workers.

III. Manufacturing Technology

This analyst has long been concerned about the lack of vitality in our manufacturing technology. Appendix A is a sketch of the engineering manpower dilemma facing the U.S. Appendix B lists many of the principal facts showing just how significant manufacturing is to our economic well being. Manufacturing represents 66% of our real wealth generating capability in the U.S. (extraction--13.5%, construction--12% and agriculture--8.5%). Yet, in 1978 the deficit due to only 20 trade categories associated with mechanical processes was $34 billion, almost the same loss we had in oil that year. Unfortunately, this means drastic loss in jobs

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*B.O. Weinschel, "National Resources for Innovation: Where We Stand," IEEE 1982 Conference on U.S. Technology Policy, February 25, 1982.

within categories frequently labeled as clean industries. No new national policy has emerged to reduce this type of loss in the future. The essential first step represented by the 1982 National Engineering and Science Manpower Act is indeed welcome as a partial solution to this dilemma.

One new situation now appears to be developing because of our strong bias toward defense related manufacturing priorities., As far as funding of manufacturing research through federal resources is concerned, certainly a very large portion (perhaps 90%) will be performed through DOD channels. This in itself is not bad. What concerns me is that a large "spin off" can only occur if sufficient and well trained manpower exists in the civil sector. The bias of manpower in consumer goods is 10 to 1 out-of-balance with the magnitude of the economic activity. That is, 60% of our total manufacturing activity is supported by 6% of our scientific and engineering manpower (both federal and industrial). The bias of federal policy is even worse approaching 100 to 1: i.e., only 0.7% of our federal R&D (which implies new manpower generation) is targeted to support this 60% of our manufacturing activity (see Appendix B).

Hence, I conclude that because of the weak manpower base in the civil sector, spin-off will indeed be weak. Other societies (say Japan and Germany) with strong civil sector manpower may actually be more effective beneficiaries of this new initiative in DOD manufacturing development. Appendix A (Attached) is a recent summary statement regarding comparative U.S. engineering manpower relative to that in competing nations.

Consequently, I recommend that more concern be placed in strengthening NSF in the field of manufacturing technologies and to ensure that the DOD augment its role in the universities to generate an increased number of young scientists and engineers. (Note that by contrast to our 5% engineering graduates relative to all graduates in the U.S., Japan has 15%, central Europe has 20%, and the Eastern block has 40%.) I am pleased to report that some initial steps to do so are now being taken.

IV. Magnitude of the Problem

In order to address a problem of this type, it is first essential to assess the magnitude of the effort required to have sufficient impact to carry out corrective action in a reasonable period of time. One way to make this assessment is to consider having "real" impact on all existing engineering schools. There are now 250 such schools and they are very well distributed geographically. Since we are now considering quality and quantity of our engineering manpower (present and future) all effective* engineering colleges must be impacted.

In this case, there would usually be 10 disciplines (or departments) in each school. In order to have impact on each department, a $100,000 increase in funding for fellowships, equipment, and faculty would be a reasonable amount. But this quickly shows that $.25 billion/year would be required to have impact, and this is just for engineering. Clearly, this is a task that must not be left only to the federal government, but to all beneficiaries including industry.

It may seem to be appropriate to ask industry to play a larger role in developing manpower. However, during the past two decades, industry has provided no more than 3% of the funds for university research and manpower generation. This is not expected to change significantly since no new incentives have been established.

* Generally, almost all states will have at least one effective engineering program which produces quality graduates and allows access to a large percentage of the U.S. entry level population.

Initial steps* by industry are becoming visible, however:

> In order to afford the higher salaries, stipends, and new machinery, schools need to form closer bonds with the industries that benefit from their continued ability to produce quality technical personnel. Many schools have already done this and they are the ones that are suffering least from a faculty shortage. Examples include Stanford University who collected $750,000 each from 14 corporations to build a center for integrated systems and University of Minnesota who raised $6 million from Control Data, Sperry Univac, 3M and Honeywell for a center for microelectronics. This includes part of the $15 million Exxon plans to spend over the next five years to support graduate student and junior faculty.

Yet, even though each of these efforts are highly desirable, they are not enough nor are they distributed where all engineering schools would benefit. But, perhaps the greatest danger would be a consensus that the need to supplement our manpower activity had been satisfied, thereby allowing other parties (especially the federal government) to consider their future participation unnecessary.

V. Specific Facts About Engineering Manpower

It is becoming well known that U.S. engineering manpower numerically lags that of our competing nations. The U.S. in 1978 produced only 5% of its bachelors of science in engineering. (Note that in the relevant age group, the percentage of engineers in competing countries was 1.5%--U.S. 2.3%--W.Germany, 4.2%--Japan, and 6.5%--Russia.) In 1978, there were 2.1 million scientists and engineers of which 1.2 million (57%) were engineers. Hence, engineering dominates our technological

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*J. Main, "Thy Engineering Deans Worry a Lot," Fortune, January 11, 1982, p. 90.

activity. But of the 303,000 doctorates in science and engineering, only 16% (or 48,500) were in engineering disciplines. Furthermore, it shows that 28% of the B.Sc. recipients in science went on to get Ph.D. degrees while only 4% of the engineers did.*

This 7 to 1 under-utilization of engineers at the Ph.D. level is the classic "eating of the seed corn" dilemma which has been widely commented on lately. Nonetheless, the fact remains that rapid and (likely) effective growth in engieering Ph.D.s could be accomplished if that becomes a national priority. The 1982 National Engineering and Science Manpower Act can do a great deal to make this priority a reality.

One of the major benefits of moving toward this priority is that most engineers work within their degree speciality during their productive lifetime; i.e., 80% or more. By contrast, the work outside of the degree speciality in chemistry is 33%, physics is 50%, mathematics is 80%, psychology M.Sc. is 84% and social science M.Sc. is 88% ** In the sciences, 17% teach while only 2% of engineers do. Hence, if we wish to get technology moving in industry as rapidly as possible, investing in more engineering graduates (and retraining those who are already working) is a very good initiative to be pursued as a national policy,

*NSF report NSF-80-316, "Science and Engineering Personnel: A National Overview," June, 1980.

**NSF report NSF 80-316.

VI. Graduate Programs in Engineering

A first step in assessing engineering doctoral programs is to determine the strength of Ph.D. production* by discipline which for 1978 was

Electrical/Computer	674
Civil/General	475
Mechanical/Aerospace	458
Chemical/Nuclear	424
Materials	229
Engineering Science	187
Industrial Systems	157
Other	237

This shows that 4 disciplines are dominant.

The present writer has more than 20 years experience supervising engineering graduate students. Consequently, I feel justified in saying that:

1. Very few graduate students (perhaps 10%) could go to graduate school without some financial support.
2. Almost all graduate students perform useful functions (as teaching and research assistants) for their support. Fellowships or outright grants are relatively rare and frequently inadequate.
3. Because of their high desirability to industry, engineering graduates must have long lead times in order to make commitments to stay in graduate school.
4. One of the most damaging aspects of federal research support to engineering faculty and students is its unpredictable "on-off" nature. Because of this fact long lead time commitments

*Based on the 1981 Engineering Manpower Commission Report to U.S. nationals cannot be made and they take a position in industry as their alternative. Foreign students are willing to deal with this uncertainty and hence they are increasingly recipients of research assistantships.

Today 39% of all foreign graduate students are in engineering. Foreigners represent 40% of all M.Sc. and 47% of all Ph.D. programs. Their percentage population by discipline is:

Aerospace	64.6%
Civil/Environmental	55.0
Chemical	53.3
Materials/Mining	52.6
Mechanical	50.6
Petroleum	50.0

Not only has the engineering Ph.D. production dropped from 3774 in 1972 to 2751 in 1980, but of these 46% were foreign nationals, a percentage which has risen from 20% in 1964. In addition, the number of foreign nationals getting permanent work visas in the U.S. had climbed* from 1555 in 1976 to 3390 in 1980 (some of these are at the Ph.D. level).

Generally, one must conclude that the 1982 National Engineering and Science Manpower Act can do a great deal to reduce funding uncertainty to U.S. nationals in pursuit of their engineering graduate education.

VII. Forecasts for Engineering Manpower

In the past few years the Bureau of Labor Statistics (BLS) and the National Center for Education Statistics (NCES) have been making the following forecasts for the major engineering disciplines:

*T. M. Chesser, "Foreigners Snap Up the High Tech Jobs", New York Times, 1981.

(In Thousands)	Job Openings	Degrees Granted	Projected Need
Aeronautical	35	28	+ 7
Chemical	22	95	-73
Civil	95	135	-40
Electrical	128	172	-44
Mechanical	95	171	-76
Metallurgical	9	16	- 7
Industrial	98	48	+50
Computer Science	553	110	+443
Other	79	140	-61
Total	1,114	915	+199

I believe that this type of forecast is based on the simplest interpretation of what these engineering disciplines represent. Certainly the field of manufacturing will be much more involved in intelligent processes and machines than in the past. The need for more computer hardware and software is obvious. But it is foolhardy to believe that these needs will be satisfied only by industrial engineers and by computer scientists. In fact, who can make computers most effective but well-trained participants in each of the basic manufacturing related disciplines (including mechanical, electrical, industrial, etc.).

There seems to be another fallacy in these predictions of available job openings. Present comments* by industrialists documented by the U.S. Department of Labor indicates that positions were hard to fill in mechanical, electrical, civil, and industrial engineering. In fact, most offers went to mechanical engineering graduates (then to chemicals and civils). Hence, I conclude that the realities of the marketplace show a continuing need for the basic engineering disciplines (a fact which runs contrary to the above recent forecasts).

The above tabulation does show that there is approximately a 200,000 deficit of the generation of technologists during the next decade. This fact confirms that some growth at the B. Sc. level is warranted.

*NSF report NSF 80-316.

VIII. Recommended International Engineering Manpower Study

This analyst has the intuitive feeling that the forecasts by the BLS and NCES are based on extrapolations of our present internal condition without sufficient integration of significant pressures from our competing nations (especially in civil sector goods). Consequently, it would be very helpful to determine the balance of manpower priorities in these nations and to establish correlations between their successes and failures as well as our own. The results should prove to be very instructive in perfecting our own national policy.

Of course, this is a very difficult request. Yet, to determine our policy for the nation's economic well-being and security, these data must be considered essential. I suggest that it is the best indicator of the long-term commitment a society has to innovation and to remain technologically competitive.

This manpower base is also a base for advocacy. The stronger the relative population in a given technological field is, the stronger will be the expression of need to maintain or establish new priorities. This advocacy influences decision making at all levels. In this respect, unbalanced or limited manpower in a given discipline is not self-correcting.

Specifically the following elements of the international engineering manpower study would prove useful:

1. Data for countries such as the U.S.A., Russia, W. Germany, Japan, Poland, Romania, the U.K., France and Italy.
2. The relative overall level of existing engineering manpower (4 years of training or more) in each of these countries.
3. A breakdown by discipline of this existing manpower. These disciplines might be: Electrical, Mechanical, Aeronautical, Chemical, Civil, Materials, Industrial, other.

4. The yearly level of new graduates entering the manpower pool in recent years by discipline in each country.

5. A comparative analysis of existing engineering manpower relative to each country's G.N.P., total population, R&D, etc.

6. A comparative analysis of existing engineering manpower relative to all trained manpower (all 4 year graduates) in each country.

7. A qualitative judgement of the effective utilization of the existing engineering manpower.

The present writer has contacted several pertinent societies (SME, AAES, ASME, IEEE,NAE, ASEE) and other study groups (CED, Congressional Research Service, NSF, Defense Needs Forecasting Group, etc.) and received only limited data in return. The study might also include other scientific disciplines such as chemistry, physics, etc.

IX. Engineering Manpower Recommendations

The following 4 recommendations to improve our competitive position in terms of engineering manpower are given in their order of probable time lag before a meaningful response would occur. The recommendation having the most immediate impact is given first.

1. Increase Engineering Fellowship Support. Since too few U.S. nationals are entering engineering graduate schools, it is recommended that:

   o The federal government make fellowships available by means of a layered* competition sufficient to support 5% of the graduating seniors each year.

   o The industrial beneficiaries should establish a fund to support a layered competition for engineering fellowships for 5% of the graduating seniors each year.

*Here layered implies participation in structuring the competition by all funding agents. This 10% added to the existing 4% Ph.D. consort in engineering would then reach one-half of the Ph.D. consort (28%) for scientists in the U.S.

2. Equipment Grants to Universities. Since U.S. engineering colleges are $750,000,000 behind in their equipment needs (over the last decade), it is recommended that:

   o Continue the tax incentives to industry to provide equipment to universities at a small penalty.

   o Make special competitive funds available to disciplines who cannot easily attract industrial equipment grants.

3. Industrial R&D Grants to Engineering Colleges. Since only 2 to 3% of all university R&D is funded directly by industry, it is recommended that:

   o Establish a new tax incentive to industry where a minimal penalty is incurred by making negotiated, mutual benefit, research grants to universities.

4. Science in the High Schools. Since science preparation in the high schools has weakened in the past few years, it is recommended that:

   o A mandate be established for enhanced science education in the high school by means of more direct federal incentives.

   o Higher college entrance standards for science be established on a national basis.

X. Comments on the Bill (H.R. 5254)

Generally, the bill meets this reviewer's approval. There are a few specific comments that may prove helpful:

1. Page 2, Lines 8-10, I would prefer: . . . with particular concern for fields of high economic or defense sector importance such as electronics, information technology, manufacturing, and energy.

2. Page 5, Lines 19-20, I would prefer:

   (C) The Chairman shall be appointed by the Head of OSTP. This is considered necessary to keep this commission dedicated to the manpower task. The Chairman of the NSB has too broad a responsibility to also fulfill this post.

3. Page 9, Lines 18-21. These matching grants do not have sufficient definition to work--what funds are being matched? It would be best initially to restrict funding to graduate student support. As the program develops a broader support could be envisioned.

4. Page 11, Lines 1-4. Relative to the magnitude of the funding required to have impact on the distributed system of engineering schools (See Section IV of this testimony), the level of the manpower fund can only be considered a first step towards a program of sufficient strength to be effective in establishing national policy.

Appendix A

ENGINEERING AND

MANUFACTURING MANPOWER NEEDS

D. Tesar, Director
The Center for Intelligent
Machines and Robotics
University of Florida
Jan. 18, 1982

One of the important questions facing the nation today is the increasingly tenuous supply of well trained engineering graduates. This limited supply is becoming distinctly noticeable in two sectors where engineering talent is essential. The first sector is in manufacturing. It will be argued briefly that our engineering manpower is approximately 1/10 of the need represented by the economic reality in the marketplace. The second sector involves engineering program functions in the military. Here the technical developments are certainly as sophisticated as they are anywhere. The primary difficulties arise from lower pay and restricted quality of life and from the lack of flexibility of the military services to remain competitive in the manpower market.

1. Status of U.S. Engineering Manpower

a. Manufacturing Manpower. The most pervasive technology associated with wealth generation is manufacturing. In this regard, the various percentages of GNP for the wealth generators can prove instructive:

Wealth Generator	% GNP
Manufacturing	24.4%
Extraction	5.0%
Construction	4.5%
Agriculture	3.0%

This shows that manufacturing is dominant. Half of the nation's R&D is associated with manufacturing. Consequently, many suggest that there is a proper balance between policy and economic reality. Unfortunately, this broad brush view does not reveal the real dilemma.

The primary problem is associated with "mechanical" manufacturing of such items as automobiles, textiles, shoes, cameras, entertainment electronics, etc. Considering the 20 most negative trade balance generators in the mechanicals, the aggregate loss in 1978 was $34 billion. Not considering trade in automobiles and aircraft, the mechanicals represent 60% of our manufactures trade. Yet, this 60% of our trade receives only 6% of our nation's manufacturing R&D and therefore the participation of not more than 6% of our engineering manpower. The conclusion is that we have an imbalance of 10 to 1 in the economic reality versus the available resources to respond aggressively to meet new opportunities or challenges [1].

The situation with federal policy is even more serious. Only 0.7% of the federal manufacturing R&D is associated with the 60% of our manufactures trade in the mechanicals. This represents an imbalance of 100 to 1. It is particularly alarming since much of the federal R&D goes for basic research in the universities and in that role is used to generate new manpower. The conclusion must be that our universities are not being enabled to produce specialists in manufacturing.

b. University Engineering Education in 1980. The issue of balance of priorities also exists in the university training of engineers. The following quote [2] by Dr. Lewis Branscomb, Chairman of the National Science Board, illustrates this point.

> "Many people in industry feel that U.S. engineering education overemphasizes preparation for careers in R&D at the expense of training in design for manufacturability, design and production automation, and manufacturing engineering - all areas vital to achievement of high quality, low cost products in American industry."

This statement is very much to the point. The only weakness is that it is not explicit enough about the very low priority given to manufacturing disciplines in our universities. Relative to the machine tool technology and system automation seen in industry, universities have archaic equipment with which to teach and to perform research in manufacturing. The present author is not aware of any institution having research facilities similar to those he has visited at the Technical Universities of Aachen, Stuttgart, Leuven, Eindhoven, and elsewhere in Europe. Dr Ray Bisplinghoff* of the National Science Board estimates that the U.S. engineering college shortfall in equipment during the past decade has been $750,000,000 or approximately $3,000,000/college.

It may be concluded that a significant problem for the nation is the low emphasis of manufacturing in the universities. What is even more disturbing is that the vitality of the engineering schools and their ability to respond has considerably weakened during the past decade [3]. The following facts support this contention:

- During the past decade enrollment has increased 50% while the faculty has been reduced by 10%.
- 34% of all graduate engineering students were foreign nationals in 1979.

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* In a speech given at the University of Florida in April, 1981.

- NSF indicates that most university laboratories fare poorly relative to non-university laboratories (the Federal FY 82 budget for university laboratory instrumentation was reduced from 100,000,000/yr to zero).
- Major needs for Ph. D.'s now exist in areas associated with productivity and innovation.
- The production of Ph. D.'s has dropped form 3774 in 1972 to 2751 in 1980. Further, of these, 46% were foreign nationals, a percentage that has risen from 20% in 1964. [4]
- Student fellowship support for engineering is woefully inadequate relative to salaries now given in industry (the Federal FY 82 budget for science/engineering fellowships was reduced from $112,000,000 to $21,000,000/yr).
- 1800 unfilled faculty positions now exist in schools. Entrance level salaries for Ph. D.'s into the faculty ranks are equivalent to the salaries their B.Sc. students now receive in industry.
- The benefits of an extended tenure of students in engineering education is high. One year of post baccalaureate work almost doubles a student's exposure to science and engineering. Contrary to most university fields, a large percentage of engineering Ph. D.'s (2/3) go to industry upon graduation.

Policy makers must realize that engineering education is not keeping pace with the needs of U.S. industry and society. The discipline of manufacturing is the clearest example of this weakness. The Society of Manufacturing Engineers (SME) is promoting graduate education and research in the universities. Their support is projected for $1,000,000/year by 1984. Only one program at NSF directly deals with manufacturing for $3,000,000/year. In total, not more than $10,000,000/year of related research funding comes from NSF. Overall, no major facility exists within a university in this country for manufacturing. Fortunately, movement is occuring but much must be done to remain competitive with organized programs as represented by those in Japan and Germany.

c. Foreign Engineering Manpower Development (Russia) vs. that in the U.S. As mentioned in the first section describing our manpower needs, the primary threats to the U.S. originates in Japan and northern Europe for our civil sector and in Russia for our defense sector.

The consensus of the civil sector threat in engineering manpower was recently presented in testimony to congress by Frank Press, Carter's science advisor [5]:

> "Although Japan's base population is roughly one-half of ours, the National Science Foundation reports that in recent years the number of degrees granted in Japan to engineers has surpassed the number granted in the United States. In Japan, 20 percent of all baccalaureate and 40 percent of all master's degrees are awarded to engineers compared with a figure of about 5 percent at each degree level in the U.S.
>
> This same report shows an overall picture in Germany of a very high level of science and mathematics achievement among high school and college graduates. It appears that while our excellence in basic research is secure, our ability to apply technology to industrial pursuits may be inhibited by the relatively low level of scientific and mathematical competence of our non-scientists and, in some respects, by the apparent cooling of science interest among our students generally."

