DOCUMENT RESUME

ED 257 667 SE 045 763

TITLE 1985 Science and Technology Posture Hearing with the Director of the Office of Science and Technology Policy. Hearing before the Committee on Science and Technology, U.S. House of Representatives, Ninety-Ninth Congress, First Session, February 5, 1985. No. 1.

INSTITUTION Congress of the U.S., Washington, D.C. House Committee on Science and Technology.

PUB DATE 85

NOTE 78p.

PUB TYPE Legal/Legislative/Regulatory Materials (090)

EDRS PRICE MF01/PC04 Plus Postage.

DESCRIPTORS Budgets; *Federal Aid; *Government Role; Hearings; Higher Education; Leadership; *Policy; *Research and Development; Sciences; Scientific Research; Student Loan Programs; *Technology

IDENTIFIERS Congress 99th; *Science Policy

ABSTRACT

These hearings consist of testimony by and the prepared statement of George A. Keyworth II (science advisor to President Reagan and director of the Office of Science and Technology Policy) on the Reagan administration's science and technology policy and the proposed fiscal year 1986 budget for research and development (R&D). Supporting documentation (remarks by Marilyn Lloyd and articles by George Keyworth titled "The Case for Strategic Defense: An Option for a World Disarmed" and "Science and Technology Policy: The Next Four Years") and the discussion between committee members (Committee on Science and Technology) and Dr. Keyworth are also included. Among the areas addressed are: (1) the practical consequences and essential role of scientific leadership; (2) a budget which permits investment in the future (by reducing federal spending) while assuring a strong national science and technology base; (3) current and future research programs; (4) ways to preserve the United States' fragile scientific leadership (such as embracing the responsibility for basic research and making every dollar count); and (5) issues related to student loan programs in the FY 1986 budget. (JN)

1985 SCIENCE AND TECHNOLOGY POSTURE HEARING WITH THE DIRECTOR OF THE OFFICE OF SCIENCE AND TECHNOLOGY POLICY

HEARING

BEFORE THE

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

NINETY-NINTH CONGRESS

FIRST SESSION

FEBRUARY 5, 1985

[No. 1]

Printed for the use of the
Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1985

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WITNESS

THE 1985 SCIENCE AND TECHNOLOGY POSTURE HEARING WITH THE DIRECTOR OF THE OFFICE OF SCIENCE AND TECHNOLOGY POLICY

TUESDAY, FEBRUARY 5, 1985

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The committee met, pursuant to call, at 9:30 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the committee) presiding.

Mr. FUQUA. The committee will be in order.

Today, we open the 99th Congress for the Science and Technology Committee with our annual posture hearing on the administration's policy for research and development. We are pleased to welcome again the President's Science Adviser, Dr. George Keyworth, for his fourth appearance before this committee.

Our hearing is intended to place into the broadest perspective the research and development budgets of the individual agencies. These budgets will be the subject of careful scrutiny when our subcommittees hold hearings later this month.

Today we have asked Dr. Keyworth to describe and discuss the general, longer term considerations which form the policy framework for those individual agency budgets.

We are all aware of the serious situation which is facing all Federal programs as a result of the deficit. That situation dictates that we give the research and development budgets the most careful scrutiny. Only those programs that truly serve the Nation's needs and which are effectively managed can make a claim on the Federal purse.

At the same time, we must keep firmly in mind that science and technology constitute two of the most important building blocks in the structure of the Nation's long-term economic health. What we do today, in terms of providing the resources for research and for the education of future researchers and engineers, will have a profound effect on the strength of our economy and on our international trade in the year 2000 and beyond.

With those thoughts in mind, we want to review carefully the thrust and direction of the budget proposals for fiscal year 1986. Our witness has played a central role in the formulation of both this budget and the broader policies on which it rests.

[The opening statement of Mr. Lujan follows:]

Opening Statement
Honorable Manuel Lujan, Jr.
Keyworth Posture Hearing
Committee on Science and Technology

February 5, 1985

Thank you, Mr. Chairman. I certainly want to welcome my colleague from New Mexico, Dr. Keyworth. I always enjoy talking with you, Dr. Keyworth, because we agree on so many issues. We particularly agree on the importance of maintaining the U.S. leadership in technology.

There was an article in this past Sunday's Washington Post that mentioned the President's Commission on Industrial Competitiveness. I understand that this Commtssion decided that the two most important factors in assuring that industries are competitive internationally are technology and talent.

If you think about the economic history of the U.S., you will discover that a continuous stream of innovation, of technology development, that brought our country economic prosperity. The fast Clipper ship was an early American invention in transportation, followed by the steamboat, the locomotive, the automobile, and the airplane. Early in American history, the cotton gin and other innovations revolutionized the textile industry. Other American ideas like interchangeable parts, made mass production possible and evolved into assembly lines. And of course there are American ideas like electricity, the telegraph and telephone, and more recently, the laser. The relationship between technological development and economic prosperity is now so well recognized internationally that industrialized nations consider science and technology as an essential element in their future welfares. The large industrialized democracies now recognize that their economic future depends on new industries spawned or fed by high technology. This means that the U.S. now competes in a world market.

Just as this technological leadership has been a major factor in U.S. prosperity in the past, it will be the basis for U.S. prosperity and world leadership in the future.

Since technology and innovation are our nation's greatest strength, we must preserve them. This means we must have a population that is well-educated in science and its application--technology. But America's future is not secure. Not simply because of the enormous and talented competition from abroad, but also because of the strains that will be put on our educational system by a society hurtling into the 21st Century--the high technology era. In the past few years, I have become increasingly concerned about the ability of the educational system to provide the scientific, engineering, and technical talent this country will need to compete in the future world market.

In summary, I agree with the President's Commission on Industrial Competitiveness that technology and talent are the two most important factors.

Dr. Keyworth, you have been a leader in this Administration's push for strong support of basic research programs and technological development. I am sure you will agree that superiority in technology is the greatest asset that the U.S. has to sell around the world. I am interested in hearing your testimony this morning.

Thank you, Mr. Chairman.

Mr. FUQUA. We welcome you, Dr. Keyworth, to what I expect to be a most helpful and productive presentation and discussion. You may proceed.

STATEMENT OF DR. GEORGE A. KEYWORTH, II, SCIENCE ADVISER TO THE PRESIDENT, AND DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Mr. KEYWORTH. Chairman Fuqua and members of the committee, the start of a new administration and a new Congress is an appropriate time to take stock and chart a course for the coming years. Many of our efforts are going to be concerned with critical choices we have to make in three areas.

One is national security; how to create a more stable world and, specifically, how to reduce the presence of nuclear weapons. A second is how we in America can ensure our economic progress in the face of rapidly growing competition in the world's industrial markets, and the third is how we can bring Government spending under better control and reduce the deficit that intrudes so rudely on our plans for the future.

Mr. Chairman, I think you will agree that our enviable lead in science is an important thread that runs through all of those issues, because science and technology are tools to forge our own destiny. They are our leverage on the future.

Fortunately, we go into the 1986 budget deliberations with our science and technology enterprise significantly strengthened over that of not many years ago. The growth of 55 percent in support for basic research over the course of these past two Congresses is restoring momentum to what is one of this country's greatest assets, our scientific enterprise.

In addition, and equally important, this high priority assigned to science by the Federal Government has elicited comparable high priority in the private sector for using that science.

Industry has been increasing its rate of investment in research and development even faster than Government has, and in doing so, it has also forged productive new partnerships with universities.

But here I have to interpose a cloud into that sunny picture. Our science and technology at present may be brighter than it has been in years, but a shining future is anything but guaranteed. Our leadership in science is fragile, extremely fragile.

That should concern us deeply, because science plays the same role for technology as a foundation does for a house. Neither structures nor modern industries can exist without those bases of support.

And today we depend, far more than most people realize, on our preeminence in science to enable us to exploit technology and maintain our economic and national security.

Two events during the past year brought home vividly to me the practical consequences of scientific leadership.

The first was my own experience serving on the President's Commission on Industrial Competitiveness, where I was a lone Federal official in a group composed primarily of industrial leaders, few of whom share my technical background and biases for science and technology.

Yet it didn't matter if they were bankers, labor leaders, seasoned heads of mammoth corporations, or young entrepreneurs, all agreed that in the international industrial arena, the United States has only two sustainable advantages over our competitors. These two advantages are our technology and our talent.

Those industrialists understand better than most people how basic research fuels those two competitive advantages. There was no doubt in the minds of these unquestionably bottom-line thinkers that scientific and industrial leadership go hand in hand.

My second observation of the essential role of scientific leadership is evidenced by the Soviet Union's response to the strategic defense initiative, the President's proposal to use our scientific and technological expertise to develop defenses against nuclear weapons.

It was the prospect that the United States would use our technological superiority to alter deterrence, and to diminish the Soviet strategic edge, that catalyzed the returns of the Soviets to the arms control talks in Geneva.

But here I must share my frustration. The Soviets recognize and justifiably fear U.S. science and technology. U.S. industry, facing a relentless challenge from other countries, especially Japan, placed top priority on assuring a strong science and technology base to produce the knowledge and talent we need to compete.

And the American people and today's students know instinctively how directly future economic progress and national security depend on our technological leadership.

As a scientist myself, I can be dismissed in coming before you touting the importance of science to our future. But we can't dismiss what we hear from the Soviets, from our industrial leaders feeling the hot breath of challengers on their necks, and from people across America; they have to be listened to.

The President knows that science and technology have been the fuel for our postwar economic growth, yet too many of us in Washington take our preeminence in science and technology for granted. But the truth is that few of our great strengths are more fragile. Unless we recognize the vulnerable nature of this precious leverage, we may find the costs of complacency to be very, very high.

Mr. Chairman, we are challenged this year to balance two dominant priorities. One is to permit investment in our future by reducing Federal spending. The other is to assure a strong national sci-

ence and technology base. The budget being presented to the Congress does both.

Funding obligations for R&D will total $60 billion in fiscal year 1986; of that, some $20 billion will support non-DOD R&D, and $8 billion will support basic research. Funds obligated for non-DOD R&D will decrease slightly from 1985 to 1986, and funds for basic research will increase slightly above the freeze level. Within these proposed budgets, I have no doubt whatsoever that we can conduct extremely effective R&D programs.

After 4 years of near-historic funding increases, there is now plenty of momentum in the system to maintain healthy progress. Moreover, as a matter of practicality, actual outlays for basic research would rise by nearly 5 percent next year, which should even permit a little real growth.

In addition, because we have deliberately postponed the start of construction for major new research facilities for 1 year, we will be able to maintain strong funding for ongoing research programs.

Mr. Chairman, dealing with budgets necessarily immerses us in what I would call the tactical problems of individual program priorities. Those are the practical steps we have to take to turn policy into reality.

However, I also want to urge us to stand back this year and do some extra strategic thinking about science and technology. I say that because I see the central challenge we face as preserving our fragile scientific leadership.

These are two things we have to do. First, we have to embrace our responsibility for basic research. Basic research is as essential to our two highest priorities, maintaining economic growth and national security, as is any other investment we can make today.

I won't deny I am concerned about our ability to sustain the kind of leading-edge basic research program this country absolutely must have. We can't take it for granted. We have to convince others of its importance, and we have to make sure that the current priority for basic research is maintained.

Second, we have to make every dollar count. Science and technology are dynamic processes, kept alive by a constant input of new energy, new people, and new ideas. The worst danger we face is to be lulled into complacency about our leadership and fail to allocate funds wisely.

I strongly support the necessity of slowing the growth of science and technology funding in the short term as part of the response to the deficit. But at the same time, I won't hide my concern about the vitality of U.S. science over the longer term and about its continued attraction for the best young minds.

Even the most optimistic forecasters warn us of several years of lean funding until we get the deficit to a level where it doesn't dominate Federal budgeting.

As I said, we are in good shape for 1986. Our real challenges will come in fiscal years 1987 and 1988, when we simply will have to find ways to ensure our ability to pursue, and pursue vigorously, new avenues of research.

Progress in science won't stagnate, and it won't wait for us. Other countries, facing equally trying times, are renewing their support of basic science. And they are doing it in emulation of our

own economic miracle. The last thing we want to do is lose sight of our own successes and what stimulated them.

So we will have to be prepared to make hard choices to fund new starts for high-priority research facilities under whatever fiscal scenario we face in coming years. What will be at stake will be the scientific leadership that we can't afford to compromise.

Last year, for the first time in many years in the United States, the number of applicants to engineering schools grew while the number of applicants to law schools declined.

I have joked with some of my lawyer friends that we could call those relative enrollment trends a "competitive index" and use it as a positive indicator of how our society is recognizing and responding to competition from other industrial nations.

We have the momentum with us now. It would be a shame if that index again turned negative because we failed in our responsibility to maintain a climate to attract our top minds to science and technology.

And let me introduce a practical point here. As we focus upon fueling the engine of technology, there are two logical buttons to push: Quality or quantity. Losers push the quantity button, and the engine sputters. Winners push the quality button, and the engine revs up. If we keep our eye on supporting quality, sufficient talent will follow to maintain our technological and scientific lead.

I raise this issue of quality as opposed to quantity because constraints on resources in coming years will continually challenge us to make wise decisions to preserve our leadership.

In terms of our immediate concerns, that means we have to make every dollar spent for basic research count. I said earlier that our budgets this year were adequate to do the job, but they are just adequate, and we can't afford to let any of it get sidetracked on less than excellent programs. And that pressure to select among excellent programs will continue, perhaps even build, in coming years when it is imperative that we make room for new starts.

Sidetracking is an occupational hazard in Washington. We have all felt pressures to support projects in which something other than pure excellence was the driving criterion.

Those pressures emerge naturally from our political system, a system that tries to accommodate local interests and national objectives. And we will find, frequently, that the scientists themselves lack national perspectives, and their advice may be unclear.

But let's at least say to each other that we will do our best to resist those distractions and that we will focus our attention on those steps necessary to advance our scientific leadership.

Mr. Chairman, let me quickly summarize the points I have tried to make here this morning. Our proceedings are dominated by a need for austerity, and we have responded to that need. Because of strong administration and congressional support over recent years, the programs for 1986 will enable American science to stay at the forefront.

But our challenge is to make sure that our fragile scientific and technology leadership isn't compromised, either by complacency on the part of others or by misallocation of limited resources by us. If we insist that we will be satisfied with nothing less than world leadership in those things we attempt to do, we can maintain the

kind of healthy and responsive climate to continue to recruit the best young minds into pursuit of science and technology, a recruitment that will serve the Nation well in coming years.

This concludes my statement. I would be pleased to respond to questions from members of the committee.

[The prepared statement of Dr. Keyworth follows:]

PROPOSED TESTIMONY OF DR. G. A. KEYWORTH, II
SCIENCE ADVISOR TO THE PRESIDENT AND
DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY
EXECUTIVE OFFICE OF THE PRESIDENT

TO THE COMMITTEE ON SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

HEARINGS ON SCIENCE POLICY AND
THE PRESIDENT'S FISCAL YEAR 1986 BUDGET FOR
RESEARCH AND DEVELOPMENT

FEBRUARY 5, 1985

CHAIRMAN FUQUA AND MEMBERS OF THE COMMITTEE:

ONCE AGAIN I'M PLEASED TO APPEAR AT THE ONSET OF THIS COMMITTEE'S ANNUAL HEARINGS ON THE PRESIDENT'S PROPOSED BUDGET FOR RESEARCH AND DEVELOPMENT PROGRAMS AND ON THE ADMINISTRATION'S SCIENCE AND TECHNOLOGY POLICY. LOOKING BACK OVER THE PAST FOUR YEARS, I CAN'T THINK OF ANY AREA OF GOVERNMENT IN WHICH THE ADMINISTRATION AND THE CONGRESS HAVE BEEN ABLE TO WORK TOGETHER MORE PRODUCTIVELY. I'M PARTICULARLY ENCOURAGED THAT WE HAVE FORGED WHAT I BELIEVE IS A VERY EFFECTIVE PARTNERSHIP, BECAUSE WE'RE GOING TO BE CALLED UPON TO TAKE STRONG MEASURES IN COMING YEARS TO RESPOND TO INTENSIFYING CHALLENGES TO AMERICA'S LEADERSHIP IN SCIENCE AND TECHNOLOGY.

THE START OF A NEW ADMINISTRATION AND A NEW CONGRESS IS AN APPROPRIATE TIME TO TAKE STOCK AND CHART A COURSE FOR

COMING YEARS. MANY OF OUR EFFORTS ARE GOING TO BE CONCERNED WITH CRITICAL CHOICES WE HAVE TO MAKE IN THREE AREAS. ONE IS NATIONAL SECURITY--HOW TO CREATE A MORE STABLE WORLD AND, SPECIFICALLY, HOW TO REDUCE THE PRESENCE OF NUCLEAR WEAPONS. A SECOND IS HOW WE IN AMERICA CAN ENSURE OUR ECONOMIC PROGRESS IN THE FACE OF RAPIDLY GROWING COMPETITION IN THE WORLD'S INDUSTRIAL MARKETS. AND THE THIRD IS HOW WE CAN BRING GOVERNMENT SPENDING UNDER BETTER CONTROL AND REDUCE THE DEFICIT THAT INTRUDES SO RUDELY ON OUR PLANS FOR THE FUTURE.