The following data from the September 1980 issue of the Atlantic Monthly provides perspective on the relative manpower priorities in the U.S. and Japan:

Manpower Category	No. of Professionals/10,000 pop. U.S.	Japan
Engineers/Scientists	70	400
Lawyers	20	1
Accountants	40	3

Another perspective about U.S. engineering manpower can be obtained from the following table:

Country	% Bachelor's With Engineering Degree
U.S.	5%
Japan	15%
N. Europe	20%
Eastern Block	40%
Russia	40%

Obviously, the U.S. has not kept a balance in priorities sufficient to support a strong environment for technology and manufacturing. This does not bode well for the civil sector and has severe implications for the defense sector as well.

d. The Russian Manpower Threat. One of the most significant threats to the defense of the nation comes from the growing Russian strength in engineering manpower [6]. The status of this imbalance is best demonstrated as:

	No. of Engineers Graduated/year	% of all Bachelors	% of Engineers in Defense Sector
U.S.	60,000	5%	25%
Russia	300,000	40%	60%

This data shows that Russia has a growth in strength in defense engineering manpower 12 times faster than that in the U.S.

The problem presented above is much more severe than the numbers indicate. A recent study of a national plan in place in Russia over the past decade [7] shows that a cohesive and effective transformation in their educational system has taken place. Not only are they doing well in educating engineers and scientists, they are doing exceptionally well in their high schools to prepare them for direct entrance into the military forces or for entrance into the university system as this quote [6] indicates:

> "In order to appreciate the scale of Soviet educational expansion, it is worth remembering that during the Stalin era, the secondary school graduation rate was as low as 5 percent - out of 1,000 childern entering the first grade in 1930, only 49 percent completed the tenth grade in 1940. In 1957 - the year of Sputnik, and just prior to the Khrushchev reforms of 1958 - no more than 1,728,000 students graduated from secondary schools. In June of 1978; however, after years of extraordinary investment and effort culminating in the introduction of compulsory ten-year schooling in 1975, over 5,200,000 students graduated form secondary schools of all types, a success rate of 98 percent (In the United States, by contrast, about 75 percent graduate form high school. Also note* that only 13% of U.S. high school graduates are adequately prepared for entrance into engineering programs, a drop by a factor of two from 28% in 1972). In the same year, 2,300,000 students graduated from technical-vocational schools, with qualifications for skilled work. Over 1,200,000 students graduate annually from secondary schools for middle-level professional, over two-thirds in engineering, agriculture, and management. In combination, these school systems produce over 3,000,000 skilled workers and middle-level technicians for the Soviet economy each year."

Some elementary statistics may bring this threat into sharper focus. For example:

> "... over 5,000,000 graduates of Soviet secondary educational institutions in 1978 and 1979 studied calculus for two years while 105,000 United States high school students have taken a one year calculus course (1976)."

This is a competitive ratio of effort in this indicator of 100 to 1. This relative strength of the compulsory elementary and secondary program can be best evaluated in terms of the years of required training in science based subjects:

*"Engineering and High Technology Manpower Shortage: The Connection with Mathematics," Southern Regional Education Board.

Topic	Years of Study Russian	U.S.	Russian Advantage
Algebra	5	3	2
Geometry	10	2	8
Calculus	2	?	≈ 2
Physics	5	1	4
Chemistry	4	1	3
Astronomy	1	0	1
Biology	5.5	2	3.5
Geography	5	≈ 2	≈ 3
Drafting	3	0	3
Workshop	10	4 (?)	6 - 10
	50	15	35.5 - 39.5

The conclusion is that while the training preparation in the sciences is increasing in Russia, the preparation in the U.S. is declining. Wirszup [7] concludes:

> "It is my considered opinion that the recent Soviet educational mobilization, although not as spectacular as the launching of the first Sputnik, poses a formidable challenge to the national security of the United States, one that is far more threatening than any in the past and one that will be much more difficult to meet."

e. Defense Engineering Manpower Needs. The manpower problem facing the Department of Defense is common to all services. W. Holden of the Navy Systems Command points out [9] the following facts:

- "The U.S. share of the world shipbuilding market is 2% down from 11% in 1960. Japan now has 48% of the world market."
- "Of 39 of 70 distinct shipbuilding technologies, best industrial practice was not found anywhere in the U.S."

H.K. Latimer of the Navy Underwater Warfare Division [6] recommended:

- "Place greater emphasis on grants and other support to colleges and universities to better meet the serious shortage of engineers."
- "In its 'tools for schools' program, the Pentagon is continuing to directly assist non-profit institutions to reduce the cost burden in establishing training curriculums."
- Manpower needs are increasing for technical judgement and inspection since systems "with automation and intelligent machines will be utilized for dangerous, repetitive, fast and/or highly accurate processes" will become more pervasive.

In October, 1981, General Robert T. Marsh, Commander of the Air Force Systems Command, presented a balanced view of the U.S. engineering manpower needs and how the present condition affects the Air Force [8]. His views are not in variance with the preceding documentation. Specifically, the following comments apply to Air Force needs for engineering manpower:

- "there is no facet of the Air Force acquisition process which does not depend on the technical competence of scientific and engineering people. At one end of the spectrum, we conduct pure research in the laboratories to provide new ideas or state-of-the-art improvements in the mathematical, physical, engineering, environmental, and life sciences. At the other end, test centers rigorously 'check out' and evaluate a weapon system as it is being brought to operational readiness.

- "In 1968, the Air Force recruited over 5 percent of the college engineering graduates. Currently, we are able to recruit about one and a half percent - far short of our goals."
- "Since 1976, we have seen our engineering resource base steadily erode to the point that now the Air Force as a whole is nearly 1,100 military engineering officers short of our minimum needs. AFSC alone is short 500 military engineers - or ten percent."
- "Lieutenants with engineering backgrounds now comprise one-third of AFSC's total engineer force - by 1985 it will be one-half. These individuals are inexperienced and obviously do not compensate one-for-one for the experience we have lost in recent years."
- One of the Air Force initiatives is an "Increase in the Air Force Institute of Technology programs, both at the undergraduate and graduate level. This year, 160 newly commissioned officers and 60 from active duty with technical degrees were sent to AFIT for a BS in electrical or aeronautical engineering - an increase of 100 over last year. On the graduate side, approximately 570 highly qualified officers were sent back to universities to to receive advanced engineering and scientific degrees - a 12 percent increase.

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8. R.T. Marsh, "Testimony to Congress - Engineering Manpower," House Science and Technology Committee, October 6, 1981.

9. W.F. Holden, "Some Applications and Limitations of Industrial Robots in Shipbuilding," Robotics in Shipbuilding Workshop, Todd Pacific Shipyards, Oct. 13-16, 1981, Long Beach, California.

Appendix B

(From a presentation at the 1979 Engineers Public Affairs Forum.)

Our Weakening Trade Position in Manufactured Goods: A Commentary on Mechanical Technology

By Delbert Tesar
Director
Center for Intelligent Machines and Robotics
Mechanical Engineering Department
University of Florida

TRADE

Purchasing power of the dollar is down by more than 50% since 1965. Imports of non-manufactures show a relentless growth capable of major damage to our economy.

Trade in manufactures experienced a $20 billion boost in the period of 1972-1974. The balance became marginal in mid-1978 and distinctly negative for all of 1978 (−$9.5 billion). There exists a "hidden technology deficit" due to the 1972-1974 boost of approximately $30 billion. The trend on deteriorating trade in manufactures was evident by 1966 at which time our investment in R&D also leveled off.

Seventy-five percent of our trade in manufactures is essentially mechanical in nature. The balance in mechanical manufactures was a deficit of $5 billion by 1972, experienced a $14 billion boost in 1972-1974, and then become distinctly negative by the end of 1978 at the level of minus $6.5 billion. There exists a "hidden technology deficit" due to the 1972-1974 boost of approximately $20-25 billion in Mechanical Manufactures. The trend on deteriorating trade in mechanical manufactures was evident before 1965 and definitely quite dominant by 1970.

Trade in heavy machinery has been positive over the past 15 years but has experienced a $5 billion deterioration in the past two years. Light machinery has been consistently negative since 1964 and now shows a $10-12 billion trade deficit in 1978. The field of aircraft remains strong although the European consortium and the Japanese have put us on notice that they intend to invade that market. Cars and trucks are nearly a disaster. Virtually no academic research is ongoing to directly support the manufacture of vehicles. The loss for 1978 was $10.3 billion. Chemicals are expected to remain strong because of a widespread R&D activity. Electrical systems are also expected to remain strong for the same reason. Chemicals and electricals benefit from 40% to 60% of our domestic R&D expenditures. They represent, however, less than 25% of our trade in manufactures. Mechanical technology which represents nearly 75% of our trade gets surprisingly little (approximately 0.7%) of our non-defense oriented federal R&D budget. Japan expects a 1978 surplus in manufactures of $63 billion, that of West Germany is $49 billion, while the U.S. shows a $9.5 billion deficit. Yet, the energy self-sufficiency is just the reverse—5%, 40%, and 75%, respectively. The 20 most negative trade categories closely associated with mechanical technology generated a $34 billion deficit in 1978, and it is worsening rapidly.

PRODUCTIVITY

Following is a break-down of the ingredients in generating productivity during the past 40 years in the U.S.:

Technology	38.1%
Capital	25.4%
Labor Quality	14.3%
Economies of Scale	12.7%
Resource Allocation	9.5%

E. Denison, Brookings Institute, 1978)

This shows that technology is dominant in protecting our standard of living.

Over the past 15 years, our Western trading partners have all had higher annual productivity growth than the U.S.:

Japan	10.5%	France	6.0%
Netherlands	7.5%	West Germany	5.8%
Sweden	7.1%	Switzerland	5.3%
Belgium	6.5%	Canada	4.3%
Italy	6.4%	United States	3.4%

From 1970 to 1977 the accumulated increases of productivity also show the U.S. lagging:

West Germany	48%	Canada	25%
France	42%	United States	21%
Italy	38%		

Labor Department figures show that productivity in the non-farm sector grew only at 0.6% in 1978. Council of Economic Advisors now suggests productivity growth in the non-farm sector is not more than 1.5% per year up-to 1985. Dr. Alice Rivlin, director of the Congressional Budget Office, estimates that real GNP growth for 1979 will be between zero and 2%. Latest Department of Commerce figures show that the rate of growth of our Gross National Output is declining: 1976—5.7%, 1977—4.9%, 1978—3.9%.

R&D COMMITMENT

About 50% of our national R&D is used to support manufacture. About 83.5% of our federal R&D budget goes to electronics and aircraft manufacturing. Only 1% of NSF's R&D budget goes to mechanical technology, the base of more than 70% of our total trade. Precedent for university-sponsored federally funded research and development centers exists of which the top ten average $125 million per year each. Only 7% of engineering basic research is mechanical of which at least half is in the thermo-sciences. Engineering represents 9% of the total federal basic research effort and mechanical engineering represents only 0.6%. Machinery R&D (both federal and industrial) represents only 6% of the national total to protect 60 to 70% of our trade. Machinery and textiles receive only 0.7% of the federal R&D budget for manufactures. Federal funds support only four percent of the machinery R&D, yet it supports 40% of the electrical and 77% of the aircraft and missiles R&D. Interestingly, 50% of our limited machinery R&D goes into office machines which represents only 3.3% of our manufactures trade.

INVESTMENT

Annual investment of capital per worker shows the U.S. is lagging:

	1967	1973
West Germany	$298	$693
Japan	$191	$324
United States	$258	$220

Percent of Gross Domestic Product invested annually in plants and equipment also shows the U.S. is lagging:

1947-1967 ....3.0% 1973-1977 ....1.3%
1967-1973 .... 2.5%

Latest Commerce Department figures show that new orders from non-defense capital goods (plants and equipment) declined 7.4% in November 1978 and 3.8% in December 1978.

Rate of savings per unit of income is 3 to 4 times lower in the U.S. than Europe and Japan and that rate in the U.S. has been declining.

1976	7.5%
1977	5.1%
1978	5.3%

BASIS FOR THE SOLUTION

In Japan, the research and development efforts of universities, government, and industry are closely linked to large-scale industrial ventures destined for commercial application. Considerable support is given to new manufacturing technologies. The West Germans have been doing the same for two decades. Canada now is establishing five technology and innovation institutes.

Simon Ramo of TRW says that the bottleneck is not science and technology per se but in the arrangement process among government, private enterprise, and science and technology. In fragmented industries, no single firm can introduce certain critical operational changes; the cooperation of many others, both within and outside industry is needed.

The lack of close relationships between engineering schools and manufacturing industries also impedes the technological innovation process—a barrier not present in some of the major competitive countries.

The Cooperative Agreement Act of 1977 (signed February 1978) was established to enhance government, industry, and university cooperation by:

1. Strengthening the existing processes for grants for basic research and procurement for specific federal needs by defining a separate and distinct process for assistance.
2. Creating a new pathway (or pathways) of assistance which would enable the rapid, controlled diffusion of developing technology to industry so that it can create new innovative technology and, hence, products and services for the marketplace.

Assistance processes will yield results only when industry participates in the formulation of priorities and commits sharing risk capital to meet agreed upon goals. R&D performing institutions must be effectively linked to those institutions that actually produce and deliver goods and services, whether in the public or private sector, if the assistance of innovation is to be effective.

Fostering the adoption and widespread diffusion of new technology presumes that federal officials possess the knowledge of market factors which govern this diffusion. Many existing agency support programs suffer from a weakness in this key management responsibility. President J. F Bucy of Texas Instruments notes that:

> "One striking difference between engineering education in the U.S. and West Germany is the production of engineering graduates for careers in manufacturing. This tradition is well established in Germany and weak in the U.S."

SOLUTION

Since about 75% of our trade in manufactures is associated with mechanical technology and since very little federal agency activity now exists in the United States by comparison with other countries it is recommended that:

- A cohesive and structured national program for mechanical technology and manufacturing be established.
- Ten centers attached to geographically distributed universities be formed as the focus of the following technologies: 1. Light machinery; 2. heavy machinery; 3. manufacturing processes; 4. industrial robots; 5. human augmentation and prostheses; 6. remote robotic systems; 7. artificial intelligence; 8. electro-mechanical components for intelligent machines; 9. tribology; 10. engineering economic and human factors.
- Heavy participation of industrial governing boards should guide the missions of each of these centers for the appropriate class of technology.
- There be heavy involvement by the federal agencies, initially, perhaps with as much as 75% of the funding.

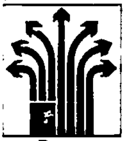
  This funding would reduce to a residual level of 25% to maintain/a centralized control and oversight function.
- The state or local region should provide land, buildings, and a constant level of 25% funding because the geographical region would be an immediate and continuing beneficiary.
- After a period of operation (perhaps five years and not more than ten years), the center would be required to bring in 50% of its funding by direct negotiation with interested industrial parties and groups of industries seeking solutions of real technological problems.
- The educational role of the centers would be substantial in keeping practicing engineers and scientists abreast of the latest developments in the mission area no matter where these developments occurred in the world.
- Each center would have specially trained management intimately aware of needs by participating industries of the mission area.

Technical Opportunity for Light Machinery

The industrial sewing machine Consew (produced by Toyota of Japan) runs faster, is more reliable, has four times less downtime for bobbin interchange, and costs 25 percent less than a similar U.S. machine. Another example involves a new tobacco manufacturing plant in Georgia which is the third largest in the U.S. All of the machines are of Italian, German, or English origin and are maintained by foreign craftsmen. The plant manager confirms that appropriate U.S. technology did not exist in 1976 to fulfill the specifications for competitive machines.

The U.S. failure in electronic cameras. The electronic camera contains sensitive electronic sensors that detect levels of light and transmit this information to a digital micro-processor, which then automatically sets the f-stop and shutter speed. The precision built into the machine comes from the intricately designed mechanical shutter which typically moves at 4 meters/second. The electronic controller must release the first shutter or curtain and then release the second or closing shutter within an allowable error of 1/10,000 second. The 1978 trade loss in cameras was $496 million, ten times the total NSF engineering research budget. The nature of this technological deficit is further highlighted when it is realized that all precision camera systems for aerial photogrammetry are now imported.

The U.S. failure in entertainment electronics. Television and radios show a trade deficit of $2.77 billion. Not only is this deficit worsening rapidly, but the ratio of imports to exports is four to one in televisions and 15 to one for radios. It is well known that Japan and other Far East countries have been able to accomplish this by having not only higher level electronic technology but also superior manufacturing quality. Much of the manufacturing quality is due to improved machine precision and automation in the component manufacture and the chassis assembly, both of which are dominated by light machinery technology. They intend to invade our markets in computers and micro-electronics (already marginal in trade) which today represents a $41 billion business within the U.S. Our inability to develop technology for quality mechanical manufacturing may prove to be our Achilles heel in this economic confrontation.



This intimate awareness is essential to enhance the required negotiations in the formulation of the assistance plan, in the performance of the task, and in the assessment of the results for further distribution.

- It is necessary that each of these centers represent a critical mass of principals capable of meeting the most advanced needs of industry. It is suggested that 50 principals and 100 support personnel would be warranted for four to five of the centers and about half that for the others.
- The prestige, effectiveness, and focus of these centers would be enhanced by a meaningful financial base. Hence, a total program of $100 million/year is recommended. This represents only 1% of our yearly loss in light machinery and its products alone. To do less is not to face the problem which is an increasing deficit already exceeding $20 billion/year and potentially much greater.

Since technology represents about 40% of our productivity base, concerted activity at this time is essential to prevent a further worsening of our technology gap. No action now will result in a much greater tax on our people which last year cost them 2½% in their standard of living.

Not solving this problem means that more jobs will be shipped out of the country, the decreasing value of the dollar will accelerate, clean light industry will be built in other countries, and the corrective pressures on our technological institutions to take compensating measures will decrease.

NATURE OF MECHANICAL TECHNOLOGY

Two major technical opportunities. Two major opportunities face the industrial community. These are (1.) the development and use of modern research and design tools to establish a resurgence in the fundamental field of machine science and (2.) the full use of distributed electronic sensors and computers combined with mechanical production devices to create more effective production systems.

Machine science is basic. Many designers have given up on our weakened mechanical technology. Since mechanical operations are mandated by human existence it would, however, be appropriate to treat the science of machines as fundamental in its own right and then augment its application with every feasible combination of electronic sensing and control. This is the major opportunity facing light industry today. It is clear that our competing industrial countries are already pursuing this opportunity. If it is energetically pursued by the U.S., a new generation of machines could evolve to reestablish the relative vitality of American industry.

Light machinery design. Light machines generally employ highly geometric devices of numerous parameters that require sophisticated or high technology design procedures to achieve optimum results. The designers of the steam locomotive spent their lives perfecting the complex valve control linkages. In many ways, today's designers frequently develop machines by the same trial and error methods, with a remarkable expenditure of time before a usable machine is obtained. An effective machine science augmented by modern computer interactive programs would drastically reduce this design-to-product cycle time.

Character mechanical systems. Mechanical devices can create large repetitive forces, provide precision at high speed, consume very little energy, have a long life with high reliability, and generate virtually no noise. Unfortunately, such systems based on cams, gears, and linkages are highly non-linear multi-parameter systems whose design is only partially understood. These systems may easily contain 50 independent design parameters making their optimal design a major unsolved task.

Weakness in machine technology—why? Work on machine science has been ongoing in Germany for 100 years. By contrast work of this class began in the U.S. only 25 years ago. During the first half of this century, companies hired expert designers from central Europe to compensate for our own inactivity. Consequently, little pressure developed on the universities to provide excellence in education of technology in this field. Even during the funding heyday following Sputnik (1957), the machine community did not respond and thus benefit from a surge of activity as did other technologies.

Nature of Robotic Technology

Intelligent machine. The integration of sensors, computers and adjustable mechanical structure would create an intelligent machine capable of perceiving the environment in which it exists and making an appropriate response. Today's example is the electronic camera. Tomorrow's opportunity could well be a full spectrum of robotic devices to assist the surgeon or to do remote maintenance in hostile environments. The micro-electronics revolution has produced a $41 billion-per-year industry and has created 100,000 new jobs. Its effectiveness will increase immensely when micro-electronics are coupled with versatile mechanical devices to make intelligent machines. Because of the weakness of mechanical technology, this is taking place either rarely or not at all.

The robotic system. The robotic system is in many ways the technological equivalent of the human system, having components such as sensors (eyes), actuators (muscles), and a computer (brain) which allow the system to perform mechanical functions by reacting to needs in its environment that it perceives and interprets. Such systems are of particular economic importance to the pressing problem of remote maintenance of nuclear systems. Complex robotic systems are not completely controllable by a human operator; his role must be augmented by digital computation. This will be one of the most demanding engineering problems yet to be fully addressed by the machine science community in the U.S.

Applications of robotics. Other applications for robotics are: Offshore oil well drilling and maintenance, coal mine accident, missions deep submergence vehicles surveillance in the ocean, on land, and in space; micro-surgery human augmentation for manufacturing prostheses for the handicapped, industrial automation and assembly, removal of operator from hostile environment.

Robotics as catalyst for machinery development. Since robotics is an emerging technology of great interest, it could become the vehicle for technological development in the whole field of mechanical design science. It is expected that as more electronics are integrated into basic machines and as robotic devices are more widely applied, a general blending of the whole spectrum will occur. Because every mechanical function of the robotic system must be electronically controlled, the robotic device will perhaps represent the ultimate marriage of these two technologies.

Are robotic systems needed? It has been shown that the 1978 trade deficit associated with the worst 20 deficit generators in mechanical technology was $34 billion. Are robotics technology and its supporting scientific and industrial communities going to face a similar fate? Can our defense posture be maintained without the highest quality in this technology? It may be argued that measurable economic and military weakness will result unless government leadership now takes steps to create the foundations for a concerted national robotics program.

Significance of the robotic system. It is generally accepted that the robotic manipulator has the same relative importance for mechanical systems as the digital computer has for electrical systems.

Appendix C

UNIVERSITY OF FLORIDA

ROBERT Q. MARSTON
PRESIDENT

April 22, 1982

The Honorable Don Fuqua
2266 Rayburn House Office Building
Washington, D.C. 20515

Dear Don:

As you know, we share your concern in the matter of how our Nation, the State of Florida and the University of Florida can work toward the production of a well-trained, adequate and stable pool of scientific and engineering manpower. We have read with interest H.R. 5254 introduced by Mr. Walgren and yourself. In our judgment this is an important piece of legislation and one which should make a significant contribution toward helping solve the problems of scientific and engineering manpower shortages.

The design you have used for the Coordinating Council in operating it within the NSF structure seems appropriate as does the proposed composition of the Council. The provision which allows expenditures on "such research fellowships, capital equipment, salaries, instrumentation and other activities as the Council considers necessary in carrying out the intent of this Act," seems broad enough to make it truly useful. We feel also that the provision for assessing both short and long-term technical engineering and scientific human resource needs as an important contribution and if carried out well, will give universities, industry and government a chance to plan realistically their responses to the Nation's needs.

Don, we are grateful to you for introducing this legislation and are willing to help you in any way that we can to secure its passage through the Congress.

Sincerely,

Bob

Robert Q. Marston
President

226 TIGERT HALL, GAINESVILLE, FLORIDA 32611 904-392-1311
EQUAL EMPLOYMENT OPPORTUNITY / AFFIRMATIVE ACTION EMPLOYER

Mr. SHAMANSKY. Dr. Tesar, we turn into a pumpkin at noon here.

Dr. TESAR. Yes.

Mr. SHAMANSKY. Your comments with respect to manufacturing prompt me to note that I have submitted a bill called the "Automobile Research Competition Act," and the equivalent bill was put in the Senate by Senator Stevens, the senior Senator from Alaska who is the majority whip in the Senate. It is a response to the apparent inability of our manufactuers of automobiles to go to the next generation of automobiles, for whatever reason. "Why" is beside the point. The fact is that they have not. So we are trying to deal with this to provide an incentive for competition which was a method used in the last century to stimulate manufacturing. We are trying to get back to becoming a manufacturing country.

I thought what you were saying was very interesting to me for the very reasons that we are falling down. I don't think the country is aware that we have missed—it seems to me also that General Motors was so long creating the market, it forgot how to cater to the market. It is not quite the same thing.

I want to thank you so much for your fascinating testimony.

The hearing is adjourned.

[Whereupon, at 11:55 a.m., the subcommittee was adjourned.]

H.R. 5254—ENGINEERING AND SCIENCE MANPOWER ACT OF 1982

THURSDAY, APRIL 29, 1982

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to recess, at 9:35 a.m., in room 2318, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Present: Representatives Walgren, Fuqua, Dymally, Heckler, Weber, Gregg, and Skeen.

Mr. WALGREN. Good morning. This is the second day of our hearings on H.R. 5254, a bill entitled the National Engineering and Science Manpower Act of 1982. Tuesday we heard from a number of witnesses regarding the importance of this legislation and the issue in general.

As noted forcefully by the former astronaut and now Senator John Glenn, "If we do not make the investment and the effort to produce the technical, scientific, and engineering manpower that we are surely going to need in great numbers in the future, we will one day look back with regret at this time and mark it as the time when the United States began a slide into becoming a second-rate technological power."

Obviously we must take action to prevent such a forecast from coming true.

Today we will be hearing from the administration's Office of Science and Technology Policy with their views on this proposal. Before that, we will be hearing from Virginia Governor Charles Robb as well as a number of other witnesses.

The committee looks forward to the testimony. Particularly for the record I want to apologize on behalf of some of the other members that are not here yet but will be coming.

Governor Robb, we are very glad to have your participation in these hearings. It has become clear to those of us who have tried to give attention to the development of our technological economy that much more has to happen on the State level, and particularly through State governmental authorities, than we could hope to make happen on the national level. This is most evident in the area of education.

Therefore, although we want to be strong supporters, we know in our system of government that nothing happens unless there is concern and execution on the State level. I truly salute your interest in this because if we do not have the interest of people like yourselves, both with respect to Virginia and with respect to other States, not much will happen. So much of this is related to the universities of our States and to the talent pool that the State level is in the proper position to develop, that we must rely on you.

Therefore, welcome to the committee. We appreciate very much your coming and look forward to your testimony.

STATEMENT OF HON. CHARLES S. ROBB, GOVERNOR OF THE STATE OF VIRGINIA

Governor ROBB. Thank you, Mr. Chairman. I am delighted to be here and to find out this morning that you are at least a constituent, although not a voting constitutent, as I understand. I am delighted to be here before you and, in absentia, the members of the subcommittee. I am very pleased to appear today, not only as Governor of Virginia but also as a representative of the National Governors' Association.

I am going to assume that you and the members of the staff and most of the members of the subcommittee have probably already had a chance to read the testimony that I submitted in advance. But I also assume that some of the others that are present this morning to follow these hearings for other reasons may not have had access to it. Therefore, I will use part of it but I will abbreviate it in some places, if I may.

Mr. WALGREN. The full statement will be made part of the record.

Governor ROBB. Thank you. I appreciate that very much.

Mr. WALGREN. Fine.

Governor ROBB. I am also a member of the NGA task force on technological innovation, and I would like to discuss with you matters that lie within the charge of your subcommittee and that are also of great concern to us as Governors of the States.

At the outset I would submit that State government has no greater commitment than the one it has to education. Under the Constitution, the States have primary responsibility for education, and I am certainly not alone among the Governors in wishing our States could play an even larger role in developing and improving the Nation's schools, colleges, and universities.

At the same time, I believe also that the Federal Government has at least two critical responsibilities with regard to education: first, to guarantee access by insuring that civil liberties of every American are respected, and by providing financial assistance to the needy; and, second, to support research that is in the national interest. I would like to focus on the problems and opportunities that various State officials face in meeting our responsibilities in an era of rapid technological development.

My testimony grows out of several assumptions. First, I assume that the industrialized world stands on the threshold of a technological revolution that will change the American way of life and the composition of the Nation's work force as much as the industrial revolution did a century ago.

Second, I assume that our ability to lead this technological revolution—as indeed the United States led the industrial revolution a century ago—will bear directly on our share of world markets, a share that in my judgment will continue to erode unless we act promptly and wisely.

Third and finally, I assume that the essence of federalism lies in sharing responsibilities, and that the private sector must also contribute to and benefit from a properly designed partnership. In my judgment, the reasons for the introduction of H.R. 5254, the National Engineering and Science Manpower Act of 1982, and for these hearings are found in the answer to a basic question, and that question is, "Are American students, schools, universities, and workers ready to meet the challenges and changes created by an information-based, technically-oriented society?"

Unfortunately, the statistics portray a nation as yet unprepared for tomorrow's marketplace. In our secondary schools, only one-third of the students take math beyond the 10th grade. Sixty-five percent of the 17-year-olds surveyed nationally in 1979 could not solve multistep word problems. A majority could not perform acceptably an exercise measuring scientific literacy.

The situation is especially critical when our schools seek teachers of math and science. The Scientific Manpower Commission tells us that our colleges and universities awarded fewer than half as many bachelor's degrees in mathematics and science in 1980 as they awarded in 1970, and it seems to me that that is cause for real concern.

The Southern Regional Education Board recently reported that the United States is graduating each year fewer than 1,000 individuals trained to teach mathematics. In my own State, during 1979 only 17 students received baccalaureate degrees in math education and only 9 in science education. Surprising as it may seem, Virginia is better than average among the States in educating teachers in these areas. At least one State has reported recently that its colleges graduated no teachers in high school science last year.

At the graduate level the prospects are bleaker yet. The number receiving master's degrees in engineering, mathematics, computer sciences, and physical sciences has decreased by more than 50 percent over the last 15 years. These shortages seem particularly acute when we compare ourselves with our foreign competition. The United States now produces only 67 engineering graduates per million population. This figure compares to 163 such graduates per million in Japan and 260 per million in the Soviet Union.

What does this mean in the marketplace? Mr. Chairman and other members of the subcommittee, I suspect you are all too familiar with that particular answer. It means that industry must raid our universities and high schools to supplement the labor pool. Lured by higher salaries and professional benefits, many science and math teachers have left schools.

The Scientific Manpower Commission found that during 1979 and 1980, almost 400 full-time engineering faculty or 2.7 percent of all permanent engineering faculty voluntarily left the universities for full-time employment in industry. In some cases the salaries earned in private industry by engineers with Ph. D.'s are almost double those of engineering professors.

There was an interesting article in the Richmond Times-Dispatch last weekend relating to this problem in significant detail, and I suspect that it was repeated in many other publications around the country.

At a recent meeting of the Governors' Task Force on Technological Innovation, one particularly distinguished participant noted that we are "eating our seed corn," and I agree with him. If we do not find solutions now, we may also find that the tractor is broken and we have no mechanics to fix it, or that the barn has burned down and we have no engineers to redesign it.

Mr. Chairman, America cannot afford to limp into the 21st century, crippled intellectually by shortages of trained personnel, and in my judgment America does not have to. The States understand that unless we act now to lay the educational foundation for the jobs of the future, the future will find us unprepared and poorly trained. Business leaders who value profits will simply find new locations beyond our Nation's borders.

I believe that our goals in the States are your goals at the Federal level: to invest in our people through major improvements in science, engineering, and mathematics education; and to stimulate and encourage innovation and technological development and to provide exciting, stable, well-paying jobs for American workers.

In my judgment, the National Engineering and Science Manpower Act of 1982 addresses these responsibilities by coordinating available Federal resources and, I hope, by providing additional incentives for State activities. As you know, this is the season for sorting out Federal and State responsibilities. It is also an appropriate time to determine who is better able to handle which educational and research functions.

In this regard, my first recommendation is that the States are best able to handle the basics—to support and govern primary, secondary, and higher education; to develop academically sound curricula that will educate productive citizens; and to support strong faculties and adequate facilities.

The National Governors' Association Task Force on Technological Innovation recently completed a survey of State actions in this area. This survey found 88 initiatives underway at the State level to increase technological innovation and productivity. I might cite some examples:

Governor Jerry Brown in California proposed a $39 million initiative to improve science education in the California schools and universities. In Michigan, Governor Bill Milliken—and I might add that Jerry Brown and Bill Milliken have been the cochairmen of this task force—Bill Milliken has put forward a 14-point plan to increase high technology development, including a $25 million high technology grant fund to support the development of robotics and mollecular biology centers.

North Carolina has a three-pronged program that includes a board of science and technology chaired by Gov. Jim Hunt, a $24.4 million biotechnology center, and an excellent statewide school for mathematics and science. This particular school ranks among the highest in the Nation in graduating merit scholars.

In Virginia, we are undertaking a comprehensive program to build critical bridges between the education community and high technology industries, specifically by: one, reshaping advanced degree offerings in high technology fields; two, by evaluating current curriculums and studying how the State can support faculties who want to improve their programs; three, by attracting math and science professionals to high schools with provisional certification while candidates satisfy the teaching requirements; four, by enhancing work-study opportunities; five, by sharing research facilities; and, six, by offering fellowships and assistantships with industry in such disciplines as computer science, engineering, mathematics, and business. There is obviously a great deal of work ahead, however, and I would hope that the Federal matching funds would be available to reinforce these efforts already underway and to encourage other States to respond.

My second recommendation is that substantial Federal support be made available for research and development in our universities. It is clearly in the national interest to retain and stimulate the capacity for research that leads to innovation and technological advances. Because at least 80 percent of all such basic research is carried out at universities, our ability to compete abroad and to provide for the common defense depends in very large part upon continued Federal support for research.

You might ask why the States do not pick up the costs of research. Well, for one thing, the States do in fact pick up the bulk of the preparatory costs for the basic research. At the public universities, the States build the teaching and research laboratories, pay faculty salaries, and provide the sustenance that allows universities to undertake the research projects that are then funded in large part by Federal agencies and others. The total State research and development expenditures for fiscal year 1977 were some $370 million. Local research expenditures for the same period were an estimated $96 million. Yet these expenditures for research, while substantial, represented less than one-half of 1 percent of total State expenditures in 1977. Even allowing for the targeted State-initiated programs that I have mentioned, standing alone, State funds for basic researc simply will not be sufficient to insure America's predominance in technological innovation.

You can expect the States to finance some research because it is very much in their own and in the national interest but what the States can currently afford obviously has its limits. We are keenly aware in Virginia, for instance, of our enormous responsibility to maintain the Chesapeake Bay and its tributaries. As you know, these waters are breeding grounds for species of marine life that are essential to the food supplies of people all over the world. Virginia and its neighbors to the north are the custodians, not just of a State resource but of a national, and even world resource. We can do some of the research that helps us to protect the great Chesapeake Bay from destructive levels of pollution but the benefits of our research extend far beyond our own borders, as do the benefits of most of the research now funded by the States, and we clearly must have Federal funds to help us do all that is going to have to be done.

My third and final recommendation is that we must develop better, more imaginative partnerships between our universities and industry. To complement the Federal-State relationship, we must share research facilities with industry and we must share the costly instruments and equipment. We must share staff because the best and the brightest of our high-technology faculties are being hired away by industry. We need to develop a system to improve the pay of faculty in engineering, computer science, and biotechnologies, to name just three pressure points, a system that is perhaps similar to that now used in the medical faculty: a combination of teaching and private practice that is sufficiently rewarding financially to keep excellent people in the basic research laboratory and in the classroom.

Some corporations, to their credit, have already come forward. You have already heard that Exxon has donated $15 million to colleges and universities to supplement salaries for junior faculty members and to fund fellowships. Carnegie-Mellon University has received $1 million from Westinghouse for robotics research, and General Motors, General Electric, and Boeing have contributed $1 million to Rensselaer for a productivity center.

However, our future good health as a nation demands that we do more. If the brain drain from universities to industry is hurting us now, the loss of outstanding intellects to teach the next generation will cripple both America's universities and its industries as this century draws to a close.

In the end, to succeed in the 21st century we must all hold up our ends of the partnership. As Governors, we have a responsibility to continue to meet the basic needs of our universities for adequate buildings, faculty salaries, and teaching supplies. We must improve the quality of higher education systems that provide a place for every American, both men and women, who want to and who can benefit from advanced education.

As our elected representatives in Washington, we would ask you to see to it that the Federal Government does not withdraw its support for basic research. Our universities need money for equipment, money to support graduate students, and money to support research faculty. In our quest for fuller partnerships with industry, we may need to offer industry incentives from both Federal and State governments and we may need to remove some barriers which at present limit the possibilities of partnership. I have instructed Virginia's industrial development and higher education planners to develop specific proposals which I hope your committee will accept as they are completed.

In summary, Mr. Chairman, my fellow Governors and I urge Congress to declare its unequivocal support for the development of advanced technologies to identify appropriate educational programs and research as a national priority in these times of economic difficulty and international tension, and to provide adequate Federal dollars when appropriate. As Governors, we pledge our support of the partnership linking the States, the Federal Government, and private enterprise. We believe that renewed emphasis on this partnership will strengthen our Nation's reputation for technological innovation and excellence. Nothing less, in my judgment, than the jobs of the next generation, and in a very significant way, America's position in the world, are at stake.

I would be happy to respond to any questions that you might have.

[The prepared statement of Hon. Charles S. Robb follows:]

TESTIMONY OF GOVERNOR CHARLES S. ROBB

TO THE HOUSE SUBCOMMITTEE ON

SCIENCE, RESEARCH AND TECHNOLOGY

April 29, 1982

Mr. Chairman, members of the Committee, I am pleased to appear before you today, not only as Governor of Virginia, but also as a representative of the National Governors' Association. I am a member of the Governors' National Task Force on Technological Innovation, and I want to discuss with you today matters that lie within the charge of your Subcommittee and that are also of great concern to us as Governors of the states.

State government has no greater commitment than education. Under the Constitution, the states have primary responsibility for education. I am not alone among the Governors in wishing our states to play a larger role in developing and improving the nation's schools, colleges, and universities.

At the same time, I believe also that the federal government has at least two critical responsibilities with regard to education: first, to guarantee access by ensuring that the civil liberties of every American are respected and by providing financial assistance to the needy; second, to support research that is in the national interest.

I want to discuss with you today the problems and opportunities state officials face in meeting our responsibilities in an era of rapid technological development.

My testimony grows out of several assumptions. I assume that the industrialized world stands on the threshold of a technological revolution that will change the American way of life and the composition of the nation's work force as much as the industrial revolution did a century ago.

Second, I assume that our ability to lead this technological revolution, as indeed the United States led the industrial revolution a century or so ago, will bear directly on our share of world markets -- a share that will continue to erode unless we act promptly and wisely.

Third and finally, I assume that the essence of federalism lies in sharing responsibilities, and that the private sector must also contribute to and benefit from a properly designed partnership.

PROFESSIONAL SHORTAGES

The reasons for the introduction of H.R. 5254, the National Engineering and Science Manpower Act of 1982, and for these hearings are found in the answer to a basic question:

> Are American students, schools, universities, and workers ready to meet the challenges and changes created by an information-based, technically-oriented society?

Unfortunately, the statistics portray a nation as yet unprepared for tomorrow's marketplace. In our secondary schools, only one-third of the students take math beyond the 10th grade. Sixty-five percent of the 17 year olds nationally surveyed in 1979 could not solve multi-step word problems. A majority could not perform acceptably an exercise measuring scientific literacy. All of us know the statistics: throughout education we have failed in recent years to build intelligently for tomorrow.

The situation is especially critical when our schools seek teachers of math and science. The Scientific Manpower Commission tells us that our colleges and universities awarded fewer than half as many bachelor's degrees in mathematics and statistics in 1980 as in 1970. The Southern Regional Education Board recently reported that the U.S. is graduating each year fewer than 1,000 individuals trained to teach mathematics. In my own state during 1979, 17 students received baccalaureate degrees in math education -- and 9 in science education. And Virginia is better than average among the states in educating teachers in these areas. At least one state has reported recently that its colleges graduated no teachers of high school science last year.

At the graduate level, the prospects are bleaker yet. The number receiving masters degrees in engineering, mathematics, computer, and physical sciences has decreased by more than 50% over the last 15 years.

These shortages seem particularly acute when we compare ourselves with our foreign competition. The U.S. now produces 67 engineering graduates per million population. This figure compares to 163 such graduates per million in Japan and 260 per million in the Soviet Union.

What does this mean in the marketplace? Mr. Chairman, you and the members of the Committee are all too familiar with the answer. It means that industry must raid our universities and our high schools to supplement the labor pool. Lured by higher salaries and professional benefits, many science and math teachers have left schools. The Scientific Manpower Commission found that during 1979-80 almost 400 full-time engineering faculty (2.7% of all permanent engineering faculty) voluntarily left the universities for full-time employment in industry. In some cases, the salaries earned in private industry by engineers with Ph.D.'s are almost double those of engineering professors. The National Engineering Action Conference describes the problem in these words:

> The United States is fast approaching a state of emergency in the institutions that educate our young engineers. There are at least 1,600 engineering faculty positions vacant, but only about 500 engineering Ph.D.'s in the nation. Few students are poised to pursue either advanced degrees or academic careers in engineering.
>
> If not addressed, the faculty shortage will inevitably bring a sharp deterioration in the quality of engineering education, with serious consequences for the nation's key industries and defense in a competitive, dangerous world.