MR. CHAIRMAN, I THINK YOU'LL AGREE THAT OUR ENVIABLE LEAD IN SCIENCE IS AN IMPORTANT THREAD THAT RUNS THROUGH ALL OF THOSE ISSUES--BECAUSE SCIENCE AND TECHNOLOGY ARE TOOLS TO FORGE OUR OWN DESTINY. THEY'RE OUR LEVERAGE ON THE FUTURE.

FORTUNATELY, WE GO INTO THE 1986 BUDGET DELIBERATIONS WITH OUR SCIENCE AND TECHNOLOGY ENTERPRISE SIGNIFICANTLY STRENGTHENED OVER THAT OF NOT MANY YEARS AGO. THE GROWTH OF 55 PERCENT IN SUPPORT FOR BASIC RESEARCH OVER THE COURSE OF THESE PAST TWO CONGRESSES IS RESTORING MOMENTUM TO WHAT IS ONE OF THIS COUNTRY'S GREATEST ASSETS--OUR SCIENTIFIC ENTERPRISE.

IN ADDITION, AND EQUALLY IMPORTANT, THIS HIGH PRIORITY ASSIGNED TO SCIENCE BY THE FEDERAL GOVERNMENT HAS ELICITED

COMPARABLE HIGH PRIORITY IN THE PRIVATE SECTOR FOR USING THAT SCIENCE. INDUSTRY HAS BEEN INCREASING ITS RATE OF INVESTMENT IN RESEARCH AND DEVELOPMENT EVEN FASTER THAN GOVERNMENT HAS, AND IN DOING SO IT HAS ALSO FORGED PRODUCTIVE NEW PARTNERSHIPS WITH UNIVERSITIES.

BUT HERE I HAVE TO INTERPOSE A CLOUD INTO THAT SUNNY PICTURE. OUR SCIENCE AND TECHNOLOGY PRESENT MAY BE BRIGHTER THAN IT HAS BEEN IN YEARS, BUT A SHINING FUTURE IS ANYTHING BUT GUARANTEED. OUR LEADERSHIP IN SCIENCE IS FRAGILE--EXTREMELY FRAGILE. THAT SHOULD CONCERN US DEEPLY, BECAUSE SCIENCE PLAYS THE SAME ROLE FOR TECHNOLOGY AS A FOUNDATION DOES FOR A HOUSE. NEITHER STRUCTURES NOR MODERN INDUSTRIES CAN EXIST WITHOUT THOSE BASES OF SUPPORT. AND TODAY WE DEPEND--FAR MORE THAN MOST PEOPLE REALIZE--ON OUR PREEMINENCE IN SCIENCE TO ENABLE US TO EXPLOIT TECHNOLOGY AND MAINTAIN OUR ECONOMIC AND NATIONAL SECURITY.

MR. CHAIRMAN, WHAT I REFER TO AS SCIENTIFIC LEADERSHIP SHOULD NOT BE CONFUSED WITH SOME KIND OF ACADEMIC MACHO OR WITH TALLER AND MORE ISOLATED IVORY TOWERS. WHEN I REFER TO SCIENTIFIC LEADERSHIP I'M DESCRIBING OUR NATIONAL CREATIVITY, OUR ABILITY TO BE AT THE FOREFRONT OF PROGRESS, AND OUR ABILITY TO MEET OUR RESPONSIBILITY AS LEADERS OF THE FREE WORLD. TWO EVENTS DURING THE PAST YEAR BROUGHT HOME VIVIDLY TO ME THE PRACTICAL CONSEQUENCES OF SCIENTIFIC LEADERSHIP.

THE FIRST WAS MY OWN EXPERIENCE SERVING ON THE PRESIDENT'S COMMISSION ON INDUSTRIAL COMPETITIVENESS--WHERE I WAS A LONE FEDERAL OFFICIAL IN A GROUP COMPOSED PRIMARILY OF INDUSTRIAL LEADERS, FEW OF WHOM SHARE MY TECHNICAL BACKGROUND AND BIASES FOR SCIENCE AND TECHNOLOGY. YET IT DIDN'T MATTER IF THEY WERE BANKERS, LABOR LEADERS, SEASONED HEADS OF MAMMOTH CORPORATIONS, OR YOUNG ENTREPRENEURS--ALL AGREED THAT IN THE INTERNATIONAL INDUSTRIAL ARENA, THE UNITED STATES HAS ONLY TWO SUSTAINABLE ADVANTAGES OVER OUR COMPETITORS. THOSE TWO ADVANTAGES ARE OUR TECHNOLOGY AND OUR TALENT.

THOSE INDUSTRIALISTS UNDERSTAND BETTER THAN MOST PEOPLE HOW BASIC RESEARCH FUELS THOSE TWO COMPETITIVE ADVANTAGES. THEY ALSO EMPHASIZED THAT, JUST AS THEY'RE RESPONSIBLE FOR MAINTAINING OUR INDUSTRIAL BASE, WHICH IS FUELED BY OUR DYNAMIC FREE ENTERPRISE SYSTEM, THAT THE FEDERAL GOVERNMENT IS RESPONSIBLE FOR MAINTAINING OUR PREEMINENT SCIENCE AND TECHNOLOGY BASE--OUR FOUNTAINS OF NEW KNOWLEDGE AND TECHNICAL TALENT. THERE WAS NO DOUBT, IN THE MINDS OF THESE UNQUESTIONABLY "BOTTOM-LINE" THINKERS THAT SCIENTIFIC AND INDUSTRIAL LEADERSHIP GO HAND IN HAND.

MY SECOND OBSERVATION OF THE ESSENTIAL ROLE OF SCIENTIFIC LEADERSHIP IS EVIDENCED BY THE SOVIET UNION'S RESPONSE TO THE STRATEGIC DEFENSE INITIATIVE, THE

PRESIDENT'S PROPOSAL TO USE OUR SCIENTIFIC AND TECHNOLOGICAL EXPERTISE TO DEVELOP DEFENSES AGAINST NUCLEAR WEAPONS. IT WAS THE PROSPECT THAT THE UNITED STATES WOULD USE OUR TECHNOLOGICAL SUPERIORITY TO ALTER DETERRENCE--AND TO DIMINISH THE SOVIET STRATEGIC EDGE--THAT CATALYZED THE RETURN OF THE SOVIETS TO THE ARMS CONTROL TALKS IN GENEVA.

THE SOVIETS HAVE MORE THAN ONE REASON TO WORRY ABOUT SDI. IN ADDITION TO THE PROSPECT THAT STRATEGIC DEFENSE WILL MAKE WORTHLESS THE BULK OF THEIR IMMENSE OFFENSIVE NUCLEAR FORCE, OUR EFFORT TO PRODUCE A DEFENSIVE SYSTEM WILL ALMOST CERTAINLY STIMULATE A NEW THRUST IN TECHNOLOGY, AND LEAVE THE STAGNATING SOVIET ECONOMY YET FURTHER BEHIND.

BUT HERE I MUST SHARE MY FRUSTRATION. THE SOVIETS RECOGNIZE AND JUSTIFIABLY FEAR U.S. SCIENCE AND TECHNOLOGY. U.S. INDUSTRY, FACING A RELENTLESS CHALLENGE FROM OTHER COUNTRIES, ESPECIALLY JAPAN, PLACES TOP PRIORITY ON ASSURING A STRONG SCIENCE AND TECHNOLOGY BASE TO PRODUCE THE KNOWLEDGE AND TALENT WE NEED TO COMPETE. AND THE AMERICAN PEOPLE AND TODAY'S STUDENTS KNOW INSTINCTIVELY HOW DIRECTLY FUTURE ECONOMIC PROGRESS AND NATIONAL SECURITY DEPEND ON OUR TECHNOLOGICAL LEADERSHIP.

AS A SCIENTIST MYSELF, I CAN BE DISMISSED IN COMING BEFORE YOU TOUTING THE IMPORTANCE OF SCIENCE TO OUR FUTURE. BUT WE CAN'T DISMISS WHAT WE HEAR FROM THE

SOVIETS, FROM OUR INDUSTRIAL LEADERS FEELING THE HOT BREATH OF CHALLENGERS ON THEIR NECKS, AND FROM PEOPLE ACROSS AMERICA; THEY HAVE TO BE LISTENED TO. THE PRESIDENT KNOWS THAT SCIENCE AND TECHNOLOGY HAVE BEEN THE FUEL FOR OUR POST-WAR ECONOMIC GROWTH, YET TOO MANY OF US IN WASHINGTON TAKE OUR PREEMINENCE IN SCIENCE AND TECHNOLOGY FOR GRANTED. BUT THE TRUTH IS THAT FEW OF OUR GREAT STRENGTHS ARE MORE FRAGILE. UNLESS WE RECOGNIZE THE VULNERABLE NATURE OF THIS PRECIOUS LEVERAGE, WE MAY FIND THE COSTS OF COMPLACENCY TO BE VERY, VERY HIGH.

MR. CHAIRMAN, WE'RE CHALLENGED THIS YEAR TO BALANCE TWO DOMINANT PRIORITIES. ONE IS TO PERMIT INVESTMENT IN OUR FUTURE BY REDUCING FEDERAL SPENDING. THE OTHER IS TO ASSURE A STRONG NATIONAL SCIENCE AND TECHNOLOGY BASE. THE BUDGET BEING PRESENTED TO THE CONGRESS DOES BOTH.

FUNDING OBLIGATIONS FOR R&D WILL TOTAL $60 BILLION IN FISCAL YEAR 1986; OF THAT, SOME $20 BILLION WILL SUPPORT NON-DEFENSE R&D, AND $8 BILLION WILL SUPPORT BASIC RESEARCH. FUNDS OBLIGATED FOR NON-DEFENSE R&D WILL REMAIN ESSENTIALLY CONSTANT FROM 1985 TO 1986, AND FUNDS FOR BASIC RESEARCH WILL INCREASE SLIGHTLY ABOVE THE FREEZE LEVEL. WITHIN THOSE PROPOSED BUDGETS I HAVE NO DOUBT WHATSOEVER THAT WE CAN CONDUCT EXTREMELY EFFECTIVE R&D PROGRAMS.

AFTER FOUR YEARS OF NEAR-HISTORIC FUNDING INCREASES,

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THERE'S NOW PLENTY OF MOMENTUM IN THE SYSTEM TO MAINTAIN HEALTHY PROGRESS. MOREOVER, AS A MATTER OF PRACTICALITY, ACTUAL OUTLAYS FOR BASIC RESEARCH WOULD RISE BY NEARLY FIVE PERCENT NEXT YEAR, WHICH SHOULD EVEN PERMIT A LITTLE REAL GROWTH. IN ADDITION, BECAUSE WE'VE DELIBERATELY POSTPONED THE START OF CONSTRUCTION FOR MAJOR NEW RESEARCH FACILITIES FOR ONE YEAR, WE'LL BE ABLE TO MAINTAIN STRONG FUNDING FOR ON-GOING RESEARCH PROGRAMS.

FOR EXAMPLE, WHEN YOU EXAMINE THE PROGRAMS PROPOSED FOR THE NATIONAL SCIENCE FOUNDATION OR NASA, YOU'LL FIND THAT THERE ARE ADEQUATE RESOURCES TO SUPPORT NEW HIGH-PRIORITY PROGRAMS. THESE INCLUDE PROGRAMS SUCH AS THE NEW ENGINEERING RESEARCH CENTERS BY NSF, LAUNCHES OF THE SPACE TELESCOPE AND THE GALILEO MISSION TO JUPITER BY NASA, AND ADVANCED R&D BY THE DEPARTMENT OF ENERGY ON THE CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY AND THE ELEMENTARY PARTICLE SUPERCONDUCTING SUPER COLLIDER. IN LIGHT OF THE INCREASED FEDERAL SUPPORT SINCE 1981, THERE WILL BE NO THREAT TO THE HEALTH OF U.S. SCIENCE. I WOULD EVEN SAY THAT, AFTER SUCH RAPID GROWTH, SHARING IN THE OVERALL FEDERAL AUSTERITY MAY WELL STIMULATE SHARPER DELINEATION OF PRIORITIES FOR SCIENCE.

MR. CHAIRMAN, DEALING WITH BUDGETS NECESSARILY IMMERSES US IN WHAT I WOULD CALL THE TACTICAL PROBLEMS OF INDIVIDUAL PROGRAM PRIORITIES. THOSE ARE THE PRACTICAL STEPS WE HAVE

TO TAKE TO TURN POLICY INTO REALITY. HOWEVER, I ALSO WANT TO URGE US TO STAND BACK THIS YEAR AND DO SOME EXTRA STRATEGIC THINKING ABOUT SCIENCE AND TECHNOLOGY. I SAY THAT BECAUSE I SEE THE CENTRAL CHALLENGE WE FACE AS PRESERVING OUR FRAGILE SCIENTIFIC LEADERSHIP.

THERE ARE TWO THINGS WE HAVE TO DO. FIRST, WE HAVE TO EMBRACE OUR RESPONSIBILITY FOR BASIC RESEARCH. BASIC RESEARCH IS AS ESSENTIAL TO OUR TWO HIGHEST PRIORITIES--MAINTAINING ECONOMIC GROWTH AND NATIONAL SECURITY--AS IS ANY OTHER INVESTMENT WE CAN MAKE TODAY. I WON'T DENY I'M CONCERNED ABOUT OUR ABILITY TO SUSTAIN THE KIND OF LEADING-EDGE BASIC RESEARCH PROGRAM THIS COUNTRY ABSOLUTELY MUST HAVE. WE CAN'T TAKE IT FOR GRANTED. WE HAVE TO CONVINCE OTHERS OF ITS IMPORTANCE, AND WE HAVE TO MAKE SURE THAT THE CURRENT PRIORITY FOR BASIC RESEARCH IS MAINTAINED.

SECOND, WE HAVE TO MAKE EVERY DOLLAR COUNT. SCIENCE AND TECHNOLOGY ARE DYNAMIC PROCESSES, KEPT ALIVE BY A CONSTANT INPUT OF NEW ENERGY, NEW PEOPLE, AND NEW IDEAS. THE WORST DANGER WE FACE IS TO BE LULLED INTO COMPLACENCY ABOUT OUR LEADERSHIP AND FAIL TO ALLOCATE FUNDS WISELY. YES, THE UNITED STATES SPENDS MORE THAN $100 BILLION FOR R&D IN THE PUBLIC AND PRIVATE SECTORS EACH YEAR, FAR MORE THAN ANY OF OUR INDUSTRIAL COMPETITORS. AND, YES, WE HAVE AN ALMOST UNBROKEN RECORD OF SUCCESS IN AMASSING PRIZES FOR

RESEARCH. BUT, AGAIN, LOOK AT AMERICAN INDUSTRY AND SEE HOW A HISTORY OF SUCCESS AND DOMINATION OF THE MARKETPLACE WAS CHALLENGED ALMOST OVERNIGHT BY DETERMINED COMPETITORS. WE WHO BEAR RESPONSIBILITY FOR THE READINESS OF AMERICAN SCIENCE BETTER LEARN FROM THAT EXPERIENCE.

I STRONGLY SUPPORT THE NECESSITY OF SLOWING THE GROWTH OF SCIENCE AND TECHNOLOGY FUNDING IN THE SHORT TERM AS PART OF THE RESPONSE TO THE DEFICIT. BUT AT THE SAME TIME I WON'T HIDE MY CONCERN ABOUT THE VITALITY OF U.S. SCIENCE OVER THE LONGER TERM AND ABOUT ITS CONTINUED ATTRACTION FOR THE BEST YOUNG MINDS. EVEN THE MOST OPTIMISTIC FORECASTERS WARN US OF SEVERAL YEARS OF LEAN FUNDING UNTIL WE GET THE DEFICIT TO A LEVEL WHERE IT DOESN'T DOMINATE FEDERAL BUDGETING.

AS I SAID, WE'RE IN GOOD SHAPE FOR 1986. OUR REAL CHALLENGES WILL COME IN FISCAL YEARS 1987 AND 1988, WHEN WE SIMPLY WILL HAVE TO FIND WAYS TO ENSURE OUR ABILITY TO PURSUE--AND PURSUE VIGOROUSLY--NEW AVENUES OF RESEARCH. PROGRESS IN SCIENCE WON'T STAGNATE--AND IT WON'T WAIT FOR US. OTHER COUNTRIES, FACING EQUALLY TRYING TIMES, ARE RENEWING THEIR SUPPORT OF BASIC SCIENCE. AND THEY'RE DOING IT IN EMULATION OF OUR OWN ECONOMIC MIRACLE. THE LAST THING WE WANT TO DO IS LOSE SIGHT OF OUR OWN SUCCESSES AND WHAT STIMULATED THEM. SO WE'LL HAVE TO BE PREPARED TO MAKE HARD CHOICES TO FUND NEW STARTS FOR HIGH-PRIORITY RESEARCH

FACILITIES UNDER WHATEVER FISCAL SCENARIO WE FACE IN COMING YEARS. WHAT WILL BE AT STAKE WILL BE THE SCIENTIFIC LEADERSHIP THAT WE CAN'T AFFORD TO COMPROMISE.