This problem of faculty-raiding extends to the high school level as well. In 1980, the membership of the Association of High School Science Teachers decreased by 10 percent, and most of the 1,000 teachers who left were hired by industry, according to the Scientific Manpower Commission.

At a recent meeting of the Governors' Task Force on Technological Innovation, one participant noted that we are "eating our seed corn." If we do not find solutions now, we may also find that the tractor is broken and we have no mechanics to fix it, or that the barn is burning and we have no engineers to redesign it.

NEED FOR HUMAN CAPITAL INVESTMENT

Mr. Chairman, America can't afford to limp into the 21st century, crippled intellectually by shortages of trained personnel, and does not have to. The states understand that unless we act now to lay the educational foundation for the jobs of the future, the future will find us unprepared and poorly trained. Business leaders who value profits will find new locations beyond our nation's borders.

Our goals are your goals.

- To invest in our people through major improvements in science, engineering, and mathematics education; and

- To stimulate and encourage innovation and technological development and to provide exciting, stable, well-paying jobs for American workers.

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The National Engineering and Science Manpower Act of 1982 addresses these responsibilities by coordinating available federal resources and, I hope, by providing additional incentives for state activity. In 1979, a report issued by the Senate Committee on Commerce, Science, and Transportation noted that there was no "central, high-level focal point for guiding and coordinating the innovation policies and programs of the Federal Government." H.R. 5254 is one remedy for that deficiency.

As you know, this is the season for "sorting out" federal and state responsibilities. It is also an appropriate time to determine who is better able to handle which educational and research functions.

In this regard, my first recommendation is that the states are best able to handle the basics -- to support and govern primary, secondary, and higher education; to develop academically sound curricula that will educate productive citizens; and to support strong faculties and adequate facilities.

States are responding with a wide range of innovative programs geared to the technological requirements of the 1980's, and beyond. The National Governors' Association Task Force on Technological Innovation recently completed a survey of state actions in this area. This survey found 88 initiatives underway at the state level to increase technological innovation and productivity. Some examples:

- Governor Jerry Brown recently proposed a $39 million initiative to improve science education in the California schools and universities.

- In Michigan, Governor Milliken has put forward a 14-point plan to increase high-technology development, including a $25 million high-technology grant fund to support development of robotics and molecular biology centers.

- North Carolina has a three-pronged program that includes a Board of Science and Technology chaired by Governor Hunt, a $24.4 million Bio-technology Center, and a statewide School for Math and Science. I might add that this school ranks among the highest in the nation in graduating National Merit Scholars.

- In Virginia, we are undertaking a comprehensive program to build critical bridges between the education community and high technology industries, specifically by:

  (1) Reshaping advanced degree offerings in high technology fields;

  (2) Evaluating current curricula and studying how the state can support faculties who want to improve their programs;

  (3) Attracting math and science professionals to high schools by providing provisional certification while candidates satisfy teaching requirements;

(4) Enhancing work-study opportunities;

(5) Sharing research facilities;

(6) Offering fellowships and assistantships with industry in such disciplines as computer science, engineering, mathematics, and business.

We will also be conducting an assessment of the high technology industry in the Commonwealth -- there are more than 420 such firms in Fairfax County alone -- to determine how the educational and economic climate might be additionally enhanced.

o Additionally, 16 states have programs to link university research and technological development. This Committee may be familiar with the $32 million program proposed for Arizona State University as well as the successful track record of Research Triangle Park in North Carolina.

There is much work ahead, however, and I would hope that federal matching funds would be available to reinforce these efforts already under way and to encourage other states to respond.

RESEARCH REQUIREMENTS

My second recommendation is that substantial federal support be made available for research and development in our universities.

It is clearly in the national interest to retain and stimulate the capacity for research that leads to innovation and technological advances. Because at least 80 percent of all such basic research is carried out at universities, our ability to compete abroad and provide for the common defense depends upon continued federal support for research.

Why, you might ask, don't the states pick up the costs of research? I can offer three answers to this question.

First, the states do in fact pick up the bulk of the preparatory costs for basic research. At the public universities, the states build the teaching and research laboratories, pay faculty salaries, and provide the sustenance that allows the universities to undertake research projects funded by federal agencies and others.

Second, we cannot do more, because we do not have enough money. In the past several months, Virginia's higher education planning agency has surveyed all the states to determine the extent to which research equipment at our colleges and universities is obsolete, in disrepair, or simply unavailable. The results of our survey indicate that we are on the brink of crisis because many of our major institutions no longer have the equipment we need to conduct research on the frontiers of knowledge.

The third reason why the states cannot provide additional support for basic research that is in the national interest is this: no one state can determine what the national interest is. This is uniquely a federal role, to be discharged here in the nation's Capitol on behalf of all of us, after careful consultation with leaders in every walk of American life.

Total state research and development expenditures for Fiscal Year 1977 were $370 million. Local research expenditures for the same period were an estimated $96 million.

Thus, state expenditures for research, while substantial, represented less than one-half of one percent of total state expenditures in 1977. Even allowing for the targeted state-initiated programs that I have mentioned, state funds for basic research will not be sufficient to ensure America's predominance in technological innovation.

You can expect the states to finance some research that is in their own and the national interest, but what the states can afford has its limits. We are keenly aware in Virginia, for instance, of our enormous responsibility to maintain the Chesapeake Bay and its tributaries. These waters are the breeding ground for species of marine life that are essential to the food supplies of people all over the world. Virginia and its neighbors to the north are the custodians not just of a state resource, not just of a national resource -- but of a world resource. We can do some of the research that helps us protect the great Chesapeake Bay from destructive levels of pollution, but the benefits of our research extend far beyond our own borders, as do the benefits of most research now funded by the states, and we clearly must have federal funds to help us do all that must be done.

PUBLIC-PRIVATE PARTNERSHIP

My third and final recommendation is that we must develop better, more imaginative partnerships between our universities and industry. To complement the federal-state relationship, we must share research facilities and costly instruments and equipment. We must share staff, for the best and brightest of our high-technology faculties are being hired away by industry. We may need to develop a system to pay faculty in engineering, computer science and the biotechnologies, to name three pressure points, which is similar to that now used for medical faculty: a combination of teaching and private practice that is sufficiently rewarding financially to keep excellent persons in the basic research laboratory and the classroom.

Some corporations have already come forward:

- Exxon has donated $15 million to 66 colleges and universities to supplement salaries for junior faculty members and to fund fellowships.

- Carnegie-Mellon University has received $1 million from Westinghouse for robotics research; and

- General Motors, General Electric, and Boeing have contributed $1 million to Rensselaer for a productivity center.

But our future good health as a nation demands that we do more.

Make no mistake about it. If the "brain drain" from universities to industry is hurting us now, the loss of outstanding intellects to teach the next generation will cripple both America's universities and its industries as this century draws to a close.

In the end, to succeed in the 21st century, we must all hold up our ends of the partnership. As Governors, we must continue to meet the basic needs of our universities for adequate buildings, faculty salaries, and teaching supplies. We must improve the quality of higher education systems that provide a place for every American man or woman who wants and can benefit from advanced education.

As our elected representatives in Washington, you must see to it that the federal government does not withdraw its support for basic research. Our universities need money for equipment, money to support graduate students, and money to support research faculty. In our quest for fuller partnerships with industry, we may need to offer to industry incentives from both federal and state governments, and we may need to remove some barriers which at present limit the possibilities of partnership. I have instructed Virginia's industrial development and higher education planners to develop specific proposals which I hope your committee will accept as they are completed.

In summary, Mr. Chairman, my fellow Governors and I urge Congress to declare its unequivocal support for the development of advanced technologies, to identify appropriate educational programs and research as a national priority in these times of economic difficulty and international tension, and to provide adequate federal dollars when appropriate. As Governors, we pledge our support of the partnership linking the states, the federal government, and private enterprise. We believe that renewed emphasis upon this partnership will strengthen our nation's reputation for technological innovation and excellence.

Nothing less than the jobs of the next generation and America's economic position in the world are at stake.

Mr. WALGREN. Thank you very much, Governor, for that excellent statement. The committee certainly appreciates having that perspective in the record, and I know that it reflects the strong feelings of a number of Governors and State officials across the country.

I wanted to ask whether Virginia can measure this shortage of science and math teachers in the high schools now. I understand you are not graduating very many replacement teachers.

Governor ROBB. That is right. As a matter of fact, we did do a survey. Of the 140 school districts that were surveyed, we found that 49 percent of those reported extreme difficulty in securing math teachers, and at least 26 percent reported some difficulty. Thirty-eight percent of those surveyed reported extreme difficulty in recruiting Earth science teachers. Just to complete the statistics, 32 percent reported extreme difficulty in obtaining chemistry teachers and 28 percent reported extreme difficulty in securing physics teachers.

At this point, more than 5 percent of the math teachers and 7 percent of the chemistry teachers in Virginia are not currently certified.

Mr. WALGREN. Without that certification, this is where you fill in with a provisional certification, is that right?

Governor ROBB. That is correct. In other words, we feel that it is important enough to get that expertise in and to conduct the additional certification process as a teacher subsequently. We have also recently had a change in the teacher certification process generally at the State level. Our State board had taken a position initially that certain requirements were necessary for the teaching colleges and universities. That has been changed so that we have provisional certification, and we are clearly expanding in the direction of finding qualified professionals first and hoping to encourage them to enter the teaching profession by providing this provisional certification in the interim.

Mr. WALGREN. The view of a number of witnesses before this committee is that along with the crisis in the graduate education levels, is the problems associated with becoming trained well enough to even participate in college level science. That the people are not really able to get that far if they get cut off in the secondary schools by an inadequate curriculum or inadequate teaching.

Governor ROBB. Mr. Chairman, you are right on one of my favorite topics right now. We have made some similar proposals recently to the education community in Virginia. When you look beneath the surface this conflict does not exist. Mr. Walgren, there seems to be a sort of a conflict between needing to upgrade the general standards and yet get people in who may not have the background of teaching that would allow them to be certified.

Mr. WALGREN. You are referring to secondary science and math teachers?

Governor ROBB. That is right. It is our view that the most critical need is for the technical training, and the pedagogical training, if necessary, can be supplemented but the scientific training is so essential, and that is where the real drain is being experienced.

Mr. WALGREN. I notice in your statement you talk about industry incentives to stimulate this sharing that you call for. Certainly there ought to be ways that we could involve the talent that is in industry in the schools presently, if not on a full-time basis, perhaps on some shorter term basis.

Governor ROBB. Precisely what we are alluding to here. I think, for instance, an educational-industrial park offers an opportunity whereby there is an interchange of the faculty with the technology as it is being practiced. We may be able to cover both ends of the spectrum more adequately. This would be somewhat analogous to the medical profession, where they have a private practice and teach in the teaching hospitals. Something along these general lines I think really makes sense, and it is a direction that we hope to move in. Some of the other States have already, with Research Triangle, for instance, made substantial strides in this direction and we hope to follow suit.

Mr. WALGREN. Well, I certainly would appreciate for the record if you could submit, when you get them, the recommendations you refer to and, as you develop proposals to eliminate some of the barriers that have separated the private sector from the schools in particular. If the National Governors' Association has any recommendations along that line, we would certainly like to be aware of that, too, because I think we all agree that on a resource basis this problem is bigger than any of the financial resources that we see either in the Federal Government or the State governments.

Governor ROBB. I certainly would not take issue with that statement.

Mr. WALGREN. Probably it is the kind of problem that has to be solved from the bottom up, and that is where this sharing that you so underscore in your testimony is essential.

Governor ROBB. I think that this and many other areas underscore the need for a cooperative partnership among government, business, industry, and labor that may or may not have existed in individual applications in the past.

Mr. WALGREN. The Chair would recognize Mr. Skeen.

Mr. SKEEN. Thank you, Mr. Chairman.

I have no questions. I would like to commend Governor Robb and the Association of Governors for their leadership role in this particular problem which is of extreme importance to us as a country because we live by our technology. The solution must start at the State level. Don't wait for the Federal Government to take a lead. We have enough problems with our own leadership here.

I would like to toot our own horn as far as New Mexico is concerned and point out that we did, as a State, appropriate some $5 million for research and instrumentation, which I think is a new innovation for States. They have had their own share of problems with not having enough extra funds, so to speak, to put into this kind of an operation. It speaks well for the kind of response that we get from States.

Governor ROBB. It does indeed. I will include that in my list of examples. I did not want to make the list too long this time but I will attempt not to overlook the great State of New Mexico.

Mr. SKEEN. I appreciate that, Governor, and I hope some of the other States will follow the lead.

Thank you very much for your testimony. I enjoyed it very much.

Governor ROBB. Thank you, sir. I am very pleased to be here.

Mr. WALGREN. Governor, one last thought: With respect to this bill, we are trying to set up on the Federal level a council that would guide or drive the distribution of what resources we can put in this direction. He would also provide matching grants as well as have the responsibility to to be evaluating where we are in the process and where we need to go.

It strikes me that we do not now, in the first draft of that bill, include on there a representative of the State level. That seems strikingly inappropriate at this point.

Governor ROBB. We would always be pleased to be represented and have a direct voice on an ongoing basis. I noted that myself. I am not here to plead for that particular representation. I think the most important thing that this bill accomplishes is to underscore the Federal commitment in this area, in research and development, and the council, we can argue about how you would mark it up and which groups would be represented.

It would seem to me that because of the State primacy in this area, that you would want to have a representative or two. I would suggest that a designated representative by one of the major associations, perhaps the NGA and perhaps the National Council of State Legislators, since this is the level that would be most involved, might be appropriate. However, I will leave that for your ultimate determination.

Mr. WALGREN. Well, I think you can trust that that is a corrective action that will be taken directly as this bill is developed because clearly we ought to have a strong representation from the State levels in that council.

I want to express again my appreciation on behalf of the committee. Virginia has such a history of leading the country in this area, all the way back to our forefathers. We appreciate your testimony very much. Thank you for coming and spending this time with us.

Governor ROBB. Thank you, Mr. Chairman. I will be delighted to provide any of the information that I alluded to or any additional information that your committee might require, either through the subcommittee within the NGA or through the Committee on Transportation which has the overall responsibility for this topic.

It is obviously of major interest to us and we would be very pleased at any requests from you or counsel or members of the committee to provide any information that might be helpful.

Mr. WALGREN. We would appreciate being able to come back to you for any further information. Thank you.

Governor ROBB. Thank you very much.

Mr. WALGREN. The next witness is Congressman Ike Skelton from the State of Missouri.

Welcome to the committee, Ike. We are really pleased you would come and share some thoughts with us in this area.

Congressman Skelton is one of the major representatives that have focused on the defense area. That is an area that is so related to both the need of what we seek to address here and, at the same time, a major Government player in the area.

We therefore, appreciate having your thoughts on this problem and hope to further involve those that have particular interests in the development of engineering manpower in the defense area with this bill in the longer run.

STATEMENT OF HON. IKE SKELTON, A MEMBER OF CONGRESS FROM THE STATE OF MISSOURI

Mr. SKELTON. Mr. Chairman, thank you so much for the opportunity to be with you and to speak with you this morning.

I am deeply concerned about this entire subject and I am pleased to have the opportunity to speak with you regarding the future of science, engineering, and technology education in our United States, and also concerning the impact of deficiencies in these areas, that they will have on our economy and on our national security. As a member of the House Armed Services Committee, I have a particular concern over the effect of shortages of technically trained manpower on the various services, and also the impact of shortages on Department of Defense civilian personnel, the defense industry, and the defense industrial base.

Because of my concern in this area I have also introduced legislation to establish a national commission on science, engineering, and technology education. The bill that your committee is studying today, while wider in scope, is compatible with my legislation in the sense that both legislative initiatives acknowledge the need for national coordination to improve science and engineering education in our country and to maintain the technological edge which has kept our country a step ahead of the international community for generations.

Mr. Chairman, today we are on the brink of a new technological revolution which will demand a broad expansion of requirements for engineers and other technical manpower. Statistics reveal that 50 new electronics companies have been forming each month in our country. We are approaching a new and exciting frontier, one that promises great fortunes for our country, but it is not without its hazards, for we are likely to experience a crisis in scientific and engineering manpower just as our journey begins.

Earlier this year, Mr. Chairman, I released a study which I had requested from the Library of Congress on the status of science and engineering education in the United States, and for the record, I would like to submit a copy of this complete report. It is in two parts, and I will leave that with the secretary of the committee.

Mr. WALGREN. We would appreciate being able to incorporate that in the record.

Mr. SKELTON. Thank you.

Shockingly, the report revealed major problems ahead in meeting this country's need for scientists and engineers in several critical areas. A shortage of trained technical personnel would have serious implications for our defense posture, which relies on sophisticated ships, planes, and tanks. It would also have a negative impact on our economy, which depends on the skills of scientists and engineers for advances in agriculture and industry. If shortages of scientists and engineers are not recognized now, Mr. Chairman, and if they are not acted on now, we are going to find ourselves in a technology gap that will be far more serious than the Sputnik gap that we had in the 1950's.

While there has been an increase in the number of undergraduates enrolled in computer sciences and engineering in recent years, the supply of graduates is still far short of anticipated demand in several vital areas. About 1.4 million scientists and engineers are going to be needed to fill anticipated growth and replacement demands by the year 1990. The Air Force predicts a 114,000 total shortfall of engineers between now and then. Shortages of trained personnel are expected in industrial engineering, aeronautical engineering, chemical, electronic, and nuclear fields, computer science, and statistics.

This situation has particularly serious implications in the area of defense. Our ships, our planes, our tanks have all become increasingly more complex and more reliant on high technology. Both the armed services and the Department of Defense, however, are experiencing problems in recruiting and retaining technically trained personnel.

Almost 10 percent of the fiscal year 1982 Department of Defense budget is for research and development. The Department of Defense employs 61 percent of all the engineers employed by the Federal Government. Nonetheless, the Air Force reported that 57 percent of its present civilian vacancies are for engineers. In 1980 the Navy reported that it needed to hire 1,950 engineers at the entry level but was only able to fill 53 percent of these positions.

All three services report shortages of qualified personnel in scientific and engineering fields. The Air Force has been the most concerned about the situation and reports a current shortage of about 1,100 engineers.

All of this is in contrast to the status of technical education in other countries, and in particular the Soviet Union. Since the Soviet Union launched a comprehensive campaign to upgrade its educational system 15 years ago, Soviet schooling has taken a giant leap forward. Today young Soviets graduate from secondary schools in much greater numbers than their American counterparts, and they devote much more study to the hard sciences.

Consider these statistics: Each student in the Soviet Union must take the following compulsory courses to qualify for a secondary school diploma: 5 years in physics; 4 years in chemistry; 5.5 years in biology; 5 years of geography; 3 years of mechanical drawing; 10

years of workshop training; and 1 year of astronomy. In addition, Soviet students are required to complete 5 years of algebra, 10 years of geometry, and 2 years of calculus.

According to a National Science Foundation study of our own high school graduates, only 9 percent receive even 1 year of physics, 16 percent 1 year of chemistry, 45 percent 1 year of biology, and 17 percent 1 year of general science.

In addition, the Soviets have raised their secondary school graduation rate from the scant 4.9 percent recorded in 1940 to 97, nearly 98 percent in 1978. By comparison, only 75 percent of all students in the United States complete high school.

A professor at the University of Chicago and an expert on Soviet science education recently stated: "The disparity between the level of training in science and mathematics of an average Soviet skilled worker or military recruit and that of a noncollege bound American high school graduate, an average worker in one of our major industries or an average member of our all-volunteer Army, is so great that comparisons are meaningless."

In 1979, the Soviet Union graduated more than twice the number of scientists and engineers than did our country and almost five times as many engineering students. The United States ranks third behind the Soviet Union and behind Japan when comparing the total number of engineering graduates and also when considering the number of engineering graduates relative to the size of the total population. There is also evidence that the standard of undergraduate study in these countries is comparable to that of a master's degree here in our country.

Another problem which will affect the long-term scenario is the large number of professors in these disciplines in our country who are leaving academia for better paying jobs in industry. The report cites 2,000 engineering and 200 computer science faculty positions currently unfilled nationwide. This problem is not expected to improve because newly graduated baccalaureate students are similarly drawn away from pursuing advanced degrees and eventual teaching positions.

Only 15 percent of the top engineering graduates enroll in graduate programs. This figure should be at least 35 percent. Those who do stay, many of them are non-U.S. citizens. A National Science Foundation study reports that if current trends continue throughout the 1980's, almost 100 percent of all petroleum engineering graduate students will be foreign nationals and non-U.S. citizens, and will comprise over 50 percent of graduate students enrolled in most science and engineering fields. This situation, Mr. Chairman, creates concern for the Defense Department, which must hire U.S. citizens, and poses a technology transfer problem which causes trouble to the military.

As you see, the status of science and engineering education and its impact on our economy and our national security is a large and a very serious problem. What I think is more dangerous, however, is the lack of any coordinated national effort to study the situation, to define its scope, and to look for more remedies. Various groups have recognized the problem but remedial efforts have been piecemeal at best.

I believe we need a coordinated national effort to promote science, engineering, and technology education in the United States. However, this cannot be just a Government initiative. The educational community, the State and local governments, school boards, the business sector, and above all the parents must be equal partners in encouraging young people to pursue technical educations and in upgrading antiquated educational laboratory facilities.

In the interest of our economic well-being and our own national security, Mr. Chairman, we must tackle this problem now. If we do not, we will find we have fallen into a technology gap and we will watch the rest of the world go by.

Once again, I commend this commiteee on its efforts to do something about a problem which is most severe.

Mr. WALGREN. Thank you very much. You certainly have underscored the problem, and in the most dramatic terms. The comparison between the numbers of graduates of high school and the kind of training they get, between here and the Soviet Union, is literally devastating. I wonder how we are going to be able to match that?

Mr. SKELTON. Mr. Chairman, we are going to have to begin. The bill I have introduced, your bill, some bill will have to at least coordinate all of the efforts in our country. This has never been done. If it is not done now, the technology gap will grow and it will be beyond catching up if we do not do something in the near future.

You know, we have always prided ourselves on being the country that can build the better mousetrap. If we are going to continue to do that, we are going to have to train people to build these technological, these engineering, these science mousetraps if we are going to remain as strong as we have in the past both economically and also in the area of national defense.

Mr. WALGREN. It makes one wonder whether some of the sort of traditional divisions in our society—we have generally tried to keep the Federal Government out of education, it is primarily a State responsibility—but at the same time, this literally rises to the level of a national defense question. When you look now at the universities, you see a great amount of their money coming from the defense research that goes on. I know that most of the advances or much of the work that was done with computers came from the direction that the defense budget gave to developing that capability out of the need for defense related problems.

I am wondering if we should not be going almost a little further than that, at least with some of our Federal moneys, to the level of trying to increase technician skill levels or the training for technician skill levels. It just seems to me that so often we get blocked looking at Federal expenditures just as some kind of Government expenditure as opposed to an investment, and if there are investments to be made in this area, we ought to get about making them.

Mr. SKELTON. Well, I think there certainly are but it is going to take a coordinated effort. Also I want to stress that I think the local school boards, the local State authorities, should remain in control of the curricula. All we need to do is give them some coordination and I think once we do that, the local school boards and the local schools will pick up the ball and go with it. They always have in the past. However, there is no national coordination.

I think No. 1 is defining the problem. We have defined it this morning. It is a terrible problem and will result in a technology gap which we cannot reverse if we do not do something about it very soon.

Mr. WALGREN. In thinking of the National Science Foundation, this committee has had testimony that has argued by implication, that because the National Science Foundation has existed for a number of years and during those years there has been a steady deterioration of our science capability, that therefore the approaches taken by the National Science Foundation were not proper. They have been dismissed by the administration as inappropriate because they were "rooted in the 1960's."

Well, when you look at what our effort truly has been, there has been a steady decline in the National Science Foundation's investment in education, per se. And if our problem is one of education as opposed to some of the other pure science research projects, the failure to distinguish between investment effort that we make through the Federal Government and other kinds of government spending that may create different problems seems to me to be a fatal error at this point. If that gap widens on us, we may find ourselves having slipped during an essential time period.

I just want to say how much I think of your underlining the problem as you have, and hope that the defense side of our Government expenditure will look at those shortages more and more. Perhaps there is some effort there that might be directed in a way that would solve that.

Mr. SKELTON. I have this bill that I have introduced pending both in the Armed Services Committee and the Education Committee.

I might add, Mr. Chairman, that the ROTC program provides 57 percent of the engineering services coming out of our schools. But for the ROTC program, we would be even much shorter in the engineering area than we are now. Therefore, that program in and of itself is making a significant contribution in keeping our head above water.

Mr. WALGREN. The ROTC program was really a direct investment in individual students.

Mr. SKELTON. No question, that is right.

Mr. WALGREN. It was not a traditional role, in a way, for the Federal Government but one that serves this Nation well.

Mr. SKELTON. One that serves our country quite well, yes.

Mr. WALGREN. The Chair would like to recognize Mr. Weber.

Mr. WEBER. I have no questions, Mr. Chairman.

Mr. WALGREN. Mr. Gregg.

Mr. GREGG. No questions, Mr. Chairman.

Mr. WALGREN. Again, I thank you so much for your concern in this area and what you have contributed to our record. We look forward to working with you in trying to develop a better response in this area.

Mr. SKELTON. Thank you.

I will leave these two reports from the Library of Congress with your reporter.

Mr. WALGREN. Thank you.

The next witness is Dr. Douglas Pewitt, representing the Office of Science and Technology Policy with the administration.

Welcome to the committee, Dr. Pewitt. We appreciate your coming and look forward to your testimony. Your written testimony will automatically be made part of the record but please proceed to summarize or outline to the committee as you feel most effective.

STATEMENT OF DR. DOUGLAS PEWITT, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Dr. PEWITT. Thank you, Mr. Chairman, members of the committee. We appreciate the opportunity to address the concerns of the Office of Science and Technology Policy on the engineering and science manpower issues, and to offer comments on the proposed National Engineering and Science Manpower Act. Dr. Keyworth has provided the staff with a statement of the administration's views on the proposed legislation. I will summarize the key points of that statement this morning.

There is no question of the importance of science and engineering manpower to the Nation's strength. Our national defense and our economic vitality are based heavily on technology and the availability of highly qualified technical personnel. However, we should recognize in our discussion of engineering manpower that there are other overarching concerns.

One is the larger problem of mathematics and science education on a broad scale, including especially education at the precollege level. The lapses here have long-term negative effects on the quality of education possible for college students.

A second concern is the deteriorating quality of life for many young scientists and engineering faculty members. This is a reflection primarily of grossly noncompetitive starting salaries compared to industry but also of large teaching loads and extreme competition for resources to support their research.

Many of the brightest young Ph. D.'s can find a more productive as well as more rewarding research environment outside of universities. This hurts not only the vitality of the university research facilities but also removes some of the best minds from teaching. We believe that any discussion of the problems relating to engineering education should also take these problems into account.

I would like to add that in a broader context, we believe the current engineering manpower issue is only a symptom of a more fundamental problem—problems resulting from a false set of assumptions upon which past public policies were based. For too many years we assumed that our Nation could afford policies that emphasized distribution of our existing resources over the creation of new resources. This has been a major factor in our current problems of flagging industrial growth compared to foreign competitors.

We think it is important, in dealing with the specific problems of engineering education, to separate the general alarms about shortages of faculty and graduates from those that have been specifically documented. We know that in some engineering specialties and in some geographic locations there are true shortages to be dealt with.

On the other hand, we are also concerned about overreacting to these reported shortages. Recent history reminds us that engineer-

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ing job markets change rapidly and unpredictably. Attempts by Washington to forecast needs and to plan manpower supply levels are not likely to succeed. A more likely result is to create a set of new, additional problems.

We believe the specific problems of engineering manpower have successfully attracted the attention of people well-suited to correct them—the universities that educate engineers and the industries that employ them. We firmly believe that they are best equipped to deal directly with the temporary or cyclical fluctuations in supply and demand.

While we do see the Federal Government providing oversight and helping to focus national attention on these problems, we do not believe that it should try to intervene in a volatile marketplace.

Our office has already undertaken several steps in cooperation with industry and universities to identify elements that will achieve this balance. Several weeks ago the chairman of the full committee, Mr. Fuqua, and Dr. Keyworth were both present at the National Engineering Action Conference, which showed the tremendous potential for cooperative actions by those organizations directly affected by engineering manpower problems. Much is already happening.

However, we are concerned that it is not always possible to describe the problem in detail or to understand fully future implications of current trends. We have seen some widely divergent estimates of future national technical needs, and we should make every attempt to improve our understanding of the situation.

Consequently, we have asked the National Science Foundation to review its science and engineering personnel data collection to determine what more information can and should be collected to further illuminate these issues. Also, in order to assure that these surveys ask the most relevant questions, NSF will establish a special technical manpower advisory group to review the manpower data collection and analysis. The interested and affected communities will be asked to work with NSF to suggest ways to best structure that review.

Mr. Chairman, we believe the proposed legislation recognizes many key problems, and it is clearly well intentioned. However, we must take exception to its basic premise. We cannot agree to an approach based on central manpower planning. Such an approach is rigid, not flexible, and would only lead to unproductive Government perturbations of what should be a responsive demand/supply employment market. I feel obligated to point out that even in the centrally planned, demand economy of the Soviet Union, centralized manpower planning has been a total failure.

It is our intention to work with the Congress to determine a wise Federal role in the area of technical manpower. We are anticipating early, useful guidance from both the Department of Education's National Commission on Excellence in Education and the National Science Board's Commission on Precollege Education in Mathemathics, Science, and Technology. Certainly we will want to address seriously the issue of assuring and improving the quality—not necessarily the quantity—of our research university faculties, and to focus attention on improving the precollege science and mathematics preparation for all of our children.

Together we can work to break new ground that focuses our efforts on programs that may wind up applying solutions appropriate to those problems facing the country today. The proposed legislation involves the Federal Government prematurely and we fear it may in fact discourage the excellent initiatives that are already being planned by others.

The Federal Government's responsibility must be to take a broad view of engineering and scientific education at all levels and to apply its resources judiciously to long-term sustenance of the Nation's talent pool. We must avoid the all too familiar, well intentioned quick fix that leads to ineffective solutions.

I would be happy to respond to your questions.

[The prepared statement of Dr. Keyworth follows:]

STATEMENT OF DR. GEORGE A. KEYWORTH, II
DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY
EXECUTIVE OFFICE OF THE PRESIDENT
BEFORE THE
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

APRIL 29, 1982

CHAIRMAN WALGREN, MEMBERS OF THE COMMITTEE, I AM PLEASED TO SUBMIT THIS STATEMENT ON THE SUBJECT OF ENGINEERING AND SCIENCE MANPOWER AND EDUCATION AND TO OFFER COMMENTS ON H.R. 5254, THE NATIONAL ENGINEERING AND SCIENCE MANPOWER ACT OF 1982.

IN THE SIX MONTHS THAT HAVE ELAPSED SINCE I WAS LAST INVITED TO TESTIFY BEFORE THIS COMMITTEE ON THE SUBJECT OF ENGINEERING MANPOWER, WE HAVE SEEN A GREAT DEAL OF POSITIVE ACTIVITY. IN THAT TIME THE PROBLEM HAS BEEN BETTER DEFINED BY INDUSTRIAL, ACADEMIC, AND GOVERNMENT GROUPS, AND A NUMBER OF CORRECTIVE ACTIONS ARE ALREADY UNDERWAY. I BELIEVE THE COMMITTEE'S EARLY ATTENTION TO THE NATION'S ENGINEERING MANPOWER DILEMMA HAS BEEN A SPUR TO THAT RESPONSE.

THERE ARE BROAD AREAS OF CONCERN AND PHILOSOPHY THAT THE CONGRESS AND ADMINISTRATION SHARE. THERE IS NO QUESTION OF THE IMPORTANCE OF SCIENTIFIC AND ENGINEERING MANPOWER TO THE NATION'S STRENGTH. OUR NATIONAL DEFENSE AND OUR ECONOMIC VITALITY ARE BASED HEAVILY ON TECHNOLOGY AND ON THE AVAILABILITY OF HIGHLY QUALIFIED TECHNICAL PERSONNEL.

I WANT TO EMPHASIZE, HOWEVER, THAT I DO NOT THINK WE CAN TALK ABOUT PROBLEMS OF SHORTAGES OF ENGINEERS WITHOUT ALSO ADDRESSING TWO OTHER CONCERNS. ONE IS THE LARGER PROBLEM OF MATHEMATICS AND SCIENCE EDUCATION ON A BROAD SCALE AND INCLUDING--ESPECIALLY--EDUCATION AT THE PRE-COLLEGE LEVEL. THE LAPSES HERE HAVE LONG-TERM NEGATIVE EFFECTS ON THE QUALITY OF EDUCATION POSSIBLE FOR COLLEGE STUDENTS. A SECOND CONCERN IS THE DETERIORATING QUALITY OF LIFE FOR MANY YOUNG SCIENCE AND ENGINEERING FACULTY MEMBERS. THIS IS A REFLECTION PRIMARILY OF GROSSLY NON-COMPETITIVE STARTING SALARIES COMPARED TO INDUSTRY, BUT ALSO OF LARGE TEACHING LOADS AND EXTREME COMPETITION FOR RESOURCES TO SUPPORT RESEARCH. MANY OF THE BRIGHTEST YOUNG PHD'S CAN FIND A MORE PRODUCTIVE--AS WELL AS MORE REWARDING--RESEARCH ENVIRONMENT OUTSIDE OF UNIVERSITIES. THIS HURTS NOT ONLY THE VITALITY OF UNIVERSITY RESEARCH FACILITIES, BUT ALSO REMOVES SOME OF THE BEST MINDS FROM TEACHING. WE BELIEVE THAT ANY DISCUSSION OF THE PROBLEMS RELATED TO ENGINEERING EDUCATION SHOULD ALSO TAKE THESE PROBLEMS INTO ACCOUNT.

I WOULD LIKE TO ADD THAT, IN A BROADER CONTEXT, WE BELIEVE THAT THE CURRENT ENGINEERING MANPOWER ISSUE IS ONLY A SYMPTOM OF MORE FUNDAMENTAL PROBLEMS--PROBLEMS RESULTING FROM A FALSE SET OF ASSUMPTIONS UPON WHICH PAST PUBLIC POLICIES WERE BASED. FOR TOO MANY YEARS WE ASSUMED THAT OUR NATION COULD AFFORD POLICIES THAT EMPHASIZED THE DISTRIBUTION OF OUR EXISTING RESOURCES OVER THE CREATION OF NEW RESOURCES. THIS HAS BEEN A MAJOR FACTOR IN OUR CURRENT PROBLEMS OF FLAGGING INDUSTRIAL GROWTH COMPARED TO FOREIGN COMPETITORS.

WE THINK IT IS IMPORTANT, IN DEALING WITH THE SPECIFIC PROBLEM OF ENGINEERING EDUCATION, TO SEPARATE THE GENERAL ALARMS ABOUT SHORTAGES OF FACULTY AND GRADUATES FROM THOSE THAT HAVE BEEN SPECIFICALLY DOCUMENTED. WE KNOW THAT IN SOME ENGINEERING SPECIALITIES, AND IN SOME GEOGRAPHIC LOCALES, THERE ARE TRUE SHORTAGES TO BE DEALT WITH. ON THE OTHER HAND, WE ARE ALSO CONCERNED ABOUT OVERREACTING TO THESE REPORTED SHORTAGES. RECENT HISTORY REMINDS US THAT ENGINEERING JOB MARKETS CHANGE RAPIDLY AND UNPREDICTABLY IN SHORT TIMES. ATTEMPTS BY BUREAUCRATS IN WASHINGTON TO FORECAST NEEDS AND TO PLAN MANPOWER SUPPLY LEVELS ARE LIKELY NOT ONLY TO FAIL, BUT TO CREATE ADDITIONAL PROBLEMS SUCH AS GLUTS IN THE SUPPLY OF ENGINEERS IN CERTAIN AREAS. THE CONSEQUENCES COULD BE WASTED RESOURCES--BOTH MONEY AND MINDS.

TO A PROMISING EXTENT WE BELIEVE THE SPECIFIC PROBLEMS OF ENGINEERING MANPOWER HAVE SUCCESSFULLY ATTRACTED THE ATTENTION OF PEOPLE WELL-SUITED TO CORRECT THEM--THE UNIVERSITIES THAT EDUCATE ENGINEERS, AND THE INDUSTRIES THAT EMPLOY THEM. I FIRMLY BELIEVE THAT THEY ARE BEST EQUIPPED TO DEAL DIRECTLY WITH THE TEMPORARY OR CYCLICAL FLUCTUATIONS IN SUPPLY AND DEMAND.

HOWEVER, I CAN SEE THE FEDERAL GOVERNMENT AS PROVIDING OVERSIGHT AND HELPING IN THE FOCUSING OF NATIONAL ATTENTION ON THESE PROBLEMS. IT SHOULD NOT TRY TO INTERPOSE ITSELF INTO A VOLATILE MARKETPLACE.

WE HAVE ALREADY UNDERTAKEN SEVERAL STEPS IN COOPERATION WITH INDUSTRY AND THE UNIVERSITIES TO IDENTIFY THE ELEMENTS THAT WILL ACHIEVE THIS BALANCE.

SEVERAL WEEKS AGO THE CHAIRMAN OF THE FULL COMMITTEE, MR. FUQUA, AND I WERE BOTH PRESENT AT THE NATIONAL ENGINEERING ACTION CONFERENCE, WHICH SHOWED THE TREMENDOUS POTENTIAL FOR COOPERATIVE ACTIONS BY THOSE ORGANIZATIONS DIRECTLY AFFECTED BY ENGINEERING MANPOWER PROBLEMS. IN LIGHT OF THE ACTIONS ALREADY UNDERWAY--SUCH AS INDUSTRIAL AID FOR GRADUATE STUDENTS AND RESEARCH INITIATION SUPPORT FOR NEW ENGINEERING FACULTY, AND MOVEMENTS TO REFLECT MARKET FORCES IN SETTING ENTERING SALARIES FOR ENGINEERING FACULTY--I HAVE CONFIDENCE THAT MUCH IS ALREADY HAPPENING. HOWEVER, WE ARE CONCERNED THAT IT IS NOT ALWAYS POSSIBLE TO DESCRIBE THE PROBLEM IN DETAIL OR TO UNDERSTAND FULLY FUTURE IMPLICATIONS OF CURRENT TRENDS. WE HAVE SEEN SOME WIDELY DIVERGING ESTIMATES OF FUTURE NATIONAL TECHNICAL PERSONNEL NEEDS, AND WE SHOULD MAKE EVERY ATTEMPT TO IMPROVE OUR UNDERSTANDING OF THE SITUATION. CONSEQUENTLY, I HAVE ASKED THE NATIONAL SCIENCE FOUNDATION TO REVIEW ITS SCIENCE AND ENGINEERING PERSONNEL DATA COLLECTION TO DETERMINE WHAT MORE INFORMATION CAN AND SHOULD BE COLLECTED TO FURTHER ILLUMINATE THESE ISSUES. ALSO, IN ORDER TO ASSURE THAT THESE SURVEYS ASK THE MOST RELEVANT QUESTIONS, NSF WILL ESTABLISH A SPECIAL TECHNICAL MANPOWER ADVISORY GROUP TO REVIEW THE MANPOWER DATA COLLECTION AND ANALYSIS. THE INTERESTED AND AFFECTED COMMUNITIES WILL BE ASKED TO WORK WITH NSF TO SUGGEST WAYS TO BEST STRUCTURE THIS REVIEW.

THIS IS A NECESSARY, THOUGH HARDLY MOMENTOUS, STEP IN THE RIGHT DIRECTION. BUT WE HOPE THAT THE KIND OF INFORMATION COLLECTED WILL CONTINUE TO HELP THE FEDERAL GOVERNMENT FULFILL ITS PROPER ROLE IN MANPOWER NEEDS OF PROVIDING OBJECTIVE FACTS SO THAT ALL CONCERNED PARTIES CAN BASE THEIR DECISIONS ON RELIABLE INFORMATION.

MR. CHAIRMAN, WE BELIEVE THE PROPOSED LEGISLATION RECOGNIZES MANY OF THE CORE PROBLEMS CONFRONTING THE EDUCATORS AND EMPLOYERS OF ENGINEERS, AND IT IS CLEARLY A WELL-INTENTIONED PROPOSAL TO BRING FEDERAL RESOURCES TO BEAR ON THEM. I ALSO BELIEVE THE CURRENT DRAFT LEGISLATION IS SUBSTANTIALLY IMPROVED OVER PREVIOUS VERSIONS.