WE'VE SEEN IN THE PAST WHAT CAN HAPPEN WHEN EVEN VERY STRONG SCIENCE AND TECHNOLOGY ENTERPRISES ARE PREVENTED FROM FOLLOWING UP ON NEW DISCOVERIES. ONE EXAMPLE THAT THIS COMMITTEE IS FAMILIAR WITH WAS THE APPARENT IMPACT ON SPACE SCIENCES OF THE UNANTICIPATED HIGH COSTS TO DEVELOP THE SPACE SHUTTLE. IN SPITE OF OUR VIRTUAL OWNERSHIP OF THE WESTERN WORLD'S SPACE PROGRAM IN THE 1960S AND 1970S, WE NEVERTHELESS FIND OURSELVES SERIOUSLY CHALLENGED FOR LEADERSHIP IN SOME FIELDS THAT WE HAD PIONEERED, AND WE FACE THE 1990S WITH NO ASSURANCE THAT WE'LL BE ABLE TO REGAIN THE MOMENTUM THAT WE HAD MADE THE DOWN PAYMENT FOR IN FIELDS LIKE X-RAY AND INFRARED ASTRONOMY AND SOLAR PHYSICS.

IN COMING YEARS WE CAN FORESEE SIMILAR FORKS IN OTHER SCIENTIFIC PATHS. FOR EXAMPLE, THE NATION--OR GROUP OF NATIONS--THAT BUILDS THE SUPERCONDUCTING SUPER COLLIDER WILL BECOME THE NEW WORLD CENTER IN HIGH-ENERGY PHYSICS. I WON'T CONCEAL MY OPINION THAT IT WOULD BE A SERIOUS BLOW TO U.S. SCIENTIFIC LEADERSHIP IF THAT FACILITY WERE BUILT IN ANOTHER COUNTRY, BECAUSE A PLACE LIKE THAT IS A MAGNET FOR TALENT AND CREATIVITY. A BIG ACCELERATOR INVOLVES FAR, FAR MORE THAN THE RELATIVELY SMALL NUMBER OF PEOPLE WHO CAN

WORK DIRECTLY WITH IT, BECAUSE IT STIMULATES INTEREST IN SCIENCE AND EXCELLENCE FAR ACROSS SOCIETY AND BECAUSE IT INEVITABLY SPINS OFF NEW IDEAS AND TECHNOLOGIES.

IN THE NEAR TERM OUR SUCCESS IN PROVIDING SEVERAL NEW RESEARCH FACILITIES, SUCH AS THE TEVATRON I AND II, AND THE STANFORD LINEAR COLLIDER, PUTS US IN A STRONG POSITION TO MAINTAIN OUR LEADERSHIP. BUT WE'RE ON NOTICE THAT OVER THE LONG HAUL THE LEADERSHIP IN HIGH ENERGY PHYSICS IS UP FOR GRABS. THE RECENT STUNNING SUCCESS OF A EUROPEAN TEAM WORKING AT CERN IN SWITZERLAND IN DETECTING THE Z PARTICLE WAS THE MOST IMPORTANT ADVANCE IN A DECADE, AND IT QUICKLY BROUGHT THE NOBEL PRIZE TO THE TEAM'S LEADERS. THAT'S A VERY REAL REMINDER THAT OUR MANY YEARS OF LEADERSHIP IN THAT FIELD ARE, RIGHT NOW, BEING AGGRESSIVELY CHALLENGED.

LIKEWISE, WE'LL BE FACED VERY SOON WITH DECISIONS ABOUT PROCEEDING WITH CONSTRUCTION OF TWO FOREFRONT RESEARCH FACILITIES FOR NUCLEAR PHYSICS--THE CONTINUOUS ELECTRON BEAM ACCELERATOR IN VIRGINIA AND THE RELATIVISTIC HEAVY ION FACILITY, WHOSE INITIAL OPTIONS ARE BEING DEVELOPED AT BROOKHAVEN NATIONAL LABORATORY. NUCLEAR PHYSICS, A FIELD OF IMMENSE PRODUCTIVITY IN EARLIER YEARS, IS ABOUT TO RE-EMERGE AS ONE OF THE MOST EXCITING AREAS OF RESEARCH INTO THE STRUCTURE OF MATTER, AND WE HAVE A WELL-TIMED OPPORTUNITY TO LEAD THE REST OF THE WORLD HERE TOO.

AND WE COULD GO ON. WILL WE REASSERT OUR LEADERSHIP IN MATERIALS SCIENCE AND BEGIN BUILDING SUCH NEXT-STEP FACILITIES AS THE SYNCHROTRON RADIATION SOURCE RECENTLY RECOMMENDED BY THE SEITZ COMMITTEE OF NATIONAL ACADEMY OF SCIENCES? OR DO WE LET THE EUROPEANS STEAL A MARCH ON THAT DISCIPLINE, A DISCIPLINE THAT'S BECOMING CRITICAL TO ADVANCED TECHNOLOGIES IN A BROAD RANGE OF MODERN INDUSTRIES. SOMEONE IS GOING TO COME UP WITH THE NEXT-GENERATION EQUIVALENT OF MICROELECTRONICS OR RECOMBINANT DNA, AND I WANT THAT SOMEONE TO BE AN AMERICAN. THAT'S NOT JINGOISM--IT'S REALISM. AND IT'S THE SPIRIT OF HEALTHY COMPETITION THAT WE HAVE TO TAKE TO HEART.

AND HOW WILL WE RESPOND TO EMERGING OPPORTUNITIES IN, SAY, THE LIFE SCIENCES? ONE CONCERN I HAVE IS THAT MUCH OF THE ENTHUSIASM FOR FUNDING OF THE NIH COMES FROM CONCERN FOR SPECIFIC DISEASES, RATHER THAN FROM ENTHUSIASTIC APPRECIATION OF THE BASIC SCIENCE BY WHICH DISEASES ARE CURED. CONSEQUENTLY, WE NOW SEE AN IMBALANCE IN FUNDING APPROACH--A "DISEASE-OF-THE-MONTH" MENTALITY DRIVING THE FUNDING AND SETTING THE PRIORITIES FOR ONE OF THE MOST EXCITING FRONTIERS OF SCIENCE, NAMELY, THE BIOLOGICAL SCIENCES. IT'S IMPORTANT THAT AGENCY MISSIONS BE SUPPORTED BY STRONG BASIC RESEARCH IN THOSE DISCIPLINES RELATED TO THEM, WHETHER THOSE MISSIONS ARE HEALTH OR SPACE OR DEFENSE. BUT A MISSION WILL BE MET MORE EFFECTIVELY BY

ADDRESSING THE DISCIPLINE. FOR EXAMPLE, IT WAS BASIC RESEARCH THAT FOUND THE CAUSE FOR AIDS. AND IT WILL BE BASIC RESEARCH THAT WILL CURE CANCER. I ALSO WORRY THAT FUNDING THAT'S DRIVEN MAINLY BY MISSION IS AN INEFFICIENT APPROACH. IT PRESUMES A WISDOM THAT MAN DOES NOT POSSESS, A WISDOM THAT RUNS COUNTER TO OUR EXPERIENCE THAT WE'RE VERY SMART WHEN IT COMES TO DOING RESEARCH AND VERY DUMB WHEN IT COMES TO PREDICTING WHERE THE PROFOUND APPLICATIONS WILL BE. OUR CURRENT SYSTEM OF FUNDING MOST OF THE BIOLOGICAL SCIENCES BECAUSE OF A PRESUMED RELATIONSHIP TO A DISEASE IS LITTLE MORE THAN BUREAUCRATIC CONVENIENCE; IT'S NOT THE WAY TO SUSTAIN LEADERSHIP IN AN INCREASINGLY COMPETITIVE AGE.

THE BIOLOGICAL SCIENCES STAND ON A BRINK OF UNDERSTANDING THAT I CAN ONLY LIKEN TO THE BRINK THAT EINSTEIN SAW FOR PHYSICS IN 1905. SO IT'S FAIR TO ASK IF WE ARE DEVELOPING THE SCIENCE BASE WE NEED TO REAP THE BENEFITS THAT WE FORESEE. OR WILL WE, BY REMAINING CAPTIVE TO PAST SUCCESSES AND HAMSTRUNG BY A SYSTEM OF RESEARCH SUPPORT INADEQUATELY SUITED TO THE OPPORTUNITIES AHEAD, DENY OUR POEPLE THE ADVANCES IN MEDICINE AND IN NEW INDUSTRIES THAT OTHERS WILL CAPTURE BY MOVING BOLDLY AHEAD?

ONE THING TO KEEP IN MIND IS THAT ONE CAN PURSUE FRONTIER LIFE SCIENCES RESEARCH ON A FAR SMALLER SCALE THAN IS REQUIRED IN MOST OF THE PHYSICAL SCIENCES. IT WOULDN'T

SURPRISE ME TO FIND NEWLY INDUSTRIALIZING NATIONS, LOOKING FOR OPPORTUNITIES IN SCIENCE AND TECHNOLOGY, TO DEVELOP STRONG CAPABILITIES TO CHALLENGE US IN BIOTECHNOLOGY. YET WE SEEM TO BE GIVING FAR TOO LITTLE ATTENTION TO PROTECTING AND CAPITALIZING ON OUR LONG-TERM INVESTMENT IN LIFE SCIENCES BY BROADENING THE DISCIPLINARY BASE.

ANOTHER AREA OF FRAGILITY SHOWS UP WHEN WE FAIL TO MAINTAIN A CONSISTENT POLICY TO RESPOND TO EMERGING FRONTIERS. YOUNG PEOPLE HAVE THE BEST NOSES FOR TOMORROW'S HOT AREAS OF RESEARCH, BUT THEIR CAREER CHOICES CAN BE CONSTRAINED BY PROSPECTS FOR SUPPORT FOR RESEARCH. UNCERTAINTY ABOUT SUPPORT--THE KIND OF UNCERTAINTY THAT RESULTS FROM START-AND-STOP FUNDING--WILL EFFECTIVELY CHASE THEM AWAY FROM A FIELD, AND MAYBE CHASE THEM AWAY FROM RESEARCH CAREERS ALTOGETHER. AS YOU'VE HEARD ME SAY ON MANY OTHER OCCASIONS, STUDENTS ARE UNQUESTIONABLY OUR GREATEST RESOURCE, AND OUR COUNTRY IS THE LOSER IF WE FAIL TO ATTRACT THE BEST YOUNG MINDS INTO SCIENCE AND TECHNOLOGY.

LAST YEAR, FOR THE FIRST TIME IN MANY YEARS IN THE UNITED STATES, THE NUMBER OF APPLICANTS TO ENGINEERING SCHOOLS GREW WHILE THE NUMBER OF APPLICANTS TO LAW SCHOOLS DECLINED. I'VE JOKED WITH SOME OF MY LAWYER FRIENDS THAT WE COULD CALL THOSE RELATIVE ENROLLMENT TRENDS A "COMPETITIVE INDEX" AND USE IT AS A POSITIVE INDICATOR OF

HOW OUR SOCIETY IS RECOGNIZING AND RESPONDING TO COMPETITION FROM OTHER INDUSTRIAL NATIONS. WE HAVE THE MOMENTUM WITH US NOW. IT WOULD BE A SHAME IF THAT INDEX AGAIN TURNED NEGATIVE BECAUSE WE FAILED IN OUR RESPONSIBILITY TO MAINTAIN A CLIMATE TO ATTRACT OUR TOP MINDS TO SCIENCE AND TECHNOLOGY.

AND LET ME INTRODUCE A PRACTICAL POINT HERE. AS WE FOCUS UPON FUELING THE ENGINE OF TECHNOLOGY, THERE ARE TWO LOGICAL BUTTONS TO PUSH--QUALITY OR QUANTITY. LOSERS PUSH THE QUANTITY BUTTON, AND THE ENGINE SPUTTERS. WINNERS PUSH THE QUALITY BUTTON, AND THE ENGINE REVS UP. IF WE KEEP OUR EYE ON SUPPORTING QUALITY, SUFFICIENT TALENT WILL FOLLOW TO MAINTAIN OUR TECHNOLOGICAL AND SCIENTIFIC LEAD.

I RAISE THIS ISSUE OF QUALITY AS OPPOSED TO QUANTITY BECAUSE CONSTRAINTS ON RESOURCES IN COMING YEARS WILL CONTINUALLY CHALLENGE US TO MAKE WISE DECISIONS TO PRESERVE OUR LEADERSHIP. I'M ESPECIALLY CONCERNED ABOUT OUR ABILITY TO MAKE LONG-TERM PLANS FOR THE FUTURE AND CARRY THEM OUT IN A TIMELY MANNER. SCIENCE IS AN OFTEN TEDIOUSLY METHODICAL PROCESS REQUIRING LONG PREPARATION. SMALLER RESEARCH FACILITIES MAY TAKE FOUR OR FIVE YEARS TO PLAN FOR AND BRING ON-LINE. MAJOR FACILITIES, LIKE A SPACE TELESCOPE OR A NEXT-GENERATION ELEMENTARY PARTICLE ACCELERATOR, CAN TAKE NEARLY A GENERATION FROM INCEPTION TO COMPLETION. IT'S OUR MUTUAL RESPONSIBILITY TO ENSURE AN

OPTIMISTIC AND VISIONARY CLIMATE, THE AMERICAN CLIMATE, IN WHICH SCIENTISTS AND ENGINEERS CAN CONDUCT THIS SENSITIVE PROCESS OF PLANNING AND BRINGING ON LINE THE TOOLS NEEDED FOR TOMORROW'S R&D.

RECENTLY DAVID PACKARD, A MAN I CONSIDER TO BE ONE OF OUR GREAT AMERICANS, OBSERVED TO ME THAT THERE ARE SOME VERY CLOSE PARALLELS BETWEEN SUCCESS IN INDUSTRY AND PROFESSIONAL SPORTS. HE SAID THAT THREE FACTORS DETERMINE SUCCESS. ONE IS THE TECHNICAL SKILLS OF INDIVIDUALS, WHICH MEANS THAT YOU CAN'T EVEN GET STARTED WITHOUT THE BASIC TRAINING AND EXPERIENCE. BUT BASIC SKILLS ARE ESSENTIALLY EVENLY DISTRIBUTED AMONG TEAMS, AS THEY ARE AMONG COMPETING COMPANIES. SO THE OTHER FACTORS MAKE THE DIFFERENCE IN THE OUTCOME OF COMPETITION. ONE IS THE INDIVIDUALS' ZEAL TO WIN, AND THE OTHER IS HOW WELL THEY WORK TOGETHER AS A TEAM. WELL, COACH PACKARD HAS A PRETTY GOOD WON-LOST RECORD OVER THE YEARS, AND I'D SURE WANT HIM IN MY LOCKER ROOM AT HALFTIME. SO I'M INCLINED TO TAKE HIS OBSERVATION SERIOUSLY. HAPPILY, IN THE PAST FEW YEARS WE'VE SEEN A STRONG REJUVENATION OF THAT ZEAL TO WIN IN AMERICA, A REACTION TO THE INTERNATIONAL PRESSURES WE'VE FELT ON ALL SIDES. BUT WE HAVEN'T COME NEARLY FAR ENOUGH IN DEVELOPING THE KIND OF TEAM SPIRIT THAT WE ALSO NEED.

MY OBJECT IN RELATING THIS STORY IS TO REINFORCE TWO POINTS. FIRST, WE CAN'T PLAY THE INDUSTRIAL GAME UNLESS WE

HAVE THE TECHNICAL SKILLS AND ZEAL TO SURPASS OUR COMPETITORS, AND THAT BRINGS US RIGHT BACK TO THE NEED FOR A STRONG BASIC RESEARCH ENVIRONMENT--THE SPAWNING GROUND FOR IDEAS AND TALENT. AND SECOND, WE NEED BETTER TEAMWORK. WE NEED TO BUILD ON THE COLLABORATION THAT'S EMERGED BETWEEN THE ADMINISTRATION AND THE CONGRESS WITH REGARD TO PRIORITY FOR SCIENCE AND EXPAND IT TO INCLUDE ACADEMIA AND INDUSTRY TOO--WITH ALL ACCEPTING RESPONSIBILITY FOR MAKING SURE WE NURTURE THOSE TECHNICAL SKILLS AND CARRY THEM INTO PRACTICE. IN TERMS OF OUR IMMEDIATE CONCERNS, THAT MEANS WE HAVE TO MAKE EVERY DOLLAR SPENT FOR BASIC RESEARCH COUNT. I SAID EARLIER THAT OUR BUDGETS THIS YEAR WERE ADEQUATE TO DO THE JOB--BUT THEY'RE JUST ADEQUATE, AND WE CAN'T AFFORD TO LET ANY OF IT GET SIDETRACKED ON LESS THAN EXCELLENT PROGRAMS. AND THAT PRESSURE TO SELECT AMONG EXCELLENT PROGRAMS WILL CONTINUE, PERHAPS EVEN BUILD, IN COMING YEARS WHEN IT'S IMPERATIVE THAT WE MAKE ROOM FOR NEW STARTS.