NONETHELESS, I MUST TAKE EXCEPTION TO ITS BASIC PREMISE THAT WE CAN CENTRALIZE NATIONAL MANPOWER PLANNING FOR THE NATION, BASED ON CURRENT ASSESSMENTS OF FUTURE NEEDS. I FEAR THAT SUCH AN APPROACH WILL PROVE RIGID, NOT FLEXIBLE, AND WILL RESULT IN UNPRODUCTIVE GOVERNMENT PERTURBATIONS OF WHAT SHOULD BE A RESPONSIVE DEMAND/SUPPLY EMPLOYMENT MARKET. I ALSO FEEL OBLIGATED TO POINT OUT THAT EVEN IN THE CENTRALLY PLANNED, DEMAND ECONOMY OF THE SOVIET UNION, CENTRALIZED MANPOWER PLANNING HAS BEEN A FAILURE.

I CERTAINLY THINK IT APPROPRIATE THAT THE CONGRESS AND ADMINISTRATION WORK TOGETHER TO DETERMINE A WISE FEDERAL ROLE IN THE AREA OF TECHNICAL MANPOWER. WE ARE ANTICIPATING EARLY USEFUL GUIDANCE FROM BOTH THE DEPARTMENT OF EDUCATION'S NATIONAL COMMISSION ON EXCELLENCE IN EDUCATION AND THE NATIONAL SCIENCE BOARD'S COMMISSION ON PRE-COLLEGE EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY. WE CERTAINLY ANTICIPATE THAT WE WILL WANT TO ADDRESS SERIOUSLY THE ISSUES OF ASSURING AND IMPROVING THE QUALITY--NOT NECESSARILY THE QUANTITY--OF OUR RESEARCH UNIVERSITY FACULTIES, AND TO FOCUS ATTENTION ON IMPROVING THE PRE-COLLEGE SCIENCE AND MATHEMATICS PREPARATION FOR ALL OUR CHILDREN.

MR. CHAIRMAN, I BELIEVE WE CAN WORK TOGETHER TO BREAK NEW GROUND RATHER THAN FOCUS OUR EFFORTS ON PROGRAMS THAT MAY WIND UP APPLYING THE SOLUTIONS TYPICAL OF THE 1960'S TO THESE IMPORTANT PROBLEMS OF THE 1980'S.
I AM ALSO CONCERNED THAT THE PROPOSED LEGISLATION INVOLVES THE FEDERAL GOVERNMENT PREMATURELY AND MIGHT ACTUALLY DISCOURAGE THE EXCELLENT INITIATIVES THAT ARE ALREADY BEING PLANNED BY OTHERS.

I STRONGLY BELIEVE THAT THE FEDERAL GOVERNMENT'S RESPONSIBILITY MUST BE TO TAKE A BROAD VIEW OF ENGINEERING AND SCIENTIFIC EDUCATION AT ALL LEVELS AND APPLY ITS RESOURCES JUDICIOUSLY TO LONG-TERM SUSTENANCE OF THE NATION'S TALENT POOL.

Mr. WALGREN. Thank you very much, Dr. Pewitt.

I find myself sort of caught by the different directions that the administration seems to go in or seems to espouse that we should go in, and find myself struck by the result that we seem to be going nowhere. I sincerely wonder whether the approach of taking the broad view, and only applying resources for the long run and concluding that there can be no quick fix is reasonable. By categorizing the Engineering and Science Manpower Act as a quick fix, I fear that may be simply words covering over an inertia and an unwillingness to do anything.

Let me just give you an example of that: I understand at the conference in New York, Dr. Keyworth said something to the effect that, and I quote, "The Reagan administration is highly amenable to appropriate new programs that address clear, agreed-upon basic problems where Federal inputs could have large effects. Examples might be instructional equipment, research instrumentation, or improving the skills of secondary teachers."

Now there he specifically outlined the goals of a number of programs in the NSF, and yet we find that each of those programs has either been zeroed out by this administration or all but eliminated. Instructional equipment has been zeroed out, research instrumentation has been cut, and science education programs, particularly those relating to secondary education and designed by the best of our educators in the past, have been totally eliminated. How do you reconcile saying, "We should do these things," and yet, "We are not going to do them," both at the same time?

Dr. PEWITT. Mr. Chairman, there are something on the order of 17,000 school districts in the United States, 24 programs spread over $60 million, you are not doing anything other than band-aiding some problems. We ought to decide what we want to do, decide on a well-founded program, and push in that direction, not try doing too many subcritical programs to address the real problems. It is too important to band-aid over. A major part of what our office has been doing for some time, and is doing now, is trying to address these problems and find out what would be significant activities, which we could get behind and lever some private sector support, something that would address the real, crucial problems of preparing our students.

What Jay has said is not inconsistent with that at all. We are not sitting here and saying that nothing is the right answer, but we are saying that everything is the wrong answer.

Mr. WALGREN. It is my information that the Congress has been seeking this kind of new proposal for a long time, and that in particular last year we asked the National Science Foundation to put forward a national program that would not just be a band-aid, and yet there is absolutely no initiative in that agency to respond to that request.

Dr. PEWITT. Dr. Keyworth asked the National Science Board to look into this matter last June. I understand now that a committee is about to start its deliberations. I know Dr. Slaughter has put quite a lot of effort into this. They are about to begin deliberations.

Mr. WALGREN. Do you distinguish at all when you mentioned in your statement, that for too long our Government programs have been based on "distributing our assets" rather than "creating new resources." In which of those categories would the investment of a Government dollar in training a mind fall?

Dr. PEWITT. Our institutions of higher education support many thousands of graduate students through assistantships that are part of research dollars. The Federal Government invests several billions of dollars in university research, and we are continuing that level of investment.

Mr. WALGREN. Wouldn't you agree that to describe or categorize the educational effort of the Federal Government as falling on the distribution side of that characterization of Government programs would be particularly inappropriate?

Dr. PEWITT. No, I would not agree with that characterization. There are some aspects of the Federal Government's involvement in education that we believe have been laudatory but we do not agree that everything the Federal Government has done in the educational field has been effective and has represented really, truly effective investments in people.

Mr. WALGREN. Well, perhaps we could leave the record open for some examples of that. It has been my experience with the approach of the administration and the National Science Foundation, that they came in saying that these particular programs were not constructive and then, when asked to evaluate each particular program, they could not hold that position.

In fact, there was testimony by the administration to the effect that the individual programs that the National Science Foundation was involved in were certainly constructive.

Dr. PEWITT. I was addressing your question with regard to the Federal role in education, not the National Science Foundation's programs. We did not believe that the National Science Foundation's program in education, was, in total, a very effective way to address what we consider very serious problems. We are supporting the fellowship programs of the National Science Foundation and we are taking a very serious look at what is effective.

There are a lot of things that have been tried over a lot of years in science education. The National Science Foundation, in its 30-year history, has run a large number of programs. We think probably any attempt to address this problem is going to be some combination, permutation, or modification of programs that have been tried in the past, but we ought to decide which one to get behind, and really put our money behind that approach, rather than trying to do a little bit of everything. We just have not been able to come to a consensus on what that is. We fully expect to finish those deliberations over the next few months and decide what we are going to be able to support, and we expect to be talking to the Congress in that period of time.

Mr. WALGREN. Well, I just would express my disappointment and encourage the administration to reconsider its opposition to this kind of initiative. It seems to me that when you emphasize the potential of the private sector and you see a program that is so driven by the private sector as would be envisioned in this bill, and a program that would call out of the private sector so much commitment by the private sector dollars into areas which the private sector was clearly recognizing the contribution in a very direct way for the purposes of the private sector, it seems to me to be wrong to characterize this kind of effort as falling into the category of a distribution rather than a creation of resources. Therefore, I just want to express my disappointment in that and hope that you will, in your office, certainly reconsider the weight that you put on private investment in this area.

The Chair would like to recognize the chairman of the full committee, Mr. Fuqua.

Mr. FUQUA. I have no questions at this time.

Mr. WALGREN. Mr. Weber?

Mr. WEBER. No questions.

Mr. WALGREN. Mr. Gregg?

Mr. GREGG. Yes.

Dr. Pewitt, to follow up on the chairman's questions, this committee—actually I think the initiative was as much from this side of the aisle—added approximately $30 million back into the National Science Foundation for the specific purpose of addressing the question of education at the secondary and elementary school level, and specifically the retention of science teachers. We feel rather strongly that this can be identified as a very real problem.

Is it the position of the administration that they cannot agree to the fact—or the position of the Office of Science and Technology Policy that you cannot agree to this concern, specifically that we are seeing tremendous attrition in the number of qualified science teachers in our secondary and elementary schools as a result of our inability to pay competitive salaries? You do not believe there is a consensus on that point that we can move on?

Dr. PEWITT. I do not think I said that. The fact of the matter is, our concern is very much in the precollege level.

Mr. GREGG. Well, if there is a consensus on that point, then why should we wait?

Dr. PEWITT. Why should you wait for what?

Mr. GREGG. Why should we wait to address that issue?

Dr. PEWITT. It is not a question of agreeing on what the problem is. We can all agree on that. It is moving on an effective solution. We have seen too many attempts at well-intentioned but not well thought out programs, and we just do not believe that we ought to move on those. I am not addressing this particular piece of legislation. I really have not seen what the committee markup is of the NSF's budget. I do not know what has been done there.

Mr. GREGG. Well, we increased a budget which had zero funds in it for science education. This markup crossed the administration's position that there should be zero funds in science education.

Now if there is a consensus—and I think it is an unquestioned consensus—that the problem we have in secondary and elementary schools is that we are losing people because we do not pay them enough, then can't we move on that issue without waiting for studies, without even passing this bill?

Dr. PEWITT. I do not agree that there is a Federal Government role in paying secondary school teachers' salaries, if that is what the proposal is. I do not know what the proposal in the legislation is.

Mr. GREGG. Well, I guess you have answered my question. You do not feel that one of the ways we can remedy the loss of science education teachers at the secondary and elementary school levels is to have some participation through funding at the Federal level in salary costs.

Dr. PEWITT. I do not think the administration is in any way prepared to endorse the Federal Government paying the salaries of precollege teachers, no.

Mr. GREGG. How about an awards program for keeping quality science teachers on the job, rather than having them go into industry?

Dr. PEWITT. I would have to look at that proposal. I do not know what our response would be. No one has proposed that to us, as far as I know. Our office is certainly not aware of such——

Mr. GREGG. Well, would you support the transfer of funding from one element of NSF that might not address science education into another element which would address science education in the secondary schools?

Dr. PEWITT. I cannot support that, no.

Mr. GREGG. Therefore, the position of the administration is that we should stay at zero for science education.

Dr. PEWITT. The President's budget that we submitted in February is what I will and must sit up here and support. We have had no conversations about any modification, and to the best of my knowledge our office has not been approached.

Mr. GREGG. Well, I will just tell you that the committee wants to reallocate those funds and would like to see more money put into science education at the secondary and elementary school levels, even if it comes at the expense of some other item in the National Science Foundation. We feel that science education at that level is critical.

Dr. PEWITT. Thank you.

Mr. FUQUA. Thank you, Dr. Pewitt.

Do you believe that there is a shortage—and I am speaking now in the college area—of people going into advanced degrees, and the amount of Ph. D.'s and future teachers and researchers that we are producing? Do you feel that there is a shortage now?

Dr. PEWITT. In engineering especially, and in other areas, we think that there will be. What our office is trying to work on and what we are trying to address is to address the whole problem, the fundamental problem of what makes teaching careers attractive to our brightest people in the sciences, as you know. We are very concerned about that. If it is engineering this year, what will it be next year? We do not know what our needs are going to be in the future. We are certainly short of people going into these fields because it is not an attractive career.

Mr. FUQUA. Why is it not attractive?

Dr. PEWITT. Well, a couple of things that we included in our statement: In some fields it is noncompetitive salaries. To a certain degree it has been the low level of graduate stipends that we have provided students over the years. They have gotten ridiculously low, and we think that those ought to be increased.

Mr. FUQUA. Well, isn't that what this bill is trying to do? You say in your statement, which I am somewhat appalled at, that it is some big centralized manpower planning for the Nation, and I do not think the bill is that at all. It only tries to address one small element, and not to direct the whole manpower needs of the country in the bill. We are trying to track the very problem you talked about; you put your finger on it.

Dr. PEWITT. Yes. We appreciate the idea of establishing a new coordinating council that is going to do all this wonderful coordination and stuff like that. We just cannot support that particular approach to centralized manpower planning. We read this legislation as an attempt to try to go to centralized manpower planning for the country.

Mr. FUQUA. Well, we had better change it because it is not intended to be that way.

Dr. PEWITT. I did not think so. I think it is well-intentioned legislation.

Mr. FUQUA. We thought people could exchange ideas on where the emphasis should be, rather than try to have some bureaucratic, centralized manpower office. We thought that there would be some industry participation, participation from the National Academy of Science and Engineering and the Science Board, and that these people who are policymakers and hold positions of high responsibility would be able to coordinate and say, "These are the areas that we deem to be in the national interest and where emphasis should be put." We are not trying to say how many people have to go into engineering or how many people must go into science or English or other types of disciplines, or any other area, only where the emphasis of matching funds that we are trying to attract from industry, where would be the most appropriate place to put them.

Dr. PEWITT. There are some aspects of this bill that we do like, and the idea of matching funds from the private sector is certainly something that we can all applaud. However, we view this bill as a mechanism that will lead to centralized manpower planning, and we want to avoid that. It is counter to what this administration supports.

We do agree that we need to strengthen our ability to understand the manpower situation in this country, and we have asked the NSF to strengthen that and we are working with them. Whatever approach that we take in this, we view it as a manpower, a scientific manpower problem in the country, of which the engineering problem is just today's symptom. We are not altogether convinced that we are smart enough even to predict where the areas are. We have seen where perhaps we need to do some more research in this area—I will not use the words "social sciences"—to understand these things.

Mr. FUQUA. I am glad to hear you say that. [Laughter.]

Dr. PEWITT. I said I would not say that so I did not say that, but we need to understand this area somewhat better. We are just frankly concerned about the way the legislation is drafted now and having a new State central planning committee for manpower. We are concerned about that. We just cannot support that particular approach. We think there are other ways to accomplish some of these ends that do not take this sort of approach.

Mr. FUQUA. Well, I would be more than happy to work with you and the administration on what they feel is the best approach in trying to achieve this end. But going back to where we started out when I asked what the problem was and you stated it, that is exactly what we are trying to address. I do not want it to be any more complicated than anybody else. It should be simplistic, a way that we can all understand and support. I think there is a shortage. I think we are facing a critical shortage in the years to come, and we must respond to it now because of national needs and also in trying to continue our efforts in productivity and innovation. We must try to address this as we proceed.

I have talked to people all over this country that are well aware of what the needs are. I do not know that we need another study to understand what the needs are. The Russians and Japanese are doing a pretty good job of understanding where their educational needs are. We have done that before. In a graph received in earlier testimony on the National Science Foundation. We saw a direct correlation in the decline in funding for elementary and secondary education at NSF and the decline in overall achievement test scores. Whether they are directly related I do not know but there is a correlation between the decline in the amount of funding going into those programs and the declining test scores.

We are concerned about that but the other, immediate problem I think is in our colleges and universities and those people getting advanced degrees that will be able to be the teachers and the researchers for the future.

Dr. PEWITT. We in the administration are as concerned as any other informed citizen in this country, Member of Congress, member of the staff, about these areas. We do not think the problem occurred overnight. It is not going to be rectified overnight, and we do want to continue our coordination within the executive offices and the other agencies of the executive branch of Government to come up with something that everybody can pull together on. It is unfortunate, but it takes a little more time to get a crowd moving in the same direction than it does a handful of people, as you well know. I think we will be prepared to talk to you or your staff within hopefully a few weeks about something. It is not going to be a budget-buster, though. We just cannot afford that, and I do not think that is the intent of this legislation, either.

Mr. FUQUA. No, it is not. It is my observation, and not only my observation but I am convinced, that industry is ready to move. It was evident in meetings that I have participated in with industry representatives. It was very evident in a meeting in New York where Dr. Keyworth was there, that industry is ready to move and cooperate in this field, and I do not think industry is necessarily noted for trying to throw money away.

Dr. PEWITT. They are worried about future profits, and I would be, too.

Mr. FUQUA. Where their manpower is coming from.

Dr. PEWITT. That is correct. We have talked to the same people extensively. Yes, sir.

Mr. FUQUA. It is affecting not only industry but also the Government. General Marsh, head of the Air Force Systems Command, testified that they were over 10 percent short in manpower needs at that particular time. It affects their ability to manage contracts that the Government, the Department of Defense may be involved in, and that is only one branch. We have it in other parts of Government, in NASA, the Department of Energy, and others. They are approaching a very critical shortage and they understand the problem.

Dr. PEWITT. We understand it, too. We really do.

Mr. FUQUA. Thank you.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Fuqua.

Mr. Dymally?

Mr. DYMALLY. Thank you, Mr. Chairman. I have a couple of questions for Dr. Pewitt but I just want to say that I am pleased that the hearings on the National Engineering and Science Manpower Act are being held at this time.

One can understand the administration's philosophy in economics, even though we may disagree with it, but I have some difficulty understanding their position on science and engineering. On the one hand they advocate a strong military defense system, and they have put so much money in military and aerospace research and development yet we have a shortage of engineers now which we cannot find, because of their deemphasis in the public sector of research, development, and education in science and engineering. This, it seems to me, is a time of retrenchment and there are those who seek retrenchment in nearly all matters but national defense. I fear that if we are caught up in this retrenchment fever, we may actually jeopardize the future of the country while, at the same time, doing damage to work which we have embarked on for the past decades.

Therefore, Mr. Pewitt, I just have a question for you. Mr. Keyworth has said in the past that the United States is faced with picking certain areas of technology and science in which we will be dominant and letting other areas go by the way. Could you tell us which areas of science you plan to pursue in the defense sector and in the private sector, and which one you plan to go by the wayside?

Dr. PEWITT. Well, let me make a couple of statements: No. 1, President Reagan and this administration do not intend to see that the engineering and science capability of this Nation become second to any, despite the characterizations. Dr. Keyworth has never said that we will pick a few areas and let the others go by the way, either.

The United States has an interest in maintaining technological leads in many areas and broad involvement in all areas. What we have said and what Dr. Keyworth has said is that in some areas, because of national interests that are different from the United States, other nations will seek preeminence, and we just cannot dominate every area.

I give you the good example of high-speed surface transportation. In the United States it makes a lot of sense in the Eastern Corridor and perhaps on the west coast of the United States. It is not of as immediate interest in the Midwest, where distances are longer. But in Japan, where you have a population that is linear, high-speed surface transportation is certainly an area that would be in much more in their national interest than ours. We do not choose to dominate that area. There are other technical options available to us.

We do not intend to take second place in any broad area of science or engineering but, just because there are specific areas where there is a foreign excellence, this does not mean we have to match everything that is in the specialized national interest of some foreign country. That is what the statement said. It has been overinterpreted too many times, and that is a mischaracterization of his statement.

Mr. DYMALLY. Mr. Chairman, I have one other question and a comment. I am also deeply concerned about a second problem, and that is the place of women and minorities in our scientific and engineering professions. Members of minority groups make up a smaller percentage of engineers holding graduate degrees than they did a decade ago, and the seventies were supposed to be a time of significant advances for members of minority groups.

Now, Dr. Pewitt, my question is: If the Federal Government withdraws its support for women and minorities and the poor, who is going to fill that gap? What happens to a bright, poor student who wishes to pursue graduate study but lacks adequate financial resources? This was perceived to be a role of the Government to bridge that gap. What are we going to do if you withdraw all of your support from federally sponsored programs?

Dr. PEWITT. You are talking about science programs.

Mr. DYMALLY. Yes.

Dr. PEWITT. Well, No. 1, our office—Dr. Keyworth—said many times that we do support a meritocracy in science, and we think that the opportunity to participate in science ought to be open to everyone. The fact of the matter is, for students in science, the Federal Government will continue to support thousands, literally thousands of graduate assistance programs through its research support of the universities. We will continue to support the fellowship programs. There are ample sources of support available for those qualified to pursue higher education in the sciences. We have not made it impossible for the poor but bright and qualified students to pursue it.

Mr. DYMALLY. Well, the way it is structured now, the interest rates are intimidating and many graduate students are backing away from having to pay that high interest rate which is due concurrently with their education. Therefore, that in itself is a barrier.

Dr. PEWITT. This is the Department of Education program?

Mr. DYMALLY. Yes. Well, I know the White House is more elitist than the Department of Education.

Dr. PEWITT. We are a little bit more compartmentalized than that but let me say this: I do know, have personal knowledge of, individuals who took out some of these student low-interest, subsidized loans, and did not use them to advance their education, because it was a terribly attractive deal. Now I do not know what the details of the programs are but that was the sort of thing that was inappropriate.