SIDETRACKING IS AN OCCUPATIONAL HAZARD IN WASHINGTON. WE'VE ALL FELT PRESSURES TO SUPPORT PROJECTS IN WHICH SOMETHING OTHER THAN PURE EXCELLENCE WAS THE DRIVING CRITERION. THOSE PRESSURES EMERGE NATURALLY FROM OUR POLITICAL SYSTEM, A SYSTEM THAT TRIES TO ACCOMODATE LOCAL INTERESTS AND NATIONAL OBJECTIVES. AND WE'LL FIND, FREQUENTLY, THAT THE SCIENTISTS THEMSELVES LACK NATIONAL PERSPECTIVES, AND <u>THEIR</u> ADVICE MAY BE UNCLEAR. BUT LET'S

AT LEAST SAY TO EACH OTHER THAT WE'LL DO OUR BEST TO RESIST THOSE DISTRACTIONS AND THAT WE'LL FOCUS OUR ATTENTION ON THOSE STEPS NECESSARY TO ADVANCE OUR SCIENTIFIC LEADERSHIP.

MR. CHAIRMAN, LET ME QUICKLY SUMMARIZE THE POINTS I'VE TRIED TO MAKE HERE THIS MORNING. OUR PROCEEDINGS ARE DOMINATED BY A NEED FOR AUSTERITY, AND WE'VE RESPONDED TO THAT NEED. BECAUSE OF STRONG ADMINISTRATION AND CONGRESSIONAL SUPPORT OVER RECENT YEARS, THE PROGRAMS FOR 1986 WILL ENABLE AMERICAN SCIENCE TO STAY AT THE FOREFRONT. BUT OUR CHALLENGE IS TO MAKE SURE THAT OUR FRAGILE SCIENTIFIC AND TECHNICAL LEADERSHIP ISN'T COMPROMISED--EITHER BY COMPLACENCY ON THE PART OF OTHERS OR BY MISALLOCATION OF LIMITED RESOURCES BY US. IF WE INSIST THAT WE'LL BE SATISFIED WITH NOTHING LESS THAN WORLD LEADERSHIP IN THOSE THINGS WE ATTEMPT TO DO, WE CAN MAINTAIN THE KIND OF HEALTHY AND RESPONSIVE CLIMATE TO CONTINUE TO RECRUIT THE BEST YOUNG MINDS INTO PURSUIT OF SCIENCE AND TECHNOLOGY, A RECRUITMENT THAT WILL SERVE THE NATION WELL IN COMING YEARS.

THIS CONCLUDES MY PREPARED STATEMENT. I WOULD BE PLEASED TO RESPOND TO QUESTIONS FROM MEMBERS OF THE COMMITTEE.

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Mr. FUQUA. Thank you very much, Dr. Keyworth. We appreciate you being with us this morning.

You mentioned, and I think you skipped over that part on page 10 about the Superconducting Super Collider and the intent to convince scientists in other fields such as chemistry and biology to support a multibillion-dollar project like that.

Do you think we can convince other disciplines of the importance of that type of project?

Dr. KEYWORTH. I think the enormity—first, Mr. Chairman, should have said at the outset, I abbreviated my testimony to allow extra time for questions. I think the SSC is an area that we should all focus upon, and it is essential that the entire scientific community and the Nation as a whole focus on.

Let me select $5 billion as an estimate. It is an unprecedently large sum for an experimental facility in a single area of science, and I think it presents to us a unique challenge, and I think the biologists, the chemists and the public as a whole have to join in making this decision.

Do we want to give up clear leadership and resign ourselves to something very much second place in a field where we have long been the clear, unquestioned leader. That is a decision to make?

It is a measure of the importance that we place on excellence in attracting our top young minds to the most creative endeavors we can pursue; because traditionally, no field has been more attractive than the science of pure creativity.

I also think the field has never been more exciting. We stand toward the end of this century to make the same kinds of contribution Clerk Maxwell made in developing the laws to combine the electric and magnetic fields.

I think the question of this facility is far bigger than I am, and the other communities in science not only can, but must be brought on in support of this, for it is symbolism for excellence and creativity and our national commitment.

Mr. FUQUA. How about the involvement of international cooperation in this project?

Dr. KEYWORTH. I think it will be essential because we must realize that there will not be two of these machines. We have reached a point in time where we can no longer continue to explore parallel paths with Europe or Japan or the Soviet Union on the United States duplicating these massive facilities.

I went to Japan last May in order to try to encourage Japanese leadership and government in science to join us at the very early stages of planning, not when we have made a commitment, and to ask them to come and pay a certain fraction of the bill if they are to use the facility, but rather, to join with us at this early conceptual stage and, of course, we have also made the same offers to our European friends.

The Japanese response was to raise the number of attendees at the next major meeting in Colorado from a few to many dozens. The Europeans, of course, are belaboring right now under a facility called the LEP, that is just beginning construction, a considerably smaller facility, but starting with the summit process, and the discussions that we began 3 years ago at Versailles, the framework is there to make this an international project.

Mr. FUQUA. I have some more questions, but I will defer to the other members and come back. I notice in the audience former member of our committee, Mr. Skeen, who escaped to the Appropriations Committee, and we are very happy to have him.

If you would like to, Joe, please come up and join your colleagues up here.

Mr. Brown.

Mr. BROWN. Dr. Keyworth, you present an excellent, upbeat statement for which I commend you, but you do raise, I think, some essential problems that we are not addressing in the most effective possible way.

I am looking at page 15 in which you make the statement:

> I am especially concerned about our ability to make long-term plans for the future and carrying them out in a timely fashion.

The Superconducting Super Collider is an example of the kind of thing that will require that kind of long-range planning. Similarly, the funding of new areas in the biological sciences, and you could almost make a very long list of things which will be competing for support, require that we make decisions with regard to the level and division of that support on the kinds of a long-range, rational basis that will produce the most effective result.

What do you see as the mechanism for achieving that, and what part does your office play in it?

Dr. KEYWORTH. Mr. Congressman, I think we all know how much easier it is to make tactical decisions and to conduct tactical plans than strategic, so I am not introducing a new challenge to any of you.

I think there is a mismatch. I think that the public priority for science and technology is far greater than that priority in the process of conducting Government in Washington, and until we can bring those two priorities into closer match, it is going to be very difficult to maintain a stable strategic plan for matters such as the superconducting supercollider, as well as capturing the promise of the biological revolution.

I am beginning this new year with this as our principal target, objective, and our principal challenge. I will say, strictly from our own point of view, we are going to be doing a lot of writing this year.

We are going to be trying to deal with the national media in a very broad context, because the national media, I believe, has developed a new increased interest in exactly this subject.

The spirit of competitiveness has elevated the priority of science and technology, our dependence upon it as well as the need for strategic thinking.

I want to join with you all in a totally bipartisan sense to try to develop the means to do this kind of strategic planning and here, I am talking about the 1986 budget and focusing heavily on 1987, 1988 and beyond for exactly that reason.

Mr. BROWN. This committee has been focusing on it for the last 10 years. It is embedded in the language of the statute which created your job. And we still see no sense that there is that kind of long-range planning taking place. We set up mechanisms in terms of 5-year outlooks that are intended to achieve that.

We see very little science being effectively pursued and we regret that, speaking for myself. I spent some time visiting the physics department at one of the universities in my own district, where the key researchers are spending half their time in CERN, because we don't have the kind of facility that we need.

That kind of thing required, and you know it, long-range allocation of resources, plans, and needs to be coordinated with the other fields of sciences.

I see no signs of that happening. You lament the fact that the level of basic research in the 1986 budget shows no growth, and you hope it will improve in 1987 and 1988.

That is not very reassuring. We don't see any signs that it is going to improve.

Dr. KEYWORTH. I did not come here to lament the 1986 budget. What I said was I think we are quite capable of sustaining our leadership in science with the budget we are presenting. I think it is a good budget, and I am proud of it, and so is the President.

I am raising attention to the future. We all too frequently measure quality in terms of how much money we spend, and we measure planning in how many reports we publish, and we measure our policy in terms of the words of the day.

I would represent policy, for example, as the budget of the last 4 years, a drastic change in priority, drastic reductions in development, drastic increases in basic research. That is policy.

The planning that we are doing is perhaps more in our heads than it is on our paper, but that is where it should be. That is akin to the matter of priority setting that I addressed throughout my testimony. We are planning, and I am proposing that we all plan together and the emphasis of that planning should be basic research and leadership in American science.

Mr. BROWN. Well, I commend you for that. I like a good deal of your emphasis, Dr. Keyworth, and I have said that to you many times; emphasis on basic research and high quality research which are absolutely essential, but they are no substitute for adequate resources to carry out the job and there is every indication that there is an imbalance.

I have one additional question without belaboring the time too much, and that has to do with your well-known interest in the possibility of creating a Department of Science and Technology, which would produce a focus for the kind of planning that we are talking about here. Would you comment very briefly on that?

Dr. KEYWORTH. What I am most interested in is having the discussion and debate on the matter of centralizing the management of science in America performed. This was originally proposed by the President's Commission on Industrial Competitiveness.

Two things we should focus upon, elevating the priority of science and technology in the process of government. If just for reasons of the magnitude of investment alone, but far more important the dependence today. That is one.

The second thing is, that what I refer to as the technology base, the talent and the tools to delve and explore new frontiers are, in large measure, supported by the Federal Government, and no nation on Earth has ever found the means to support that type of research area other than by largely Government support.

I would even go so far as to call it a Federal trust and I believe in order to insure that we meet that trust and that we elevate priority, we have got to look very carefully at raising science and technology to the cabinet level, to the level that so many other priorities that are represented by the cabinet departments maintain, and I believe that the policy which we perform in our office, and I certainly believe that the degree of priority in our White House is most certainly highly supportive, but I believe that that has to be linked with line management.

Mr. FUQUA. Before I recognize Mr. Sensenbrenner, I would like to ask unanimous consent to place a statement and a question in the record for Mrs. Lloyd and also an article for the record.

[The prepared statement of Mrs. Lloyd and attachments follow:]

HON. MARILYN LLOYD

REMARKS FOR DR. KEYWORTH

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

FEBRUARY 5, 1985

DR. KEYWORTH, FIRST I SHOULD LIKE TO COMPLIMENT YOU ONCE AGAIN FOR YOUR THOUGHTFUL ARTICLE ON THE "CASE FOR STRATEGIC DEFENSE...", AS WELL AS YOUR VALIANT EFFORTS WITHIN THE ADMINISTRATION IN BEHALF OF THE STRATEGIC DEFENSE INITIATIVE (SDI). AS I WROTE YOU IN OCTOBER, I BELIEVE YOU MADE A SOLID ARGUMENT FOR A TRANSITION FROM MUTUALLY ASSURED DESTRUCTION (MAD) TO AN EVOLVING DEFENSIVE STRATEGY. THE COUNTRY OWES YOU A DEBT FOR THIS VALUABLE CONTRIBUTION TO WHAT HAS BEEN AN UNFORTUNATELY POLARIZED DEBATE ON THE SDI.

ALSO, DR. KEYWORTH, I WANTED TO EXPRESS MY APPRECIATION FOR YOUR SUPPORT IN BEHALF OF ADVANCED REACTOR INITIATIVES FOR PASSIVELY

SAFE MACHINES SUCH AS THE MODULAR HIGH TEMPERATURE GAS-COOLED REACTOR (MHTGR). THE CHAIRMAN AND I ARE MOST PLEASED THAT OUR NOVEMBER, 1985 COMMITTEE INITIATIVE IN THIS AREA IS RECEIVING SUCH WIDESPREAD AND GROWING SUPPORT.

NOW THAT I AM FINISHED WITH THE COMPLIMENTS, DR. KEYWORTH, I WOULD LIKE TO ASK YOU SEVERAL QUESTIONS IN AREAS WHERE WE MAY NOT BE IN SUCH STRONG AGREEMENT.

- DON'T YOU BELIEVE THAT YOUR STRONG EMPHASIS OF THE "SCIENTIFIC ASPECTS" OF THE MAGNETIC FUSION ENERGY PROGRAM HAS, IN FACT, MADE IT MORE VULNERABLE TO FUNDING CUTS BY THE APPROPRIATIONS COMMITTEES AND OMB ON THE BASIS THAT MUCH EFFORT IS UNFOCUSED? AS YOU KNOW, THE PROGRAM REQUEST FOR FY 1986 IS DOWN ROUGHLY 25% IN REAL DOLLARS FROM FY 1984 SO, IN THIS REGARD, WOULD YOU GIVE US YOUR VIEWS ON THE NEED AND EFFICACY OF FUNDING A LOW-COST IGNITION EXPERIMENT (U.S.-FUNDED OR WITH INTERNATIONAL COST-SHARING) TO BETTER

FOCUS THE MAGNETIC FUSION ENERGY PROGRAM?

- I ALSO WOULD LIKE TO HAVE YOUR COMMENTS ON THE LEVEL OF FUNDING FOR THE NUCLEAR FISSION R&D PROGRAM IN THIS POST-CLINCH RIVER PHASE. AS YOU KNOW, THE DOE HAS STRUCTURED THE PROGRAM IN THE MANNER WHICH THE COMMITTEE RECOMMENDED LAST YEAR, I.E., TO EMPHASIZE ADVANCED REACTORS, INCLUDING INNOVATIVE LIQUID METAL DESIGNS AND NHTGRS, BUT THE DOE REQUEST FOR FY 1986 IS DOWN ROUGHLY 20% IN REAL DOLLARS FROM FY 1985. DO YOU BELIEVE THAT WE CAN MAKE THE BEST OF OUR FEDERAL INVESTMENT IN NUCLEAR R&D AT THIS BUDGET LEVEL? HOW WOULD YOU APPROACH THE QUESTION OF THE FEDERAL ROLE IN SUPPORTING TEST REACTOR EXPERIMENTS TO VERIFY ADVANCED CONCEPTS?

- FINALLY, DR. KEYWORTH, I READ YOUR ARTICLE "SCIENCE AND TECHNOLOGY POLICY IN THE NEXT FOUR YEARS" AND WAS VERY CURIOUS ABOUT ONE MAJOR ITEM YOU DID NOT ADDRESS IN VERY MUCH

DETAIL, I.E., THE OVERALL QUALITY OF THE RDT&E EFFORT IN DOD, AS WELL AS THE DOE DEFENSE PROGRAMS ACTIVITIES. IT SEEMS CURIOUS TO ME THAT YOU ARE NOT CONDUCTING ACTIVE REVIEW OF THE QUALITY OF THESE PROGRAMS, WHICH WILL AMOUNT TO NEARLY $45 BILLION FOR FY 1986 AND WILL COMPRISE OVER 75% OF THE ENTIRE FEDERAL R&D EFFORT. DO YOU BELIEVE, FOR EXAMPLE, THAT THE THREAT ASSESSMENT ACTIVITY UPON WHICH WEAPONS SYSTEMS R&D IS PRESUMABLY INITIATED IS DONE CAREFULLY ENOUGH TO PRECLUDE DOD LAUNCHING INTO EXTENSIVE TEST AND EVALUATION EFFORTS ON SYSTEMS WHICH RAPIDLY BECOME OBSOLETE?

MARILYN LLOYD

Congress of the United States
House of Representatives
Washington, D.C. 20515

October 1, 1984

Hon. George A. Keyworth II
Science Advisor to the President
Office of Science and Technology
Policy
Executive Office Building
Washington, D.C. 20506

Dear Dr. Keyworth:

I read your article "The Case for Strategic Defense: An Option for a World Disarmed" and I believe it represents a most valuable contribution to what has been an unfortunately polarized debate on the Strategic Defense Initiative (SDI). I found your approach sensitive, your remarks thoughtful and have taken the liberty of inserting the article in the Congressional Record.

I believe that strategic nuclear policy and the related question of the deterrent aspects of strategic defense are much too important to be victims of election-year rhetoric. In that regard, the historical perspective that you provide and the manner in which you superimposed Soviet thinking and doctrine represents a refreshing framework from which to view the SDI. I have been dismayed, on one hand, by the more simplistic arguments of the Administration in support of the initiative and, on the other hand, by extreme attacks by opponents who are so shortsighted that they do not believe that it is worth spending significant sums to even learn whether an adequate system can be developed and deployed. I believe that there are very intelligent people who are capable of convincing arguments on both sides of this issue, but the SDI program, based on the rationale outlined in your article, represents a meritorious program deserving both the attention and expertise of this nation's best technical and policy people.

I intend to maintain a dialogue with the Administration and interested parties in the Congress on this program. I have a very keen interest from both the viewpoint of the space power development needed to support the various technologies and the SDI systems R&D being conducted at the national laboratories.

Sincerely,

MARILYN LLOYD
Member of Congress

ML:DJs

Other factors in Conrail's turnaround have been the leadership of L. Stanley Crane who, as chairman and chief executive officer, has guided the railroad to profitability over the last three and one half years. Conrail employees made significant concessions to help the company, accepting 12 percent less than prevailing industry wages. Finally, Conrail's success owes much to its efforts at cutting out underused and unprofitable branches and adopting new technologies, such as "piggy back" containers and double-bottomed cars that can also be towed by highway tractors.

In all of the above points, the key item is the need for a careful and thoughtful review of the proposed sale by Congress. Why the rush to sell? The system is not costing the Government any money. The goal of the privatization of Conrail should be a good sale, not just a quick one.

THE MUCH NEEDED STRATEGIC TRANSITION: FROM MUTUALLY ASSURED DESTRUCTION (MAD) TO CAREFULLY ASSURED DEFENSE (CAD)

HON. MARILYN LLOYD

OF TENNESSEE

IN THE HOUSE OF REPRESENTATIVES

Friday, October 5, 1984

Mrs. LLOYD. Mr. Speaker, Dr. George Keyworth, the President's Science Adviser, recently wrote a sensitive and thoughtful article entitled "The Case for Strategic Defense: An Option for a World Disarmed," which appeared in the first publication of Issues in Science and Technology. Dr. Keyworth places the nuclear strategic aspects of the recent defense initiative in an historical perspective, superimposes the framework of Soviet thinking and behavior and makes a solid argument for a transition from mutually assured destruction (MAD) to an evolving defensive strategy. As Dr. Keyworth notes, "only when stockpiles can be measured in the dozens rather than the tens of thousands will arms control have any real meaning to ordinary people." I have provided major excerpts for my colleagues and I strongly recommend that they read the entire article.

The article follows:

THE CASE FOR STRATEGIC DEFENSE: AN OPTION FOR A WORLD DISARMED

(By George A. Keyworth II)

(Success/four flights Thursday morning/all against twenty one mile wind/started from level with engine power alone/average speed through air thirty one miles/longest fifty nine seconds/inform press/three Christmas—Kittyhawk, December 17, 1903.)

The First World War started in 1914, lasted four years, and engaged approximately 14,000 combat aircraft on the western front. Not one was of American design or manufacture. My subject is not airplanes. Rather, it is the lessons that four generations of Americans since Kittyhawk should have learned. It is about opportunity, in some cases lost opportunity, and time. It is about fear. And it is about hope, which the opportunities we now possess could leave as a legacy for the next generation.

Early this year, Freeman Dyson wrote a book entitled "Weapons and Hope". In it he identified two philosophies of war: that of the warrior and that of the victim. He went on to explore his sense of the root human causes of modern war and some of the reasons the superpowers find themselves at odds. He found these are the same reasons that warriors and victims have difficulty communicating—they simply do not speak the same language. He also found that "... the world seems now to be supporting a fork in the road with two ways only marked by conspicuous signposts: 'Ban the Bomb' and 'Don't Rock the Boat!'" Ban the Bomb, a slogan of the victims, says that our existing weapons and strategy are unacceptably dangerous. The warrior slogan, Don't Rock the Boat, says that it would be unacceptably dangerous to upset the delicate political balance established by our existing weapons and strategy. As Dyson observed, both parties are right. It is this dilemma—and an opportunity to escape it—that I propose as my subject.

II

In 1984 the superpowers confront each other with a combined arsenal of approximately 17,000 ballistic missile warheads, based in both silos and submarines and about 700 more bombers, which can carry an assortment of cruise missiles, short-range attack missiles, and bombs. All in all there are more than nine gigatons of combined arsenal—an explosive force equivalent to 9 billion tons of TNT—spread over a combined population of a little more than a half billion people. To date we have deliberately left ourselves exposed and hostage to these weapons.

In the warrior's world these are the tools of deterrence. The concept of deterrence is not new, though it has come to have an almost exclusive connotation associated with the nuclear age. Since time immemorial, rational men have used the two aspects of deterrence—deny the enemy his objectives and retaliate against him if he tries—to preserve peace. To date it has worked well; the warrior would correctly point to 35 years of nuclear peace.

The victim is not swayed by the complex arguments and analyses of deterrence strategists. Instead, he sees roughly 50,000 pounds of high explosive equivalent, destined for every man, women, and child in America, and about 20,000 pounds destined for every Soviet. The victim hears the warrior's argument of adverse exchange ratio but does not understand it. On the one hand, he knows very well the destructive power of thermonuclear weapons—and that they exist by the thousands, if not tens of thousands. He knows the delivery systems that carry them are currently unstoppable—deliberately so—to ensure that rational men will never consider their use. And he knows that the physical controls and safeguards on those systems make the probability of error extremely small.

On the other hand, the victim has an intuitive sense that there is no such thing as perfection, that man's history is more one of a series of irrational wars than it is one of reasoned peace. And that while one can always hope, leopards do not easily change their spots.

An even more deeply rooted barrier exists between the world of the victim and the world of the warrior: the difference in currency. The victims' currency is not weapons—it is the lives and suffering of their children.

It truly is the children that seem to be at the heart of the issue. Throughout man's history both individuals and nations have faced innumerable threats to their present existence. Rarely, however, have they faced a situation that foreshadows the end of their future. It is that vision of catastrophe that fuels the nuclear freeze movement, as well as calls for unilateral disarmament. In this respect, both the warriors and the victims share a common ground. As Meg Greenfield said in her April 30, 1984 Newsweek editorial "The Keepers of the Bomb": "I do not for a moment believe all those elaborate they-do-this-so-we-do-that comparisons the double-dome strategists expect their military men to put into effect, could happen: a nuclear war wouldn't be so considerately tidy and tame. But that is not the fault of the men and women who preside over these [nuclear] installations. They are as much victims as we, and—my final observation—they truly embody the American nuclear dilemma."

This dilemma is exacerbated because we continue to judge Soviet perceptions and objectives by our own standards. We automatically assign to them our Western logic, cultural values, historical perspective, and demand for absolute guarantees reflected in a "number." As a result, we have been unable to steer Soviet actions and are thus frustrated by their reactions.

We have built a strategic system that tends to work at cross purposes to that of the Soviets. We compound the problem by further assuming a perpetually rational relationship between a perpetually limited club of superpowers—with no provision for mistakes, miscalculation, or madmen.

The American people seem to instinctively grasp these inconsistencies, probably because they are not mesmerized by the numbers or mathematical elegance of the proposed theories. And they are demanding change.

III

I do not argue with the past. Some have snidely remarked that we seem to have gone from "Assured Ascendancy" in the 1950s to "Assured Destruction" in the 1960s and 1970s, ending with "Assured Anxiety" in the 1980s. But this does not recognize the challenge met by the men at the dawn of the nuclear age. Without real technical or political alternatives these men walked a razor's edge with delicate balance. Global peace attests to that balance, and that balance must be maintained; our nuclear deterrent posture must be kept healthy—for the immediate future.

I feel uncomfortable, however, with reasoning that says that mutual offensive deterrence—wherein the promise of complete national destruction is presumed—must remain as policy ad infinitum. I believe we must consider a transition.

I say this for several reasons. First, there is great concern among military analysts about the imbalance between the projected scale of loss in the United States versus that of the Soviet Union as a result of nuclear war. Make no mistake, the results on either side would be catastrophic. But differences in socioeconomic assets; the locations, density, structure, dissipline, and civil defense of the populations; and weapon types, numbers, and targeting strategies all combine to produce reasonable estimates that the Soviets might expect 20 to 35 million casualties, while the United States could experience number's four to five times that. These are staggering figures. After all, the United States has had only a little more than 1.2 million battle and battle-related deaths in all its wars combined—a period covering more than 200 years and ten generations. (Confederate deaths during the Civil War are estimated at two-thirds that of Union forces.)...

Some specifics are included on American, European and Soviet casualties in past wars

The message here is that both the American and Soviets finally believe the other will fight—and that is the essence of deterrence. Left to themselves, the peoples of the two nations would undoubtedly pronounce any conflict to its bloody conclusion.

But times change, as do weapons and leadership. Beginning in the late 1950s, ordinary citizens began to realize the futility of global thermonuclear war. More recently, the American Roman Catholic Bishops consolidated a large body of thought in their discussion of the ethics of defending ourselves with weapons we cannot morally use, in a way we cannot possibly win.

Nevil Shute was probably the first to anticipate the demise of the policy of massive retaliatory deterrence in his book "On the Beach." His message was simple: it describes matter who starts the conflict, for in his scenario neither the United States nor the Soviet Union is the initiator. Nor does it matter whose fault it is—his thesis is that the superpowers mistakenly retaliate against each other through unavoidable error. And no matter how much either side wants to stop the conflict after it starts, the war rapidly assumes its own momentum. Finally, it does not really matter who the combatants are: in Shute's vision, everybody dies.

It has been almost two decades—about one generation—since "On the Beach" was written. Shute's view can now be said to reflect the mood of the people. As Elie Wiesel put it, so simply and poignantly—they are scared.

They're scared because they watch a tremendous amount of money being spent on defense, yet they feel no more secure for it. They're scared by predictions that Armageddon, or something very like it, might result from nuclear explosions totaling only a few hundred megatons—and the gross stockpiles on both sides are at least two orders of magnitude larger than that already, and growing. They're scared because they can see no logical end to the arms race, because no balance of power has ever lasted forever, and because they want to leave more hope to their children.

IV

In A.D. 14 Tiberius became emperor of Rome. He succeeded Julius Caesar, who brutally reorganized and expanded Greco-Roman civilization, and Augustus, who had continued Caesar's expansion with unparalleled administrative genius. Although Tiberius inherited one of the greatest societal upheavals in history, he passed on 200 years of peace. In this context, Tiberius was often heard to comment: "As they say, I have got a wolf by the ears."

We, too, have our wolf by the ears. It is a world in which the superpowers have established a tense nuclear standoff. Each has an arsenal sufficient to destroy the other. Each has an abiding distrust of the other's intentions. Each views the other as preparing to strike first. For both nations, the future is growing less stable and predictable. And their leaders' technological options for maintaining stability are becoming increasingly marginal.

We chose this route two generations ago when we acquired a power we dared not turn away. Once we had nuclear weapons, deterrence as we know it evolved for several reasons. Some were political—to consolidate and maintain our world leadership after World War II. Some were military, such as the need to offset Soviet nuclear development. And some were monetary—conventional forces were too expensive. One rose on the nuclear wolf, however, has become a balance of terror. To paraphrase Winston Churchill, we are rising to and fro on an animal that we dare not dismount, and the animal is getting hungry. . . .

The questionable merits of relying heavily on offensive nuclear weapons and the difference in U.S. and Soviet views of such weapons, as well as the comprehensive nature of the Administration's SDI proposal are discussed.

V

Seemingly, we have led ourselves back to Freeman Dyson's paradox. The victim says we cannot live with our present nuclear weapons and strategy; the warrior says we cannot live without them. The public sees itself trapped by weapons of mass destruction, a de facto policy of guaranteed delivery, and de facto policy of massive retaliation. They perceive that both sides maintain a preemptive capability to curtail the damage of a retaliatory strike, that we proliferate our offensive weapons as a counter to preemption, and that proliferation and preemptive capabilities lead to increasing instability.

Can we get a handle on the first of these issues? Can we reject the weapons of destruction themselves? Regardless of the calls to disarm, I believe we are long past that stage. Nuclear weapons are too firmly established as the centerpiece of the world's balance of power. More important, many Third World nations see nuclear weapons as an indispensable trump card in their scramble for ascending status and power. Although perhaps only six countries have built and tested nuclear weapons to date, it is estimated that there are at least ten more who could build them within six years, and eleven more who might within ten years. No matter how much one may want to return to the prenuclear era, we have eaten from that tree of knowledge.

Do we want to abandon deterrence? Even though many critics may state that those of us who advocate strategic defense are calling for such a policy, there is no question that we must retain a specific retaliatory capability. Nuclear weapons, because of their small "kill-to-destruction ratio," are a most precious commodity. The destruction resulting from just one weapon is so high that countries might consider any means to acquire one. Ultimately, the value for countries considering initiating nuclear war is: is it worth it?

Are the gains worth the risk of retaliation? I propose that if there were no risk of retaliation, then the chances that nuclear weapons might be used would be even greater than they are today. Even if one were to have perfect defenses, an overt no-retaliation posture would be precisely the fatal fascination of the fortress that has proved disastrous throughout history.

But do we have to maintain nuclear weapons as part of this posture? To retain its credibility, retaliation must balance itself against the potential damage that an enemy can inflict. Unless and until the world can completely rid itself of nuclear weapons, an admittedly unlikely prospect, the nuclear weapon will remain one aspect of any deterrent policy. But I submit that the massive retaliatory arsenals that threaten our future today can be made effectively obsolete if the defense technologies we can now foresee are followed to emerge and evolve.

I propose here a central thesis: It is not deterrence, per se, that has caused the general public to lose faith in our policy and that has caused the buildup of our offensive weapons to turn cancerous. Rather, it is our deliberate and continued inability to protect the socioeconomic structure of our society—coupled with our growing inability to protect the retaliatory deterrent. . . .

The changing nature of deterrence is described from the U.S. and Soviet points of view.

That brings us to the crux of the most immediate argument in favor of developing active defenses: they remove the preemptive option, both for the Soviet Union and the United States. Growing preemptive capability has been and continues to be the prime factor in the spiraling arms race. In Soviet eyes, U.S. technical know-how in the 1960s and 1970s provided a unique qualitative edge for preemption that could be overcome only by sheer mass and a strategic force—that could get at the enemy fast—the ICBM.

In U.S. eyes, this Soviet ICBM force, coupled with its dramatically improving technological performance and survivability, gave the Soviets an overwhelming preemptive potential, unparalleled flexibility, and an unacceptable strategic reserve in times of conflict; hence, the concerted U.S. attempts to modernize its strategic forces starting in the late 1970s.

At that time, however, the United States was just beginning to emerge mentally from the Vietnam War. The defense budget as a portion of the gross national product was dropping precipitously from a peacetime expenditure of close to 10 percent a decade-and-a-half after World War II to 5 percent at the close of the 1970s, and SALT II was on everybody's lips. . . .

The Soviet achievement of parity and the impact on our arms control bargaining position is discussed.

VI

How, then, do we agree on any arms control measures that matter? As Admiral Noel Gayler recently commented on Braden and Buchanan's Cross-Fire program, today's arsenals are such that one side's strategic advantage of a thousand weapons or so is really lost in the noise. Going further, Carl Sagan postulates that the detonation of just a few hundred weapons would, in his opinion, trigger nuclear winter. Admittedly, Sagan's thesis is undergoing heavy scrutiny and criticism. Both his phenomenology and threshold levels, as well as the winter, or perhaps summer, effect have come under question. But in the end the precise numbers really are not the issue. It is clear that a large portion of the earth's population—perhaps a quarter billion people or considerably more—could die as the result of a global thermonuclear war involving even a fraction of present-day arsenals.

Sagan is probably close to being correct when he says the only real answer is to disarm. But he forgets that retaliatory deterrence is not a phenomenon of the nuclear age. In one form or another, it has been man's primary international stabilizer for all of recorded history.

And as I have described, in deterrent theory the punishment must fit the crime. In our nuclear age, both crime and punishment have accelerated to the point of suicide. The reason for this escalatory spiral—the reason why real arms control has been unable to take hold—is the continually improving ability, real or perceived, of each country to disarm the other. . . .

The alarming ability for a first strike is discussed from several different aspects.

It is time to pursue the technological options for active defense. Significant technological advances have occurred since the last serious debate on ballistic missile defense in the late 1960s. We have before us the prospect of advanced defenses that can provide crisis stability and slam the lid on the MIRV. James Fletcher's Defensive Technology Study team spent over 100,000 man-

hours in the summer of 1983 reviewing the state of the relevant technology. They called in several hundred technical and industrial experts, which probably brings the total man hours up to a half million. I really could not improve upon their summary of the differences new decades have brought:

"In the 1960s, there were no credible concepts for boost-phase intercept. Today there are multiple approaches based upon directed energy concepts and kinetic kill mechanisms. Midcourse intercept was hampered in the 1960s by the lack of credible approaches for decoy discrimination, unmanageable signal and data processing loads, the cost per intercept, and the undesirable collateral effects of nuclear weapons used on the interceptor warheads. Today, multispectral sensing of discriminants, hit-to-death tracking in midcourse, and small kill vehicles that have promise of inexpensive interceptors appear to offer capabilities that overcome the limitations in midcourse.