I also knew that I would have been qualified to have one of my children receive a subsidized loan, and I think that it is a travesty for a person in my position to be subsidized by the taxpayer to send his kids through college. I should save my money and put them through college, not be subsidized by the taxpayer, and those things were happening. I do not know all the details of the programs but there were some misallocations of taxpayers' resources to subsidize those loans, and we have proposed corrective action. I do not know all of the details but there was clearly inappropriate support being provided to some people.

Mr. DYMALLY. Thank you very much, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Dymally.

Mrs. Heckler?

Mrs. HECKLER. Mr. Chairman.

Dr. Pewitt, I am surprised at the statement in your testimony that this bill would suggest and achieve some form of centralized national manpower planning. I cannot imagine how that could occur with a bill that is going to be funded with $50 million at most, and is dealing with a very small segment of manpower, in which a coordinating council is formed in an advisory capacity to direct and to recommend proposals to the Congress and to the President which will be the source of his future directions and the congressional response. How that small, 10-member council centralizes the planning of manpower for the whole country and leads us down the path of, maybe a socialized economy, as you have suggested here, bewilders me. I just cannot imagine how you could draw that conclusion.

Dr. PEWITT. This is an opening in exactly that direction, Mrs. Heckler.

Mrs. HECKLER. How is that?

Dr. PEWITT. We view this as an attempt at centralized manpower planning. We do not believe that the President requires another executive level 2 and nine executive level 3's paid at an outrageous salary to advise him on or to establish policy and to distribute Federal funds aimed at targeting where manpower should be directed in our economy. We simply cannot support that aspect of this bill.

Mrs. HECKLER. Are you saying that you approve of every other aspect of the bill and disagree with this one?

Dr. PEWITT. No, I am trying to respond to your specific question. There are some attractive features to this bill, the sharing with the private sector, et cetera, that we do think are aspects that we could support but the central feature of this bill is this manpower planning commission and we cannot support that.

Mrs. HECKLER. Well, the fact is that commission reports are as ordinary as a printed sheet in Washington, and I do not think anyone suggests that they have the power to run the Government. They have the power to make recommedations, and certainly with a problem as serious as we currently have and the forecasting of it, it is very hard to understand why you would object to having a purposeful, directed look at manpower needs in an economy which is finally looking at increased productivity. There is no way we can achieve those goals if we do not have the trained manpower.

We have career counseling in many, many other agencies: the Veterans' Administration, the Education Department, the Labor Department, et cetera. Now all of these are based on projections of the U.S. Government, its needs, and giving guidance to students. Here is a major industry, high technology, dealing with one of the central problems in the economy, and an industry that is faced with serious manpower shortages which down the road can affect the whole leadership potential of the United States. I really am amazed that the mere possibility of recommendations by a small, 10-man council dealing with this question is offensive and constitutes an onerous concept. It seems to me in the absence of some look and some direction toward our educational goals and the achievement thereof, we are simply going to lose the international competition for preeminence in the high technology field.

Dr. PEWITT. We have been down the road of the Federal Government setting forth manpower objectives, and we have seen the wasted talents of this country going to overproduction of unneeded Ph. D.'s in scientific fields based on Government encouragement. We want to avoid that in the future, and look at the structural problems that underlie these apparent problems of the moment in any particular scientific or engineering field. We are looking at this area. We do not think that the Federal Government is any better than the free market and that is the market when people start applying for jobs and people start making their career decisions in predicting demand. We do not think the Federal Government here in Washington can do that any better than the collective wisdom of the economy as a whole and the individuals in it. We just do not see trying to forecast these needs and then trying to set up national goals to satisfy them as a proper thing for us to get involved in. We think that people will look after their own interests, and we think that the involved parts of the private sector and the educational institutions collectively can do that. The idea that we will somehow improve the situation by some central planning and review and analysis does not appear attractive to us. We have seen it tried before, and we are not encouraged by the results.

Mrs. HECKLER. Well, if we do not look at this in an organized, structured way, I do not see how the private sector can deal with the real needs of a virtual technological revolution. In fact, many of the most outspoken advocates of this legislation have come from the private sector. They do not want economic planning in a centralized way, but this is hardly a centralized function: 10 persons who would make recommendations which would be submitted to the Congress, funded by the President in his budget and the Congress. This is not giving them authority to actually determine our lives. It is merely giving them the responsibility of suggesting and recommending structural changes that will produce the manpower needs of the country.

Now the people who are crying the loudest for this are from the private sector. They also discuss the question of the defense contractors versus the commercial contractors. Many of our major private firms in Massachusetts are very disturbed, if not in the defense contracting field, at their inability to compete with the demand for engineers in the defense field. The U.S. Government is funding defense, which I think is appropriate; we do need to increase our defense expenditures, and whether we agree or disagree on the level of that increase, the fact is the problem is very real.

At the same time, we have indications of a shortfall between the supply of engineers for commercial industry and the demands for engineers in the defense industry. How can this shortfall be addressed if there isn't some coordination? How will we meet the engineering needs in the commercial field when we have such an emphasis on defense, which offers a far more lucrative market for engineers?

Dr. PEWITT. I will try to give you a substantive, rather than just a political response to both of those.

No. 1, how to—there are really two questions there—how do we avoid the overproduction when national priorities are changed? I think no forecasting methodology known to man is going to be able to prevent or give us foreknowledge of national changes in priority. I just do not think that any planning commission or anything else is going to do that. I know that based on current planning, we may pump up a market for people and then wind up overproducing an area.

In the area of how are we going to satisfy the requirements, the deans of the engineering schools tell me that they have all the students that the engineering schools can handle right now and they are the highest quality they have ever seen. They can be very selective because so many people are trying to get into the door.

There is a fundamental problem in trying to hold the best of our Ph. D.'s in the teaching profession so that one can accommodate surge loads. There are many things that can be done. The National Engineering Action Conference, I think, suggested some of those things. While there are many things that can be done, the Federal Government alone should not do all of them.

The matter of salaries, and whether the universities are going to provide salaries that are competitive with the private sector, that is a real problem. Universities are eventually going to have to recognize they are in a manpower market, too, and have to meet the market if they are going to solve some of their problems. The Federal Government can do some things in this area, but we ought to look at how we treat this whole problem of making academic careers attractive, rather than the problem of the moment, and we are trying to devise approaches to that.

We are also concerned about the precollege problems and how to do something effective, and not try to do too much but pick out a key lever area where we can address these problems. We are just not prepared to present any proposals. We are still talking about it within the administration. We are not head-in-the-sand on this, and I regret that you perceive us to be head-in-the-sand.

We do not—and we have seen the mechanisms of Government work for a long time in Washington—we do not think that such a commission would be a useful approach to these problems. We simply do not. It mandates executive level 2 grades for the head of the National Science Board. I think it will be very difficult to get a man of the quality of Lew Branscomb to take a salary of $62,000 a year and work full time.

There are many problems such as that with this legislation. We think there are better ways to approach the issue. However, the central thrust of this legislation is that commission, and we do not see that aiding the executive branch in any way in the world in fulfilling its responsibilities, which are very real in this area.

Mrs. HECKLER. Well, what is your response, sir, to the growing concern of the commercial electronics companies who are not able to replace the drain of engineers to the defense industry? How are we going to meet those manpower needs?

Dr. PEWITT. I think that the engineering schools of the country are pumping out people as fast as the string can be pushed, and the Federal Government's action in that is not going to change that situation for many years. By that time we may well be in an excess situation. We have reviewed those analyses that show these tremendous shortfalls and what it appears to us to have been is a poll of, "What are your manpower plans and manpower requirements if all your plans work out?" Adding all that up, where everybody was expecting to capture 70 percent of the market, the problem may have been considerably overstated.

The reason that we have asked NSF to look at what it can do to examine manpower needs more thoroughly—and they will be setting up a special advisory group to help them in doing that—is because we need to sort out the real data on the manpower situation from the perhaps a little bit alarmist studies that we find coming out from various groups around town here, which are well-motivated but not necessarily always well-founded.

There is a gentleman named Charlie Falk at the National Science Foundation who has tremendous credibility in this area, and I think that we ought to get him directly involved in looking at this situation, together with the people who are worried about the statistics, the numbers and what they really mean, and try to sort this out and understand it as best we can. We certainly do not understand it now, based on some studies that were done by the various groups around town.

Mrs. HECKLER. Well, I am not basing my statements on the information of lobbying groups around town. I just want you to know—and you probably do know, of course—that Massachusetts is a major high-technology State——

Dr. PEWITT. Yes.

Mrs. HECKLER [continuing]. And the information that I receive comes from the presidents of major companies, most of whom generally support the philosophy of the administration wholeheartedly and are crying for help in this field. As a matter of fact, we do have a capacity for engineers at the academic level. What we do not seem to know is the number of young students who are capable and are being rejected because they cannot find a place at universities.

The capacity to meet the demands of the students and the industrial sector are not being addressed at all. I am delighted that you have some intention of addressing this problem. Yet, if the shortfall that is projected by people that I respect, from their own experiences and international companies that have experience abroad, continues while we study the problem ad infinitum and question the reality of their assessments, we could fail to meet one of the major problems of this decade. A problem which is closely allied with the productivity question and the economic war in which American companies find themselves. This is directly related to the quality of life and job opportunities in America.

The shortfall in Massachusetts for engineers was 3,000 people alone last year. Right now, there is a competitive environment in which the raiding of qualified personnel from one company to another is almost shocking. In California I am told that over 50 percent of the engineers constantly go from one company to another, getting another bid, upping their salaries, et cetera. This destroys the continuity of employment and manpower in some of our major industries.

Now if this is not a serious problem that demands some response by the Government, I do not know what other problem can rank above it. I would like to see the administration participate in improving the bill. If that is not a viable option, then I think it is incumbent upon Dr. Keyworth to provide an alternative program for response, based on valid assessment. The statistics and the validation can be easily achieved in this society. To ignore the problem and to study it as usual is to fail in the basic thrust of what I think the President is trying to do in improving our technology and our productivity.

No more questions Mr. Chairman.

Mr. WALGREN. Thank you, Mrs. Heckler.

Well, I hope that you will take a copy of Mr. Skelton's statement home for nighttime reading. Although you indicate that the Federal Government cannot solve all the problems but can do something, as you said, in my view we are still looking for you to identify what you admit you can do. This really is not a question of manpower alone. Although you can cite your feelings about these manpower projections, and perhaps the economy will draw the necessary manpower, that is only one piece of the puzzle.

Regarding the instrumentation question alone in the universities, there is no dispute about the inadequacy of the instrumentation in the universities, and it certainly would seem to me that we could agree on an initiative that would be driven in that direction. I certainly hope that the administration, instead of saying, "Well, this requires an additional level 2 or level 3," could suggest some present level 2 or level 3 that we could phase out and bring this effort on because it is more important. I personally feel that the administration is taking very little initiative in an area that has grave consequences for the security of the country and for our economic well-being in the future.

Well, thank you very much, Dr. Pewitt. We appreciate your time, and we look forward to working with you on this problem.

Dr. PEWITT. Thank you.

Mr. WALGREN. The next witness is Dr. Sheldon Glashow of the physics department of Harvard University, accompanying Reena Beth Gordon, who is the Westinghouse Scholar, won first prize in the Westinghouse Science Competition this year.

We are very happy to have both of you, and particularly want to honor the potential that Miss Gordon represents for our country. We are proud to have you with us.

Can I first ask Dr. Glashow to make a presentation, and then Miss Gordon.

STATEMENT OF DR. SHELDON L. GLASHOW, LYMAN LABORATORY OF PHYSICS, HARVARD UNIVERSITY, CAMBRIDGE, MASS.

Dr. GLASHOW. Thank you very much, Mr. Chairman, member of the committee. It is a pleasure to be here.

Actually I am going to read my report. I never do this in Cambridge but I am trying to keep within the confines of my time.

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I do agree with the previous speaker that we do not have a manpower problem: We have a crisis.

I have divided my talk up into a few separate paragraphs. The first one concerns Nobel Prizes. Americans win the lion's share of Nobel Prizes in physics, chemistry, and medicine, and this is frequently but wrongly quoted as evidence for the health of American science. In fact, it is interest earned by past investments in science education and research. Prize-winning research was done 10 to 25 years ago, when research was considerably more generously supported than it is today. Prize-winning scientists got their crucial precollege education in the first half of the 20th century. Since that time, European investment in science education and research has been much larger per capita than ours. The French have just announced that they intend to increase the spending on R. & D. from 1.8 of the GNP to 2.3 percent of the GNP, a rather considerably large number. This conflict in spending will become apparent with the Nobel Prizes of the next two decades, when it might be a little too late for us.

Two, the United States as a post-industrial society: Once upon a time, this country was the unquestioned technological hub of the world. Today most of our industry is in deep trouble. Steel, ships, sewing machines, stereos, and shoes are lost industries. Japanese cars are generally thought to be cheaper and better-made than ours. Proud RCA is now a distributor of Japanese goods which are assembled in Korea. American Motors is controlled by the French Government. We buy Polish robots. Advanced electronics and computers, which are still healthy and profitable, are soon to be seriously challenged by the Japanese. As we exhaust our heritage of capital and raw materials, Americans will no longer be able to afford the technological society to which we have become accustomed. We shall be left with our Big Macs, our TV dinners, and perhaps our federally subsidized weapons industries.

How is it that the forces of the marketplace have failed us? Is it too late for a technological renaissance? We have been leading our young people away from science and technology. The Vietnam experience, the failures of our nuclear power industry, and the threat of nuclear holocaust are partly responsible. The almost complete lack of precollege teachers with competence in science and math has played a very important role. The forces of the marketplace have driven what few good science teachers there are into the desperate but better paying arms of U.S. industry. Without these teachers, who will industry turn to next? Most of our high school students do not—with some conspicuous exceptions, one of them next to me—most of our high school students do not understand algebra or chemistry. Do not count on them to reconstruct our technological society.

My third remark is about educational philosophy. I was educated myself in the public school system of the city of New York. So was Miss Reena Gordon. I was incidentally supported for 6 years by National Science Foundation fellowships. The State regents exams in high school demanded serious, substantive, and standardized curricula. Reading and math levels were often tested when I went to school, and students were assigned in accordance with their skills.

This sort of quantitative testing seems to be very unpopular today. Students are put into open classrooms and told to do their thing. Self-expression is important. Grammar and history, let alone science and math, are not. We had to fight in Brookline to be sure that they would teach cursive writing; they thought printing would be enough.

Our schools are fascinated by complicated and expensive scientific toys and audiovisual aids. What they really need are scientifically literate teachers. Frogs, cow hearts, scalpels, siphons, a few leaves, a few drops of pond water, the night sky, an inexpensive microscope, a good chemistry set, some batteries, wires, and bulbs, are enough to teach a lot of science if the teacher knows what science is. What my kids get in Brookline is prepackaged commercial pseudoeducational pap, sometimes called "magic powders." They are given various white powders and told to figure out what they are, and the only thing they are told they cannot do is taste them. So mommy tastes them. Meanwhile they cannot even tell an oak tree by its leaf.

Five hundred nonscientific Harvard undergraduates take my core course called "From Alchemy to Quarks." Many of them cannot name one chemical element—these are Harvard undergraduates—nor can they identify one planet or one constellation. Some of them have never thought to look at the sky. They will become famous sociologists and famous political scientists. They are allergic to numbers. They have a disease that I call dysmetria, as do most Americans, the inability to calculate. Probably they are the people who will be entrusted with the U.S. budget a few years hence.

My fourth remark concerns Halley's Comet. My father, Lewis Glashow, was a young immigrant to America in 1905. He saw Halley's Comet in 1910. Then he saw the explosive technological growth of this country, of which he was very proud. He never ceased to wonder at the marvels of United States technology. He saw radio come, and he saw the subway come to his house in New York.

He explained to me as a child that Halley's Comet would return in 1985, and that American scientists would voyage into space and meet it and solve its mysteries. He was almost right. However, he would not have been too pleased to discover that it will be the Russians, the French, and the Japanese who will launch the probes of Halley's Comet. We could do it, of course, and we could do it best but we have chosen not to. The torch of scientific endeavor, it seems, has been passed to other hands.

I will conclude with a fifth paragraph that has something to do with high-energy physics, which is my specialty and something that this country was once best in. We were once the acknowledged leaders in high energy physics. We invented atom smashers, and until recently we had the biggest and the best of them. With the opening of the CERN–ISR 12 years ago in 1971 and the CERN-COLLIDER last year, we have been completely outclassed by our European friends. We will have no comparable facility for another 5 years.

The new and exciting and different field of electron-positron collisions was pioneered in France, Italy, and the Soviet Union in the

1960's. Despite this, we became triumphantly successful in this field in the 1970's. The 1970 Nobel Prize in physics was awarded partly for work done at these machines. Probably there will be another Nobel Prize or two coming to other very deserving colleagues who have worked there. However, since 1978 we have been completely beaten at our own game by the Germans and within a few years by the Japanese, and a few years later by the Europeans again. Western Europe spends twice as much money on high-energy physics than America does. The future of this field in our country is not good. Ironically, it is the force of the marketplace that impels the Europeans to push high-energy physics. Perhaps more clearly than we do, they see technology as the key to a healthy industrial society.

Thank you.

Mr. WALGREN. Thank you very much, Dr. Glashow. That is a telling and wry statement.

Ms. Gordon, we welcome you to the committee. It is not that often that we have people your age but not that often that we have people with your accomplishments, either. We are glad you are here.

STATEMENT OF REENA BETH GORDON, WESTINGHOUSE SCHOLAR, BROOKLYN, N.Y.

Miss GORDON. Thank you.

It is an honor to present a student's perspective on education. I still have many years to go before my formal education will be complete but I know that I have largely been academically and intellectually formed. I am aware of most of my capabilities, my weaknesses, and my interests.

Similarly most students will pursue particular interests, through study or work, upon high school graduation. Many are far more sure than I of specific future plans. I should, therefore, like to address myself to the emphasis of my written presentation: the improvement of precollege education, an investment in our future which ultimately will have the greatest impact in quantity and in quality.

You have received the statistics from specialists; instead of reiterating numbers, I will introduce my own experiences in this matter to supplement the five areas stressed in my testimony.

I am in a fortunate position to do this. I have had one of the finest science and mathematics education attainable, as these disciplines are emphasized in the New York City public high schools more than in schools in other parts of the country. I am a participant in a magnet program within my school and am, therefore, able to see the affect specialty courses and specialty high schools have upon students, and am at the same time privy to the experiences of students not within such specialty programs.

Finally, I have been the very happy beneficiary of corporate participation in our education system—the recent Westinghouse Science Talent Search. Equally as important, university involvement in the precollege level was crucial to my formation, for my project was fully supported by Prof. D. Terence Langendoen of Brooklyn College.

You have heard much today on the importance of teacher quality. I can testify both from my own experience and from the experiences of all my friends, that this is the single most important factor in education. In my case, Mr. Mathew M. Mandery, mathematics chairman of Midwood High School, made all the difference.

When I entered Midwood I had many different interests. I had a literature background and I was interested in languages. Mr. Mandery was my calculus teacher, my math team coach, my supervisor. Furthering my love for mathematics, he backed me up 150 percent and showed me firsthand what fine quality teaching can be. Without him, I would not be sitting here talking to you nor would I be in a position to seriously discuss science education.

This personal incident illustrates the impact instructors generally have upon their students. My chemistry teacher, Ms. Levine, wields tremendous influence over her classes by superb teaching combined with enthusiam for the material. An exceptional number of students from her past classes have gone into chemistry or related fields, such as biochemistry and chemical engineering, because of her in a single chemistry course taken in high school. She conveys the positive feeling that science is not a stagnant process. It is a creative process, a process in which students wish to become involved.

Not only does a superior teacher influence students; a bad teacher also has influence, and is capable of irreparable harm. I had no science education until the eighth grade because of problems within the small school I attended. In the eighth grade I was tought biology by a teacher who was 1 day ahead of her students in the text book. Perhaps she had never taught before; I am certain she was not a science teacher. It has taken me 3 years to overcome my distaste for biology. In addition, I have never been in a biolaboratory, and though I now recognize the importance of this field, I no longer can express any sustained interest in it.

What does poor teaching mean in elementary school? My sister a bright and mature adult, has an approximation of the fear of numbers which was just discussed. She had a terrible third grade teacher who ruined any interest in math. The man who taught third graders before her and taught third graders after her. A student's self-esteem—confidence that a task can be done—must be implied when young by the teacher. Thus, a direct relationship exists between the quality of instruction and student interest, particularly in primary school.