"In the 1960s, the inability to discriminate against penetrators side at high altitudes and limited intercepter performance resulted in very small defended areas for each terminal defense site and gave the offense unacceptable leverage over the number of interceptors needed. Today, technology provides the potential to discriminate at high altitudes, and improved interceptor technologies should allow intercepts at these higher altitudes. When these improvements are coupled with the potential for boost-phase and midcourse intercepts to disrupt pattern attacks, robust terminal defenses seem attainable. Finally, 1960s technology in computer hardware and software and signal processing was incapable of supporting battle management for a multilayered defense. Today, the rapid advancement of these technologies is believed to permit realization of the complex command and control systems needed."

We are already in an era when warning and decision times are becoming extremely short. As technology advances during the next decade, these intervals may be reduced to the point at which in times of crisis—or misdiagnosis or human error—a policy of shoot-first-and ask questions-later may become an option, a terribly dangerous option, for both sides. As the very least, active defenses can conceivably give us precious time to make these decisions. At best, they can reduce the consequences of an accidental or erroneous launch, nuclear adventures by Third World countries or mayhem, and massive retaliation and the loss of hundreds of thousands of lives. Of possibly greater import, once having made a mistake, the offending country would not automatically have to deal with what I'll call the "failsafe" dilemma—that is, a decision on whether to immediately follow the mistake with a completed nuclear attack rather than face retaliation. Experts, of course, dismiss this possibility. The ordinary citizen has a deep-rooted fear of it. . . .

The Soviet situation as a result of SDI and the variety of Soviet responses to it as well as the various benefits which the initiative can provide in the case of real arms control are discussed.

Strategic defense therefore provides an option for a world effectively disarmed of nuclear weapons, yet still retaining national sovereignty and security. In fact, deployment of strategic defense is the only way in which the superpowers will be able to achieve these very deep arms reductions. It now becomes extremely important to reconcile that the ballistic missile and air defenses that might look less than 100 percent perfect in the confines of an offensive exchange involving tens of thousands of warheads could be expected to perform magnificently against an attack by only tens, or at the most hundreds, of weapons.

I do not offer this scenario lightly. Moving out from under the nuclear umbrella under any circumstance is a serious, sobering, and expensive proposition. Neither our military structure, organization, nor technology is prepared for it now—not strategically or tactically.

Moreover, I must issue one caution. Strategic defense must never be perceived as a technological panacea. It is a tool, a catalyst, nothing more. The roots of our security problems are political. However, pending a benign transformation in the ways of the world, it behooves us to invest in a military capability that increases the prospects for meaningful arms control and gives hope to those that follow us.

Admittedly, there are many "ifs" in the prospects for strategic defense. But the President proposed that we use our ingenuity to pursue these defensive technologies, and outstanding scientists substantiate his faith. It is our obligation—our responsibility—to provide new options for our political leaders.

We cannot look down each other's gun barrels indefinitely, regardless of the rational balance we think we can maintain. Rational men have rarely started history's wars. Nor can we play into the Soviets' strong suit—men and material. Instead, we must start to play our trump—technological leverage. We must move rapidly to develop the means to both reduce our own reliance on tactical and strategic nuclear weapons and the Soviets' perception that either side could use them to advantage. And we must couple these technical moves with negotiations for deep reductions in nuclear weapons. We must begin our transition from the 1980s to the year 2000. And we must offer hope that we can achieve a world free of the fear of nuclear war.a

CONGRESSMAN FEIGHAN HAILS MAYOR PAUL CASSIDY OF PARMA HEIGHTS

HON. EDWARD F. FEIGHAN

OF OHIO

IN THE HOUSE OF REPRESENTATIVES

Friday, October 5, 1984

• Mr. FEIGHAN. Mr. Speaker, the Plain Dealer featured a profile of the distinguished mayor of Parma Heights entitled "What Makes Paul Cassidy Run?" I have known Mayor Cassidy for a number of years and one thing is certain: As Mayor of Parma Heights for 27 years, the interests of his community have been his prime concern. The residents of Parma Heights are proud of their community because of Mayor Cassidy's dedication to make the city an enjoyable place to live, work, and raise a family. The litany of his accomplishments includes the Greenbrier Community Center; a city theater, a library, an ice skating rink, and a lovely community park. City streets are safe and municipal services excellent.

Mr. Speaker, I want my colleagues and the people of Parma Heights to know I appreciate Paul's drive because his outstanding leadership makes my job much easier. Thank you, Paul, for a job well done.

WHAT MAKES PAUL CASSIDY RUN?

(By David Beard)

Paul W. Cassidy started peddling the Saturday Evening Post, Country Gentleman and Ladies' Home Journal around his old Glenville neighborhood at age 8, graduating to paper routes for both the Cleveland News and the Press a few years later.

"He's been moving ever since," said his son, Steve, after watching his father in action at a Parma Heights restaurant. The jovial Cassidy greeted the hostess, dominated table conversation, gulped down a meal, then apologized for having to rush to his law firm.

Cassidy, 64, had started the day at Parma Heights City Hall. He has been the city's part-time mayor for nearly 27 years—longer than any Cuyahoga County mayor except Brooklyn's John M. Coyne.

During the morning, Cassidy had outlined strategy for his latest challenge: convincing voters in the suburb of 33,112 that the city income tax should be doubled from 1% to 2%.

Then had come lunch and an afternoon at the firm, where he handles work for private clients and, occasionally, other suburbs. He is legal counsel to Parma Community General Hospital and Cox Cable Inc., which numbers Parma Heights among its west suburban clients.

"He certainly wears a lot of hats," said Parma Heights Councilman Jim Pastor, who opposed Cassidy in the last two mayoral campaigns. "Being around as long as he has been, he is almost considered an institution . . . One reason I decided to take him on was because he never seemed to have any opposition."

The abundance of Cassidy's public and private interests has raised eyebrows, and it has extended his influence far beyond city limits. Many politicians regard the fast-talking, hand-shaking Cassidy as one of the shrewdest, most powerful politicians in southwest Cuyahoga County.

"He's not to be No. 1 or 2," said Democratic Ohio Senate candidate Ronald M. Mottl, the other half of the Cassidy & Mottl law firm. "I say he's top in his party. And (Parma Mayor John M.) Petrunka is top in his party."

In 1974, Mottl won the seat that friends say Cassidy always wanted: congressman. It was the first of four two-year terms in the old 23d District for Mottl, who admitted it was rocky when Cassidy had declined to run.

"There's the person that could have probably beaten me," Mottl said. "I would have hated to run against him. He's more articulate than I am and is a tireless campaigner."

Cassidy had run unsuccessfully for Congress in 1950 against then-Rep. Michael Feighan. When he chose not to try again more than 20 years later, he explained he would be in his 70s before he could get anything done in Washington.

Cassidy is a Republican, yet last year, his re-election committee gave more money to the Democrat Petrunka than did any other contributor. It also gave to Brook Park Mayor Thomas J. Coyne and Brooklyn Heights Mayor William M. Bittle, both Democrats. Bittle had hired Cassidy's son, Michael, an accountant and lawyer, as finance director.

"I'm a good Republican, a lifelong Republican, but when it comes to political races, I always back the person," Cassidy said.

In 1957, about a year after being appointed Parma hospital counsel, Cassidy was elected to his first term as mayor. Several residents of Brooklyn, which the hospital serves, accused the hospital board of playing politics and urged his ouster as counsel.

Since 1981, U.S. science policy has emphasized the contributions of basic research to industrial competitiveness. That major theme, the president's science advisor asserts, will be refined during the second Reagan administration.

Science and Technology Policy: The Next Four Years

BY GEORGE A. KEYWORTH II

Four years ago the Reagan administration, as part of a broad reevaluation of the relationship between government and society, took a fresh look at the rationale and impacts of the federal government's large programs in support of research and development. Certainly, one driving force behind this reevaluation, which continues today, is the sheer pervasiveness of science and technology in the modern world. The rise of fierce foreign competition in both the world and domestic market means that industry rises or falls on its technological advantages.

A quarter century ago, U.S. industry had few worries about competition. The United States dominated essentially all industrial technologies, and had always been able to develop and introduce them at its own pace. Today we must use our technological resources much more aggressively. Technology and talent are virtually our only clear competitive advantages in a world where the dollar may be permanently overvalued, where foreign governments are subsidizing capital costs, and where foreign labor is often an order-of-magnitude cheaper than domestic labor. Thus, in the second Reagan administration, we intend to use our funding of R&D most effectively to guarantee that we continue to retain those two advantages.

Getting Value for Money

Industrial technology is the end-product of a multistep process of research, development, and application. Modern electronics illustrates the steps, which begin with the kind of fundamental research done in universities and federal laboratories. In this case, one strand of that research was highly theoretical work on the quantum theory of solids. Scientists and engineers then applied those basic concepts in a device to switch electric currents; that became the transistor. Finally, the crude early transistor was refined into a commercial reality that, in turn, became the basis for the industrial explosion into microcircuits applied to computers, automatic control, and a whole new world of consumer electronics. This process emphasizes the critical role of basic research in the development continuum.

Most industrial nations invest roughly comparable fractions of their GNP in the broad process of R&D. The United States will invest some $110 billion in R&D next year—more than Japan, France, West Germany, and the United Kingdom combined. That's roughly 2.7 percent of U.S. GNP—about the same as the most ambitious of our competitors, and more than many of them. So in both relative and

Reductions in funding for federal energy projects enabled the U.S. to finance its spectacular growth in basic research.

absolute terms we would appear to be in good shape to maintain our technological leadership.

However, impressive as those figures are, they may mask a serious weakness. The federal government supports nearly half of U.S. R&D—about $55 billion—to meet public needs. These include space, health, energy, and, particularly, defense, reflecting the post-World War II role of the United States in anchoring the security of the free world. In fact, we spend far more of our R&D funds than our international competitors on objectives other than strengthening industry's ability to compete. To me, that looms as the central issue in examining the U.S. relationship between government and industry. We must capture substantial long-term benefits for our industry from the $55 billion in federal R&D that can be used to strengthen U.S. competitiveness.

The key question then becomes: how much *does* that federal R&D contribute to our industrial technical strength? To get a handle on that, we have to look at a little history.

In the decades after World War II, technology spinoffs from federal R&D—particularly in defense—helped lay the foundation for some of today's most successful industries, including computers and commercial jetliners. Thus, industry was strongly stimulated by and benefited from this federal role. But the commercial market for technology has expanded tremendously in the past decade or so. Today industry, not government, is pushing hardest at technological frontiers in many areas. For example, government relies heavily on industry to provide it with state-of-the-art electronics of every kind. Similarly, the proliferation of commercial firms trying to stake out positions in the biotechnology market is transforming a field dominated by government and universities into one with strong industrial leadership.

My own discussions with industrial leaders confirm that there's been a striking decline in industry's dependence on government to stimulate the development of new commercial technology. But at the same time there's been an equally striking increase in industry's reliance on two items it can't produce for itself. One is the fundamental knowledge that ultimately drives the process of industrial innovation—tomorrow's equivalent of the quantum theory of solids. The other is the new technical talent that can use that knowledge to respond to industrial opportunities. So the more that industry has become the prime developer of new technology, the more it has become dependent on universities. Ironically, the ivory towers are emerging as the bulwarks of industrial competitiveness in the 1980s.

The First Four Years

The Reagan administration took decisive steps during the past four years to adjust the federal role to this new reality. With strong bipartisan congressional cooperation, the administration has beefed up support for basic research, focusing particularly on engineering and many of the physical sciences. We have also tried to build an adequate supply of people well-trained in these areas and able to apply the results in development projects chosen and funded by industry. At the same time, government has moved out of the development of technology that industry is far better qualified and motivated to do.

The most striking example of how the government can flounder in development has been in energy technology. For the billions of dollars spent on energy development in the 1970s, our biggest return was a lesson in Economics 1A—the law of supply and demand as it operates in the marketplace. Those expensive federal programs, which never did offset any significant amount of imported oil, were launched on the premise of "technology push" rather than "demand pull." However, they were overtaken by a combination of marketplace responses that held down oil prices and made most alternative sources of energy uncompetitive.

Reductions in funding for federal energy projects enabled the United States to finance its spectacular growth in basic research (*see the chart on page 48, left*). This shift in priorities is one of the clearest manifestations of the administration's science and technology policy. Basic research, for the first time ever, has climbed from the smallest fraction of nondefense R&D to the largest—from 27 percent to 38 percent. At the same time, development has dropped from the lion's share—42 percent—to the smallest, at only 27 percent. What we're saying is that basic research is clearly the federal government's responsibility, while development of new commercial technologies is best left to the private sector. Of course, that situation is totally different in defense R&D. Because the government is the only customer for defense technology, there is no comparable means of shifting development funding to the private sector.

The pattern of growing support for basic research

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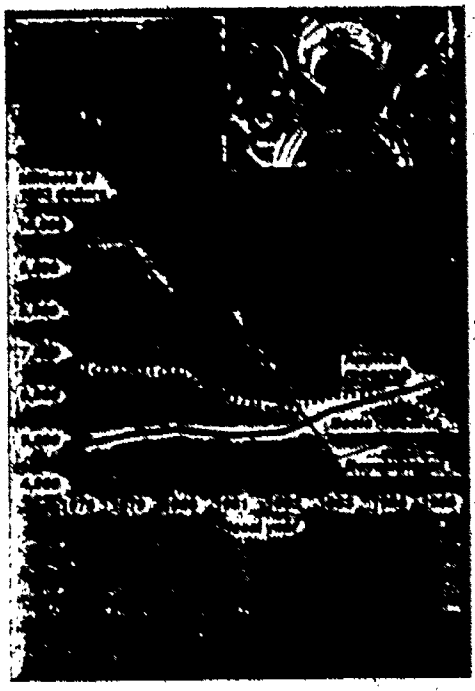
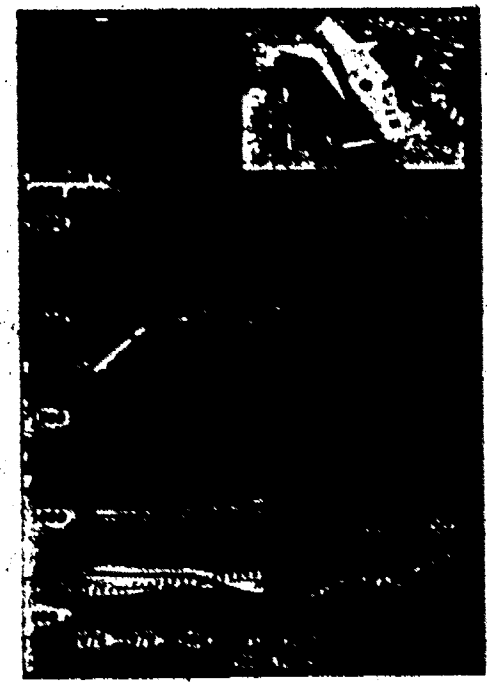
The federal government's allocation of funds for nondefense R&D has changed drastically over the past four years. Basic research has jumped from the smallest function to the largest, while development has moved in the reverse direction. The vertical line between fiscal years 1981 and 1982 corresponds to the transition between administrations.

Funding for basic research among the five largest R&D agencies, which account for 90 percent of all federal support for basic research, has shown strong and consistent growth over the past four years following half a decade of either level or declining budgets in real terms. The fiscal 1985 total for basic research is almost $8 billion, up from $5 billion in 1981.





shows up across the board. The five largest R&D funding agencies—the National Aeronautics and Space Administration, the Department of Defense, the Department of Energy, the National Science Foundation, and the National Institutes of Health—have shown strong and consistent growth over the past four years (*see the chart above right*). Together these agencies account for about 90 percent of all federal support for basic research. Moreover, their growth follows either level or declining budgets in real terms during the five previous years. That's an important turnaround that many observers have still not grasped. Overall, the United States will spend just under $8 billion for basic research in this fiscal year, in contrast with just $5 billion spent in fiscal 1981.

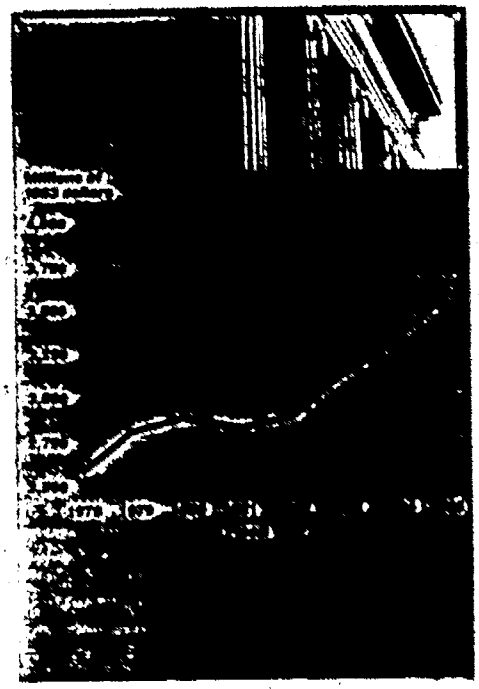
Similarly, funds for basic research targeted specifically to universities and colleges have increased substantially (*see the chart on page 50*). These funds declined consistently from 1968 to 1979 and remained steady for the next two years. But since 1981, that support has grown by nearly 30 percent in real terms. Yet even though the basic research budget was expanding dramatically, we had no illusions about the necessity of spreading those increases evenly among disciplines, and certainly no illusions that we had to make sure that as many researchers as possible got their share of it. That wasn't how we did science in past four years, and it won't be in the next four.

Instead, we followed two general principles in deciding which projects to fund. We demanded that research be the best we could identify, even if that meant cutting back or eliminating ongoing projects. In light of the abundance of high-quality research projects needing support, we would have been derelict in our duty if we allowed limited resources to

Continued on page 50

DIAGRAMS: OMNIGRAPHICS

Federal funds granted competitively to universities and colleges for basic research grew by about 20 percent during the first Reagan term. That followed two years of essentially no growth and more than a decade of declining funds. The administration thinks this investment will help guarantee the nation's continuing industrial competitiveness.



be siphoned off to anything but the best. We also concentrated funding in areas most likely to benefit society, or where we could sense pure scientific excitement waiting to be turned loose.

The strong emphasis by the National Science Foundation (NSF) on engineering projects and research centers reflects this goal. Programs in supercomputers, mathematics, and materials research have also been expanded. Topics of pure scientific excitement that may benefit society include many areas of biology such as neurobiology, which we feel may be most exciting of all; particle physics, because it deals with the most fundamental questions imaginable and attracts some of our brightest young people; and space science, because our exploratory tools now allow us to take giant steps in understanding the macro environment. At the same time, we cut back support in areas where research did not offer enough intellectual excitement or industrial potential. The cuts in some of the social sciences were an example.

The decision to terminate the Isabelle Project at Brookhaven National Laboratory on Long Island was another example. Although the huge particle accelerator was years behind schedule, hundreds of millions of dollars over budget, and being overtaken by progress at other experimental facilities, there was a tacit assumption within part of the physics community that the project, once started, was guaranteed completion. However, the administration asked the high-energy physicists to determine which major facilities should receive priority. The recommendation, which the community would probably never have made without this prod, was to terminate Isabelle to ensure adequate support for more productive facilities at Fermilab outside Chicago, and at the Stanford Linear Accelerator Laboratory in Palo Alto.

Five Areas for Improvement

These considerations will continue to play the dominant role in science and technology policy in the coming four years. We will emphasize strong growth for basic research, especially at universities; programs to ensure more and better-trained technical talent; better cooperation between universities and industry; strong growth in defense R&D; and clear delineation of the responsibilities for R&D between the federal government and the private sector.

In spite of the changes that we've already made, much more remains to be done. I see five major concerns characterizing federal R&D programs in coming years.

☐ First, government must help colleges and universities attract and retain faculty of the highest quality. In simple terms, that means improving the campus climate so that ambitious scientists and engineers won't feel compelled to take jobs in industry if they want to be competitive in research. An academic brain drain is ultimately devastating for universities and industry alike, because universities simply won't have enough faculty to teach students, particularly in the fastest moving areas of science and engineering. And without newly trained talent, new industrial technology will dry up.

Of course, overall support for university research has increased. And we've taken important steps to rejuvenate funding for campus instrumentation, improve access of university researchers to supercom-

puters, and establish the presidential young-investigator program to attract and retain new faculty in critical disciplines. In addition, after a half-year review, a panel chaired by David Packard will soon make several recommendations for further action to strengthen universities for their long-term job of generating knowledge and talent to meet national needs.

The second area of emphasis for government support is the generation of basic knowledge, especially in areas of particular importance to industrial competitiveness. The newly emerging biotechnology industries exist today because of decades of federal support for basic research in molecular biology. We should make sure that we're investing in comparable kinds of frontier research to fuel tomorrow's new technologies.

For example, we have expanded and redirected the biotechnology research within the Department of Agriculture. We hope the new program will attract highly qualified scientists who might not otherwise be interested in agricultural problems.

We've also made good progress in restoring support for basic research within the Department of Defense, especially at universities. At one time DOD suported much of the best university basic research. And DOD funds were largely responsible for the strength of some of today's major research universities, such as Caltech and M.I.T. That productive relationship has never really recovered from the Mansfield Amendment of the late 1960s, which prevented DOD from supporting research unless it could be directly tied to the defense mission.

We're rebuilding now because America's strength—our leverage over the Soviet Union—comes from the quality of the technology we're able to apply to defense systems. The Defense Department needs both technically trained people and broad access to knowledge about science and technology that emerge from basic research. The best means to assure the availability of both is to fund research in universities.

At the same time, we place high priority on maintaining the open communication of scientific results that has made our university system the world leader. During the past two years, there has been concern in the scientific community over a few incidents in which the government imposed restrictions on scientific papers originating in unclassified research projects. In response to those concerns,

Government must help colleges and universities attract and retain faculty of the highest quality.

"The federal government must constantly endeavor to strengthen the private economy while supporting research and development, particularly in universities, to train tomorrow's industrial and academic scientists and engineers," stated President Ronald Reagan, seen here consulting on science and technology policy with the author, presidential science advisor George A. Keyworth II.

we're in the final stages of preparing guidelines and regulations that restate and protect the basic policies of free communication. Only classified information will be restricted, and very little academic research is classified. We must distinguish between the transfer of technology to our adversaries—a serious, well-documented problem—and the flow of scientific information, which must remain essentially unimpeded.

☐ Emphasis number three concerns changes we have made in government's traditional support for university research on a narrow, project-by-project basis. That method, while very successful for progress within narrow disciplinary boundaries, is severely limited in its usefulness to broad areas of industrially important topics.

I'm particularly excited about the new program in the National Science Foundation to establish cross-disciplinary centers for engineering research. There, faculty from many different departments can work together on industrial problems that none could solve on their own. And these centers will enable students to receive the kind of practical experience in solving problems just not available at universities today, and will allow industry to help determine which advances can most likely be applied to commerce.

Universities are very enthusiastic about participating in this kind of program. In the first round of proposals for these engineering centers, NSF was inundated by 142 proposals from 106 different schools, from which up to 10 will be chosen. Eventually the program will be expanded, but before that happens we need to be sure the initial centers are working well. We must also get a sense of what the balance in support should be between such interdisciplinary centers and traditional programs.

☐ The fourth major responsibility of government is to find better ways to stimulate the flow of ideas, expertise, and people among the federal laboratories, universities, and industry. One-sixth of the nation's scientists and engineers are employed in federal laboratories, which have a combined annual budget of some $18 billion. These superb resources are often underutilized. We should find ways to reap substantial industrial benefit from a federal investment of that magnitude.

A year ago the White House Science Council recommended that we take better advantage of the talent in the labs and bring their missions more in line with national needs. In accordance with these recommendations, lab directors are now given more discretion in using research funds. Lab missions are also being updated and revised, and the labs are cooperating with universities and industry.

One practical result is the effort to marry the technical expertise of the labs with the needs of the steel industry. The national labs will not do the steel companies' jobs for them; this program provides access for a threatened and important domestic industry to existing taxpayer-supported technical resources. The Oak Ridge and Argonne National Labs are trying

PHOTOGRAPH: THE WHITE HOUSE

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The U.S. space program must follow both the practical and the visionary paths.

to identify areas where concentrated R&D could significantly improve steelmaking efficiencies.

☐ Finally, the fifth goal of government is to be more responsive to opportunities to support emerging technologies. For example, the same federal programs that made possible the birth of today's biotechnology industry have neglected generic applied research in bioprocess engineering, despite the expenditure of billions of dollars. This research, which is necessary to facilitate development of industrial products, includes development of thermodynamic data and principles of biosensing for process and quality control. We're in real danger of letting other countries assume the industrial lead in profitable new fields of technology that American scientists have done most to establish—and that American taxpayers have underwritten.

The Promise of Space

That danger is certainly a driving reason for our determination to create improved opportunities for commercial activities in space. Under the umbrella of the National Space Strategy, signed by the president last August, we're encouraging the development of private-sector launch services and other space-based industry. Now that the space-shuttle fleet is almost fully operational and cost-effective, we must expand on our advanced space technologies by bringing in the special perspectives and market-oriented motivation of the private sector.

We hope soon to establish full-cost pricing for shuttle launch services. We expect these prices to be competitive for the kinds of highly sophisticated services that the shuttle can provide. At the same time, that price schedule should allow room for companies producing expendable launch vehicles to maneuver, and we certainly expect them to provide alternatives to both the shuttle and the Europeans' expendable Ariane system.

The U.S. space program is confronting two paths—the practical and the visionary. My firm opinion is that we have to follow both paths aggressively. Only by continuing to push at the boundaries of the vast space frontier will we be able to assure our world leadership in the more practical space technologies. We must also provide opportunities for the private sector to use its vision and creativity in addressing the enormous challenge in space. Accordingly, we're working to give federal agencies other than NASA responsibility for commercializing space activities. We intend to reserve NASA for what it does best—research and development—and to generate far greater involvement of the private sector in what it does best—serving commercial needs.

Our manned and unmanned space programs have been remarkably successful, and we need to maintain both thrusts. The repair in space of the Solar Max satellite and the retrieval of two lame communications satellites last year reminded us that the brains and dexterity of people can be crucial in space, even though automated equipment is adequate for many routine operations. Of course, one of the glories of the U.S. space program is its success in long-distance unmanned missions. We would be foolish not to take advantage of our capabilities in robotics, advanced communications, and computers as we plan for new commercial ventures. Thus, one of the challenging tasks in designing the space station now being funded is to decide which objectives should be met by humans. Industrial participation in the early planning stages for the station will ensure that it will serve industry's needs.

Challenge for the Future

The progress over the past four years has shown that we can harness basic research to achieve societal goals. But my continuing concern is that we can do more, and that our piecemeal approach fails to capture truly the potential that a $55 billion federal R&D program holds out. We want to see a better balance in federal R&D spending between essential mission requirements and the strong science and technology needed to support American technological leadership.

I believe that the science community, the universities, the administration, and Congress can make great progress in strengthening science and technology in coming years. Perhaps more than at any time in the recent past, we have a firm sense of our national needs and of the actions we have to take to build a base for long-term growth and prosperity.

GEORGE A. KEYWORTH II is science advisor to President Ronald Reagan and director of the White House Office of Science and Technology Policy. He assumed his post in 1981 after 13 years as a nuclear physicist at the Los Alamos National Laboratory. This article is an updated and expanded version of a speech given to the Council for the Advancement of Science Writing.

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Mr. FUQUA. Mr. Sensenbrenner.

Mr. SENSENBRENNER. Thank you.

I have been leading the charge in support of the integrity of the peer review process and the siting of various scientific facilities and where the Federal Government finances those facilities, and opposing very rigorously the proposals to bypass the peer review process, to build facilities at Columbia University in New York and Catholic University here in the District of Columbia.

I know you have sent me a letter supporting my efforts on behalf of those two pork barrel projects and I will read an article in the November 26, 1984, edition of C&E magazine which quotes you as follows. I will read the pertinent part in its entire light.

The magazine says on charges that Representative Don Fuqua, Democrat of Florida, sidestepped the peer review process in securing for Florida State University a supercomputer funded by the Department of Energy, you were quoted as follows:

> I think Don Fuqua has been erroneously maligned. There has been blatant pork and that came through universities that went to lobbying organizations in Washington and tried to literally play the policy. That is sheer unadulterated pork.
>
> Don talked to me about the supercomputer opportunity in Florida. He was interested in it. It was spontaneous in Florida and from the very beginning his argument to me was, "Gee, I want nothing but quality in my State and I would appreciate your technical judgment as to the quality of that project." He was using me for my honest opinion, whether this was a first-class facility. First of all, I said I would give him my opinion.
>
> Second, I gave him my opinion. I said they have a very good and very promising computer-science capability. What they have in mind is very much what we are trying to do in stimulating supercomputers and I will continue to give my objective views on it. I did all the way along. There was no pork. It bore no resemblance to what was being done by the lobbying process. There was very careful comparison to other opportunities and other agencies.

I have two questions for you, given the fact that the Department of Energy kept on urging me to pick a fight with my good friend and able chairman, Mr. Fuqua, out of this subject and that the DOE did think this was a pork barrel project sidestepping the peer review process, what is the administration's policy on the peer review process and legislative attempts to sidestep it, and the second question I have, given your quote which I have read in its entirety, is what you are telling us in this magazine is that if a university hires a lobbying firm, that is pork, but if they are represented by you first, it isn't.

Dr. KEYWORTH. That is a very interesting interpretation.

First, I must say that I support peer review as a mechanism more today than I did when I was on the other side of the fence as a working scientist. It works. It is effective, and I think it is entirely the best we can do in our system of government, and I think that is superb. It works. It has led to excellence. I must also say in spite of a few twists of yours, your efforts in supporting this have been absolutely essential, and I believe they have been important in raising the level of public concern that we have seen expressed in these two examples.

You began by using the word "integrity" in science. The reason I answered C&E news in the way I did, I wanted to preserve my integrity, because it happens to be true. I don't believe I ever said that I was "used."

We were beginning an initiative to try to support a stronger science base in this country in supercomputers.

It was new and different and whenever we are starting new areas of science, not just biotechnology, but the science of supercomputers, we have to make it exactly clear what our basic objective is, and then the scientific response.

At the outset, it is occurring in many of the new areas of engineering.

In this particular case, I talked to dozens of university presidents around the country. They came to me, and I said we would be very encouraging of your university trying to use your best talent to come up with new proposals.

I didn't hear first of the proposal from the chairman but through the scientific channels of communication that we maintain. There was no aura to the best of my knowledge at any point in the Florida State project of pork. Excellence was the criteria. As far as the DOE responses, in my many years of experience with the Department of Energy, 17-plus years, 20-plus years, in fact, counting graduate school, I have been astonished at one thing and that is, it is far more dominated by the mentality of the legal profession. I do not mean to make a tax on the legal profession.

Policy at the Department of Energy is far more dominated by why we cannot do things under the law than it is how we can accommodate the spirit and the letter of the law and move forward.

I think the Department of Energy has found many, many impediments to resist change in science, in supercomputers, in this particular project, as well as in the way we use better our national laboratories, the Department of Energy and I don't mean the policy apparatus but the bureaucracy of the Department of Energy has made it in many ways difficult for us to best use the Federal laboratories. This was an exception. It was not pork to the best of my knowledge.

Mr. SENSENBRENNER. I don't think you answered my question, Dr. Keyworth. What concerns me is that the administration is now singing out of one hymn book and it is very hard for us on the other end of Pennsylvania Avenue to find out what administration policy is, if there is a Tower of Babel going on in the White House and the DOE, particularly those of us who are on the Republican side of the aisle and who are supposedly supposed to carry forth the administration's viewpoint.

One of the conclusions that was reached in the C&E news article is that your office does have poor communications with Congress and this is one very good example of that, when one part of the administration is telling me to pick a fight with my chairman, whom I respect quite greatly, and the other part is my administration is quoted as saying what I just quoted, and I would hope during the second Reagan administration the communications on this particular subject would be better than the first because it puts us Republicans in a potentially embarrassing position, and I am speaking as one who opposed the siting of the accelerator in Illinois which is in my region of the country because the peer review process urged that that be sited in Virginia, and I told my own university people and the representatives of my own region, that peer

review said it should be in Virginia, and that is where my vote will be and it was.

Either you got to be for the peer review process 100 or 0 percent, and I hope as these questions come up the administration will make its decision rather than having exceptions that might be based on factors other than peer review.

Thank you, Mr. Chairman.

Dr. KEYWORTH. I acknowledge the failure in communication, and for that I apologize.

I will maintain, however, that the Florida State facility clearly was reviewed by the peer review process, and we strongly support your actions in the past and hopefully your actions in the future in maintaining excellence as the priority, and I will make sure that these failures of communication do not occur from my side.

Mr. FUQUA. Mr. Ritter. Do you have any questions?

Mr. RITTER. There has been a lot of talk about how to further link the Federal R&D product with the needs of the American industry and the need to foster industrial competitiveness worldwide, and some small steps have been taken in that direction, by you and by people associated with you.

On the other hand, there is countertalk within the scientific community, that this kind of effort would distort the freedom and the essential objective thrust of science and basic research.

Could you comment on that, in view of perhaps a $52 billion Japanese investment in a place called Tsukuba which is driven by industries needs?

Dr. KEYWORTH. Few people have been more effective than you yourself in trying to narrow the gap between science and the application to technology.

You are asking a very fundamental question, because in the last 25 years, the course of advance in American science has been to isolate the pursuit of science from the application of science.