Enough on a point on which we all agree.

The curriculum: If students are not exposed to it, they cannot like it, and if they do not feel they have a part in it they will not want to pursue it. That is as best as I can put it.

I brought some materials with me—"creative mathematics" on the third and fourth grade level. I went back to my old school and said, "Mr. Gross, do you have any of those wonderful games that we used to play?" Those ideas that we were actively involved improved his ability to teach. Because my science background is poor, I talked to friends who had gone to public schools. They, too, had felt that their science education in the primary schools was extremely nonproductive. They did not get a taste of scientific fields that they should have gotten. They were exposed at most to the basics of the human body, and perhaps they did learn to recognize an oak tree. However, what is the periodic table? What are the basic ideas of gravity, of physics? What does an engineer do? How about those stars up there? Are they interesting, too?

Therefore, survey courses must be offered to students, especially in the primary schools when students are still open to different ideas. Young children are willing to learn; their minds absorb knowledge like sponges. I think we owe them a wide exposure to science, and I am not merely concerned with high-ability students.

On the secondary school level general electives for interested students of average ability should be devised. What is digital electronics? Why not a workshop? What is astronomy, zoology? These are the courses that the specialty schools in New York City provide. Throughout the country, there must be increased support for specialty schools and special programs which draw students in the junior and senior high schools to science- and mathematics-oriented centers, as exemplified by Stuyvesant High School and the Bronx School of Science. A great part of the success of these programs, besides student and teacher quality, is the number and variety of electives offered: philosophy of physics, biochemistry, organic chemistry, to name a few. These courses encourage different perspectives on science, open new experiences for students while still in high school.

A high-ability student must be grabbed, because a high-ability student has many interests among which to choose—history, science, business, literature. If that person takes a phenomenal economics course and has no experience whatsoever with science beyond basic biology, he or she is more likely to pursue economics and not biology on the college level.

This brings us to my favorite topic: enrichment programs. I think this key area of education has been nearly deserted. Its potential impact upon students cannot be overestimated, not only upon those of high ability but for any student with an after-school job, hobby, or not purely academic interest.

A friend of mine, who is not a top student, worked for a graphics company. It is her developed talent in art that she will pursue when she enters college. Quite often, it is an outside-of-the-classroom interest that determines what students wish to do with their lives.

I was lucky; my parents were willing and able to send me to challenging summer programs. I was able to take a linguistics course this past summer at Harvard, and, previously, a computer workshop at Northfield Mount Hermon Secondary School. These experiences were crucial in the formation of my academic perspective.

Furthermore, when I returned this summer from Harvard and contacted Mr. Mandery, a university professor was willing to open up a whole new world to me. Professor Langendoen not only directed my Westinghouse project but also introduced me to colleagues in linguistics and related fields at prestigious research centers. He took a personal interest in me. Because of his guidance, I will continue research this summer at Bell Laboratories. One individual's participation in my life became a turning point for me. It is an example of what must be achieved on a larger scale. Increased university involvement with precollege education, and, similarly, increased, industry-initiated programs.

I would never have done the project had Westinghouse not provided a motivating support system. After the competition, one question was asked of me again and again at school: "How do I get involved in research?" Juniors, sophomores, even freshmen approached me: "What can I do, Reena, to become involved? I hear about your Westinghouse project." "I am interested in dolphin communication," I heard from one person. Another student told me he had always wanted to learn mathematical topics not taught in standard high school courses. Could these potential scientists participate in programs to stimulate their creativity?

I sent them to Mr. Mandery and to administrators in the school but I had no answers because programs such as the NSF summer programs no longer exist. An example of the widespread impact of the program on its thousand participants a summer is my brother, who attended an NSF program in mathematics several years ago. He is now a mathematics major at the University of Pennsylvania.

It might be helpful to give one or two examples other than within my family. A friend at Stuyvesant who is graduating will pursue an electrical engineering degree next year at Massachusetts Institute of Technology. He chose this particular field because he had taken a computer workshop in seventh grade and then had worked for his seventh grade teacher after school on the computers. He is presently employed by a computer company in New York, which has further stimulated his interest. He is also taking a digital electronics course at Stuyvesant.

All these experiences are outside of the classroom. Similarly, a program that a teacher at my school coordinated several years ago for primary school students in biology and laboratory research encouraged many of the participants to enroll in the Midwood Medical Science Institute, to pursue these interests. The program was short lived due to a completed halt in funding.

Such programs are increasingly offered in nonscientific fields. These include internship programs in politics, summer programs in broadcasting, and the business-sponsored junior achievement, which directly involves high school students in the financial world. If students don't find enrichment programs in the sciences, they will find them outside and they might well continue in that other field.

Career orientation is a minimal-outlay, maximum-output idea. Mine is an economically conscious generation. Most of my friends have part-time or full-time jobs. We are worried about our ability to pay for college and to live comfortably later. If we do not know what jobs are available in which we may earn a decent salary and find satisfaction in our jobs, we will not go into those positions clearly of such significance to the Nation.

What are the applications of school subjects? Until this year, I did not know what an engineer did, and until I worked on Lemma, our math magazine—I was unaware of many of the applications of mathematics. Just this year, Lemma's lead article, "math beyond the classroom," introduced students in Midwood to the applications of their mathematics courses.

The need for comprehensive career orientation became clear to me in a health education course, when a Board of Health representative addressed the class on jobs available in the health field. He discussed job responsibilities, schooling, benefits, and compensation. A university or industry practitioner should likewise lecture briefly to science classes, in order to inform students of the varied scientific, engineering, and technical occupations that are both fascinating and rewarding.

As for scientific equipment: the basics in schools are atrocious. At Stuyvesant the microscopes have no knobs. At my own school we are lacking in magnets, paper, and chalk, hardly laboratory equipment.

The math department sponsors a bowl-a-thon each year. In this manner we first bought our computers. People pitch in a penny per pin, so the students raised the money to get our nine little commodore pets, and, thus, we have a computer program. Otherwise, we would have none whatsoever. Again, sharing of laboratory and computer equipment is another opportunity for greater industry and university involvement in the precollege level.

We are now trying at Midwood to have the AP chemistry and biology classes use the facilities at Brooklyn College. Expensive equipment should not be bought for high schools. Obviously the money must be spent on basics, but to have the equipment available for advanced classes to use at industry or university facilities would be most worthwhile.

In conclusion, I wish to reiterate my thanks for considering my statement. Yet, perhaps you should have heard from someone who was less fortunate than I. Perhaps you should have heard from the student who decided not to pursue science who never got the teacher support and never was exposed to the various things to which I was exposed. Maybe you would have heard from such students why they did not continue in the sciences instead of why I will.

Thus, I can only hope I impressed upon you not simply how these experiences were unique to me, but how my exceptional experiences and the exceptional activities in which I have been engaged can become the general rule for precollege students.

Thank you.

[The prepared statement of Reena Beth Gordon follows:]

WRITTEN TESTIMONY OF REENA BETH GORDON RE: "THE NATIONAL ENGINEERING AND SCIENCE MANPOWER ACT OF 1982," APRIL 29, 1982

Students form tastes and perferences for fields of knowledge early in life. If we wait until the college years to provide students with effective scientific and technical training, we lose the opportunity to stimulate greater interest in the sciences and advance critical thinking skills. We must focus upon solid primary and secondary school education in order to develop the nation's most valuable asset: our human resources. As a high school student who has been fortunate in acquiring an excellent mathematics and science foundation, I believe that my experiences and those of my acquaintances—both positive and detrimental—may offer critical insight into the improvement of science education. Although these views may have been presented previously, I must emphasize from personal observations that our successful utilization of scientific talent requires the coordinated efforts of the public and private sectors in upgrading five essential components of pre-college education, as follows: (further details will be presented in my oral presentation)

1. *Instruction.* Teacher quality is the single most important factor in education. Particularly upon first exposure to a subject, a student's reaction to and mastery of the material depends largely upon the effectiveness of the instructor.

a. *Teacher Training.* Faced with a severe drain of potential science and math teachers into industry, we must combat the declining standards of those already in the teaching profession.

i. Teachers must be kept abreast of new development in their fields and related areas so as to convey a sense of science as an ongoing, creative process, a process in which students would like to become involved.

ii. Teachers must be informed of the vocations in and applications of science in order to highlight for students the practical relevance of school sugbjects.

iii. Teaching and testing methods emphasizing clear thinking and problem analysis must be achieved.

iv. Educators must be made aware of the unique needs of the gifted, women, and minority students to maximize the talents of these individuals. The first years of primary school merit particular attention to this issue.

v. Out-of-license teachers should be kept to a minimum. If employed, they should receive special assistance from expert science and mathematics supervisors.

vi. The above needs may be satisfied through a variety of seminars, lectures, and workshops, both mandatory and optional.

b. *New teachers.* For long-term results, the shortage of qualified mathematics and science teachers must be filled.

i. Industry in particular should recognize the dangers of this situation; industrial leaders might adopt policies encouraging their scientific personnel to devote a number of years to teaching.

2. *Curriculum.* Many of the introductory science and mathematics courses currently offered fail to capture student interest and to establish a sound base for future work. Few pre-college technical and engineering courses are offered. State and local courses of study should be carefully assessed and the curricula appropriately redesigned.

a. *Primary school level.* Students should be exposed to a broad range of scientific areas. They might then pursue fields in high school and later which they might not have otherwise considered.

i. After fundamental mathematical skills are secure, general survey courses should introduce students to basic concepts in the physical, engineering, and computer sciences, along with the usual mathematics and natural science classes.

ii. Laboratory procedures should also be introduced.

b. *Secondary school level.* At present, most students do not continue in science or mathematics past the tenth grade, when they exposed to biology and geometry. They remain ignorant of chemistry and physics, advanced algebra, trigometry, and calculus.

i. Reexamination of graduation requirements and standardized examinations in science and mathematics is necessary.

ii. Computer, technical, and engineering electives for students of average ability should be devised.

iii. It is especially desirable to increase the number of special junior and senior high schools and the variety of advanced electives for high ability students. These selective programs have proven invaluable in providing an atmosphere conducive to learning and research.

iv. English classes can make a worthwhile contribution by stressing writing, reading, and research skills. Social studies courses can focus upon the history of science and mathematics and technology's impact upon our civilization.

3. *Enrichment Programs.* Supplemental experiences are vital in directing student interest toward careers in science. Unfortunately, the importance of these enrichment programs has been underestimated, and they are extremely limited in scope. Government, industry, and universities should coordinate facilities, personnel, and funds to enhance such programs:

a. After-school computer and laboratory workshops for small groups of primary school students should be conducted at high school and colleges.

b. Weekend and summer instruction, research, and internships in industry and at universities must be available to high school students.

i. The National Science Foundation SST program in a variety of scientific fields successfully attracted over 4000 students per summer. This program stimulated interest in the participants that spilled over into their regular highschool environment. The program no longer exists.

ii. Industry specialists and university professors may become role models and field contacts for high school students.

iii. Tours of laboratories and other facilities should be arranged.

c. Contests stressing research and scientific study stimulate student projects. Problem-solving contests spur student participation. The number of these scholarly programs is limited.

d. Mathematics, engineering, and science clubs and teams within the school and the region are a springboard for ideas and student-initiated science activities.

e. Information concerning these programs must be widely disseminated to students and participation encouraged by the school faculty and administration.

4. *Career Orientation.* Many students become career oriented early in their lives. To attract students to scientific, engineering, and technical careers, students must be made aware of job possibilities, educational requirements, and the satisfactions of such employment. Career education is sorely lacking in our high schools. Such programs could include:

a. Speakers from industry and universities to address individual science classes on each class level.

b. Films and pamphlets produced by industry and government, and widely distributed.

c. Science and mathematics textbooks presenting materials on career opportunities.

d. Career education classes.

5. *Equipment.* The availability and use of equipment at a pre-college level is essential for student motivation. Existing equipment is often outmoded and defective; newer equipment is generally lacking in the schools.

a. *Computers.* Modern computers should be introduced in the primary schools and used extensively in the secondary schools.

i. Students of average and high ability must learn rudimentary computer programming, and interested students should be afforded the opportunity to progress to advanced work.

ii. The use of the computer as a teaching device in mathematics and science for drills, problem-solving, laboratory simulations, and other educational purposes should be examined and appropriately encouraged.

iii. Advanced students should be able to utilize computer facilities at universities and industrial establishments.

b. *Laboratory equipment.* Funds must be made available to primary and secondary schools for the purchase of basic scientific equipment.

i. The choice of such equipment should be left to the judgement of the individual schools.

ii. An advisory council should assist the schools in choosing equipment.

iii. Students in advanced courses should be able to utilize laboratory facilities at universities and industrial establishments.

c. *Libraries.* School libraries are badly lacking in recent scientific, engineering, and technical books, and journals, films, and magazines.

i. The schools should be encouraged to acquire such scientific and mathematical materials, and to present exhibits of scientific content.

Biographical Sketch—Reena Beth Gordon

Raised in a middle-class family in Brooklyn, New York, I have learned to value education from my father, a former high school chairman and author of history texts, and my mother, a high school English teacher. I attended the Bialik School, a small bilingual day school, until the eighth grade, am presently a senior at Midwood High School, a large public school with a magnet program called the Medical Science Institute, and will enroll in September at Radcliffe College.

At Bialik, I won a number of Hebrew competitions, participated in school science fairs, and advanced several years in mathematics, English, and science. This advancement, coupled with summer courses in computer and creative writing taken at Northfield Mount Hermon, allowed me to accelerate from my freshman to junior year of high school. I am extremely involved in Midwood activities; I am captain of our champion senior math team and Editor-in-Chief of our mathematics magazine, and participate in Model Congress, orchestra concerts, and student musicals. I have taken four Advanced Placement courses, and have been awarded the Rensselear medal for excellence in science and mathematics and the Brown award for excellence in English.

After enjoing an introductory linguistics course at Harvard University last summer, I became intrigued by the mechanisms of human communication. I was encouraged to pursue this interest by the mathematics chairman at Midwood, Mr. Mathew M. Mandery, who had previously supported a research paper in pure mathematics for which I received two medals. Mr. Mandery contacted Professor D. Terence Langendoen of Brooklyn College and the CUNY Graduate Center, who helped me explore a specific problem within mathematical linguistics. I entered the project in the 1982 Westinghouse Science Talent Search, and was granted the first place award.

I will continue this summer in linguistics and artificial intelligence research at Bell Laboratories. Because I am uncertain as to my eventual career, my current plan is to study mathematics, physics, economics, political science, linguistics, and psychology.

Mr. WALGREN. That is a very nice statement. It is good to see what an enriched education can do and produce and we appreciate that presentation very, very much.

Mrs. Heckler?

Mrs. HECKLER. Well, I would like to say that I enjoyed Dr. Glashow's testimony very much and agree substantially with his very important remarks. I think that the perfect expression of the ideal educational system lies in the career that you already have achieved.

As a student, Miss Gordon, you are probably the youngest witness ever to appear before this committee, but you rank very high in terms of your potential and your intelligence and your achievement thus far. I am particularly pleased to see you and to listen to you because one of my favorite subjects has been the advancement of women in the field of science.

You are already, as you have noted in your own testimony, a role model not only for the girls, but the young men as well in the schools that you attend. I think your comments on the role of education are particularly significant. The potential that you offer for engaging that other 51 percent of the population in the main thrust of public policy and achieving their potential is also, I think, inherent in your own goals and your own achievement.

I really commend you and hope that you will continue to speak out. As important as your scientific breakthrough will be, your enrichment to the body politic in public forums such as this will also be very, very significant. One of the essentials that is needed in America today is a public consciousness of the goals of this society and how they can best be achieved. That would not only deal with the problems of the poor and the handicapped but the problems of the bright and the promising as well. The quality of life can be greatly improved by giving those with talent and even those with mediocre ability the chance to be their best selves and achieve their careers.

Therefore, I would say to both of our witnesses that you have made unique contributions today; that we on this committee see the significance of education and especially scientific education. We have been condemned as a scientifically illiterate nation. Your scientific literacy is extremely high, but the message has to be told by those who come from the disciplines that you will engage in, not only by those of us who are in government or elected to office. There has to to be this public/private partnership on academics issues.

I look forward to following your career in the future. Much will be expected of you because there is much that you can give this society. I hope that your endeavors will surpass what I see as a very promising scientific achievement into the areas of moving society into the directions that will recognize science and meet it fully and joyfully.

My only regret today, Dr. Glashow, is that we do not have the privilege of listening to your father. I think he would have added a great deal.

Congratulations, Miss Gordon.

Miss GORDON. Thank you.

Mr. WALGREN. Well, I would like to add my congratulations in particular.

I wanted to ask just a little bit about this threshold high school that you apparently had access to.

Miss GORDON. We have a magnet program at Midwood called the medical science institute. It functions in various ways: Pulling students in from out of the immediate district of Midwood—my particular district school is not Midwood—within Brooklyn; allowing Midwood to choose its students; offering a number of bio and medical electives, such as photomicography, and the AP courses, et cetera. Essentially, it provides an atmosphere for learning and stimulating high-ability students, especially in regard to the medical and scientific professions.

Mr. WALGREN. Perhaps best directed at Dr. Glashow, we have a proposal, one of our members in particular, Mr. Gregg from New Hampshire, is interested in a program that would set up a relatively broad program of awards to high school teachers for being the best teacher. Since so much of what has been brought out here is the impact of the ability of an individual teacher to inspire an individual student, that could not but be helpful, I imagine.

Dr. GLASHOW. Absolutely yes. I agree completely with Miss Gordon that the most important thing is to have at least one good teacher, and optimally at least one every year.

There are not enough awards for good teachers. There also are not enough good teachers.

For me, too, when I went to high school the important thing was that we had some superlative teachers. As it happens, at the Bronx High School of Science the superlative teachers were teachers of history and literature as well as mathematics, not sciences, but they should have gotten awards. Your teachers should get awards, Miss Gordon. Good teachers, wherever they are, should be so awarded. I think it is a great idea.

Mr. WALGREN. That was the Bronx High School of——

Dr. GLASHOW. I went to one of the specialized schools. There are, I think, four in New York. It was the Bronx High School of Science. The city of New York has a very long history of having these specialized, by-examination schools. Not Midwood: Midwood has this apparently ancillary program but Bronx High School of Science, Stuyvesant for the sciences, Brooklyn Tech for Engineering, the High School of Music and Art, Hunter High School for the Liberal Arts, these are fantastically good schools. They were good when I went 30 years ago and they are still very good.

Just yesterday I advised one of the best freshmen that I have seen at Harvard for many, many years, and needless to say, he is from Stuyvesant.

Miss GORDON. Mr. Walgren?

Mr. WALGREN. Yes?

Miss GORDON. I would like to add that the quality of these schools is usually recognized. Recently, in my own experience, 5 of the 40 Westinghouse finalists were from Stuyvesant, the largest number of winners in 1 year ever to attend one school.

Dr. GLASHOW. And 10 or 12 of the finalists were from New York.

Miss GORDON. Yes; 17 or 16 were from the State.

Dr. GLASHOW. Seventeen out of forty?

Miss GORDON. New York clearly has a commitment to science and mathematics precollege education.

Dr. GLASHOW. Well, Brookline High School is a good school but nobody from Brookline High School has ever applied for a Westinghouse award, to the best of my knowledge. It is not encouraged, it is not supported, it is not mentioned.

Miss GORDON. There weren't any from Massachusetts. I am sorry.

Mrs. HECKLER. I am very embarrassed, but you have given us a new goal.

Mr. WALGREN. Is there anything that can be suggested to create good teachers? What would go into that?

Dr. GLASHOW. It might be nice to try—these days, in the next 10 years we will probably see a reduction of 20 percent, I think it is, in the number of college students just because the demography is the way it is, and a lot of small but good schools, colleges, are probably going to fold, unfortunately. That produces a large number of experienced teachers who have the technical skills to teach science and mathematics but none of the educational requirements that are normally required of our teachers. If some way could be found to inject this cohort of highly skilled people into high school teaching, it might do a great deal to solve the problems of the next decade.

Mr. WALGREN. I see.

Well, let me thank you both, and again say how much we enjoyed a glimpse of what might be for the future. I am sure there are lots of other young people like you out there, Miss Gordon, and we hope for real good things from them and from you.

Thank you very much. This hearing will be adjourned.

[Whereupon, at 12:05 p.m., the subcommittee recessed, to reconvene at the call of the Chair.]

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