Now what we are proposing to do is to say that we are engaged in such intense economic competition, trade competition, that we are proposing to do, in a much more modified way what we did in the Second World War, and couple technology to, at that time, our military engine. We can't afford the luxury of growth in science. People resist change.

The scientific community is offering some resistance, although their common sense shows that we have to do this. I do not think American leadership in science is threatened at all. In fact, where I see the strongest links between industry and university, Carnegie Mellon, for example, Lehigh, RPI, Stanford, MIT, I see nothing but improvement in their standard of excellence.

If you wish, broadening the environment simply provides a greater intellectual challenge. So, yes, there will be some resistance from science but the country as a whole will benefit and the scientific community is beginning to realize that there will be benefits for them, too.

Mr. RITTER. Thank you. It would seem to me that what we have established in the massive committment of the Federal Government to basic research, science research and development, all of these categories, is that we have linked the R&D community in with a Federal economy, and I guess my concern is, whereas that is

essential in certain areas, is it possible to moderate that system, modify it somewhat, so that the concerns of industrial competitiveness which are so paramount in the minds of our competitor nations who are actually spending far less on R&D than we are, that those concerns get into the process.

How do we do more of this without encouraging a reaction within the community that feels defensive about this kind of situation? How do we build the bridges where we prioritize or defederalize the overall scientific establishment in this country?

Dr. KEYWORTH. Patiently and with good judgment, but what we are focusing upon here is a change in the attitude of Government. Over the last 25 years in the development of American science, the Government has played the dominant partner, the tough father, and the scientists have been the willing children.

What we are moving to is a change where government and industry, the user of technology and the primary employer of the talent coming out of the university process, as well as the universities, are going to be much more equal partners, is going to represent a much more equal arrangement.

In other words, I think government, and that means the entire process, has got to learn to accept a somewhat more passive role than it has in the past, and that is a tough change to wreak, but I also believe that the spirit of competition that is rising in America is forcing us to do this.

It is being accepted and I wouldn't worry about the attitudes in the scientific community.

The scientific spokesmen in Washington are very different than the 350,000 scientists and many times that number of engineers in the country.

Mr. RITTER. Thank you, Mr. Chairman.

Mr. FUQUA. Mr. Volkmer.

Mr. VOLKMER. Dr. Keyworth, as you point out the amount that is for the research and civilian sector, approximately $20 billion civilian R&D, does that lead me to believe that $40 billion is for defense R&D?

Dr. KEYWORTH. That is correct.

Mr. VOLKMER. There has been basically a freeze in the civilian R&D. What is the circumstance regarding defense R&D?

Dr. KEYWORTH. Defense R&D has been again increased very drastically. The President and Secretary Weinberger have made it very clear that the priority for defense is drawn by the Soviet Union's own steps, not by our own, and the President has chosen to keep that at the highest priority, and separate from the freeze on most domestic budgets.

I support that.

Mr. VOLKMER. Give me a percentage increase in defense R&D of 1986 over 1985?

Dr. KEYWORTH. Approximately 20 percent.

Mr. VOLKMER. I am not going to get into the policy decisions at this time.

One question we have, and we are trying to address on this committee through the Science Policy Study that is ongoing, whether the United States can or should continue its efforts to maintain scientific preeminence in all fields of science.

Reviewing your testimony, it seems to indicate that we should not. Do you agree with my conclusion as to your statement?

Dr. KEYWORTH. Not at all. What I am saying is that in science, as contrasted to research and development, I believe that America should aspire to leadership in all those areas where the promise is high, and I would accept nothing less than U.S. leadership in those areas.

I certainly believe that there are areas—for example, there may be areas of energy research, where the economic needs and time scales in other countries are different from our own, and I believe that it is to be expected, and we should accept the fact that other countries may accelerate those just as countries like Japan have different requirements for transportation, and therefore, transportation technologies may very well exceed our own.

In the basic sciences, I believe we should accept, and for that matter, we can afford to accept nothing less than being the best.

Mr. VOLKMER. My last question, as I view the administration's budget proposal for the NIH, it appears to me that there is only about 5,000 competing research grants. It is my understanding that the congressional intent is to fund 6,500 of those research grants.

Can you explain the reasoning behind that?

Dr. KEYWORTH. One year ago, we would not have used the word "only" in referring to 5,000 grants. Last year, the Congress chose to raise the grants up to 6,500. With the present austerity, we are proposing to take that enormous increase of last year and distribute it over 2 years; and in essence, we are also concerned about something other than austerity, so-called roller-coaster funding in science.

We are proposing, if we can distribute that huge increase over 1985 and 1986, that we will be able to maintain a stronger overall base in the biological sciences, that we will be able to do a better job of attracting top young people into a field that appears to be sustainably strong instead of suffering from roller-coaster funding.

Mr. VOLKMER. Philosophically, it appears that the administration believes that a 20-percent increase in defense R&D, in order to do research and development into weapons systems, is much more important than research and development into making sure we have a strong economic basis through new technologies, and also into the biological fields.

I come to that conclusion, because of the 20-percent increase in one and a flat zero in the other. Is that a valid conclusion?

Dr. KEYWORTH. First of all, in my own opinion, there is no question that Government's No. 1 responsibility is to defend its people. Life is more important than quality of life, but most of the defense R&D budget is development of new defensive weapons, not research, and when we look at the Nation's overall science base in order to compete effectively in the future, it is not $60 billion.

It is, if you wish, the basic end of the line that we call our national technology base, and that is what I am trying to focus upon here today.

Mr. FUQUA. Mr. Roe.

Mr. ROE. Thank you, Mr. Chairman.

I want to compliment you, Doctor, on a masochist's statement. I see two things, the first, the clarion call of concern, and the second

is that we meet the administration's call of austerity and get the job done.

For example, I comment from your statement on page 6:

> Mr. Chairman, we are challenged this year to balance two dominant priorities. One is to permit investment in our future by reducing Federal spending. The other is to assure a strong national science and technology base.

On page 13:

> The biological sciences stand on a brink of understanding that I can only liken to the brink that Einstein saw for physics in 1905. So it is fair to ask if we are developing the science base we need to reap the benefits that we foresee. Or will we, by remaining captive to past successes and hamstrung by a system of research support inadequately suited to the opportunities ahead, deny our people the advances in medicine and in new industries that others will capture by moving boldly ahead?
>
> Mr. Chairman, let me quickly summarize the points I have tried to make here this morning. Our proceedings are dominated by a need for austerity, and we have responded to that need. Because of strong administration and Congressional support over recent years, the programs for 1986 will enable American science to stay at the forefront.

Praise be the Lord for the Science and Technology Committee, because that is who fought the battle on the floor in the first place. We are coasting along a little bit. I am not criticizing the administration on that.

You speak of roller-coaster financing, which concerns us, and about policy, and what is coming out in your testimony, is budget policy. We speak specifically of quantity and quality of research, you made that point over and over again, and it puzzles me a little bit when we talk of the concern of funding, the concern of quality and quantity, what should take priority, and it doesn't speak to the issue in any great depth here.

What are our policies going to be, if we have to be austere and cut back? Where would you put the emphasis on quantity and quality?

Dr. KEYWORTH. One thing I can't let by, there is an implication which does not come from a correct perspective of the last 4 years, that the administration has come to the Congress with cuts in science, and the House Science and Technology Committee has restored them. That is false.

We have come with very strong increases in basic research for 4 years, and I believe that they have been met by bipartisan support.

Mr. ROE. I think the administration working with this committee has set that surplus at the moment.

Dr. KEYWORTH. Right; I think it is important for us to realize, right now, we are strengthened, we have had 4 years of increase, and what that means to a working scientist or a manager of science is the fact he is still putting into place some significant change.

And I am acknowledging, and I have worked with many of the agency departments and talked to a lot of people performing the work, with a year of no cuts but little growth, we believe some careful management decisions can be made that may actually be strengthening in themselves.

I am worried about the future. You ask, how do we determine quality? By judgment, and by judgment in setting priorities. There is no other way. I am raising numerous examples, the Superconducting Super Collider and others.

And I emphasized the biological sciences, and I cannot even distinguish because all the biological sciences are comparable. Perhaps neurobiology would be at the forefront in my own judgment. All of these have got to be pushed. We cannot allow pork to come into the process.

We have to make judgments, pick the best and allocate resources effectively.

Mr. ROE. What we are simply saying is OK, we have momentum now for 1986. We got to look beyond that, which you manifest your concern and during this 1986, 1985-86 year, we should be able to evaluate what we are doing, where we are going across the board, and what we are going to do.

If it takes more resources, we should deal with that. Is that what you are saying, basically?

Dr. KEYWORTH. Exactly.

Mr. FUQUA. Mr. Glickman.

Mr. GLICKMAN. I have a couple of questions, and one has to do with the Soviet-United States exchanges. What do you intend to do this year with respect to following up on scientific exchanges between the United States and the Soviet Union? How are you going to pursue those?

Dr. KEYWORTH. That is up to the Soviet Union in large measure. The President has told the Soviets that we might be interested in pursuing opportunities to collaborate in space, and we are waiting for a response from the Soviets on the already outstanding question of a rescue satellite.

We have got to realize that conduct, cooperation in science and technology is not separate from our overall relations with the Soviet Union, which since Poland, Afghanistan, have been at a low level. If we look forward to science and technology cooperation, we might look to the conduct at the Geneva arms control talks.

Mr. GLICKMAN. There is total linkage between United States-Soviet scientific exchanges and what happens in arms control?

Dr. KEYWORTH. Not total linkage. There is close linkage, and if we look back, since the Second World War, you will see the ups and downs, S&T cooperation corresponding to our highs and lows in foreign policies.

Mr. GLICKMAN. We have continuing agreements, and some have been allowed to lapse, and at this stage, I would encourage you to consider those with an open mind as they come up. I was in the Soviet Union and in some areas like in housing, medical-related issues, the benefits of mankind in general may outweigh linkage with specific arms control agreements, particularly if there is mutual benefit, like in cancer research.

And so, I just would hope that you keep an open mind.

Dr. KEYWORTH. We study these carefully. They are important. I am not sure I would want to have a terribly open mind about dealing with a country that is inherently adversarial in its form of government. I would want to keep a sharp mind.

Mr. GLICKMAN. I am not going to play a rhetorical game with you, but there may be some agreements there that may benefit us as well as the Soviet Union, and I would hate to see us shoot ourselves in the foot because of other reasons.

Kind of unrelated to what you are talking about, have you been asked to make a determination how a flattened income tax would affect scientific expenditures in this country?

Dr. KEYWORTH. I have talked to a few people, not so much about the flat income tax to citizens, but how the lack of R&D incentives or nature of R&D incentives to industry would influence it.

And what I have done in turn is try to talk to R&D leaders in American industry, and the response is not one of great concern. What they look at is whether the tax is disadvantageous to the productive sector of our economy or to the consumption sector of our economy.

That is the fundamental ball that they keep their eye on. The various schemes for flat taxes represent a——

Mr. GLICKMAN. You have not made any studies on the R&D credits, investment tax credit would affect the expenditure of funds on scientific exchanges in this country.

Dr. KEYWORTH. It took us 3 years before we could begin to really have data to understand what the accelerated depreciation, for example, introduced in 1981, did for R&D, and we are now beginning to see that clearly.

Mr. GLICKMAN. Two more things.

I compliment you on the aeronautics budget. I think that you have recommended numbers that I think the committee can live with, and I appreciate the fact that the administration has accepted the fact there is a real scientific role in preserving the basic and some other kind of research in aeronautics issues.

Thank you, Mr. Chairman.

Mr. FUQUA. Dr. Slaughter.

Mr. SLAUGHTER. What are the prospects of moving forward on the continuous electron beam accelerator in Newport News, VA?

Dr. KEYWORTH. Very few projects have received as extensive and critical scientific peer review as this project has. I believe if the United States is to maintain leadership in an extremely important field that is today thoroughly revitalized, nuclear physics, we must move ahead on this facility as exploring the options for relativistic ions at the Brookhaven project.

From my vantage point, no major facility has a priority greater than the CEBAF should. We have introduced it. It is in this budget, in spite of our desire to constrain new starts, and I feel, I feel we should get on with the task, and I think the prospects are very high, and I ask for you all to carefully examine the importance of this project, and to try to filter the extreme noise within the scientific community that around this project are an awful lot of have-nots.

Mr. FUQUA. Mr. Boehlert.

Mr. BOEHLERT. Dr. Keyworth, is there any conscious effort within the administration to encourage in a bland way the commercialization of the technological breakthroughs anticipated from a heavy R&D into SDI?

Dr. KEYWORTH. Very much so, and that is something we are very much involved in right now. We are trying, for example, to carry out more and more of the research in SDI as it begins to take shape in firms that are different than the traditional defense contracts. We are trying to introduce, for one thing, an element of

speed here. This is a research project, and we are trying to draw upon entrepreneural firms. We are trying to draw upon other sectors of our industry than the traditional aerospace. We are trying to get universities linked with industries in trying to pursue some of the fundamental research that underlies this.

So I think that it is and will continue to take on the nature of the Apollo project in these years in terms of post-Sputnik years, in terms of fueling our engine. I think we have an exciting plan here.

Mr. BOEHLERT. Would you have your staff get me more information on that question?

Dr. KEYWORTH. Certainly.

Mr. BOEHLERT. Second, on the student loan programs in this budget for fiscal year 1986 as proposed, are you concerned that a lessening of the commitment on the part of the Federal Government for these various student loan programs for the scientists and engineers, that we need to maintain our preeminent position in technology?

Dr. KEYWORTH. Not at all. I do not think that is a concern. What we have done, of course, is to elevate the threshold for qualification for these student loans. We see no sign, and I have talked to a large number of university presidents, that this will occur.

Instead I think we are seeing something else which I think is even more important to our society. We are seeing parents go back and accept educating their children as a truly fundamental responsibility. I think that is healthy, and I think it is bringing us together and allowing us to become a more competitive society as we move in this direction.

Mr. BOEHLERT. You can say that in view of the fact that schools like Yale are now charging $15,000 a year for tuition, room, and board, and the average American family is probably making just over that figure?

Dr. KEYWORTH. You know actually, Mr. Boehlert, I think that is really in essence better testimony to why we should maintain the President's steps in 1981 for tax indexing than any other. I graduated from Yale, and just last year I took from my alumni magazine the tuition at that point, which is about $14,000 and divided it by the inflation that had occurred since I was an undergraduate, and do you know that it was almost exactly the same sum. The reason it has become somewhat more difficult for parents to accommodate is simply because people have moved into higher income brackets; $15,000 is a lot of money for tuition, no question, and for families whose income is $15,000, there is no question whether they will qualify for student loans.

But when they are two and more times that, that is another question. What we are saying is that people should target and save in order to support their kids in college.

Mr. BOEHLERT. Excuse the observation, but I don't think that is the real world.

One further question. What is the status of this computer center's initiative that we established in last year's NSF authorization?

Dr. KEYWORTH. One last comment. It may not be the real world, but I think university presidents speak more to the real world than we do, and I have talked to large numbers of university presidents,

and they certainly are not worried about being able to draw the best talent into science and engineering. I think that is the real world.

Now, as far as the supercomputer initiative we are continuing strong thrusts in many different agencies, the National Science Foundation will be certainly continuing their efforts to broaden access and to build a stronger science base. The increase is approximately $4 million, as I recollect, in the Department of Energy, we will be continuing strong programs.

The Department of Defense, with probably the broadest program from most fundamentals and artificial intelligence all the way out to fundamental mathematics, here we will be also continuing. It is probably a slower growth rate than would have occurred in zero-deficit times, but I think it is a very healthy growth rate.

Mr. BOEHLERT. Thank you.

Thank you, Mr. Chairman.

Mr. FUQUA. Mr. Nelson.

Mr. NELSON. Thank you, Mr. Chairman.

Good morning, Dr. Keyworth.

Originally it was thought that the administration would put in an item for the space station of $280 million in this budget, and it is an item of $230 million up from $150 million in this present fiscal year.

Does that presuppose that we are going to see a stretch-out of the planning, design and construction of the space station so that we are not going to be able to hit our target for 1992?

Dr. KEYWORTH. I think it does represent a delay in itself of about 6 months, but I think the positive thing to us and to many people, I believe, is that we are now beginning to see what has long been missing which is a clearer and clearer definition of exactly what role a space station will play, what the space station will be. I think we can move from a perspective a few years ago, as sort of a motel in the sky, into now a promising opportunity for research, for development and for new space opportunities.

I think this delay of 6 months is healthy, and I think by the time we get to 1992, it will very much be lost in the backward perspective.

Mr. NELSON. Thank you.

Let me ask you this. There has been some talk about a so-called science czar which is a Cabinet-level position. Do you all have anything in the works on that?

Dr. KEYWORTH. No; as you probably know, the President's Commission on Industrial Competitiveness has proposed formation of a Department of Science and Technology to encompass most of the nondefense R&D activities. That, in a sense, could be the science czar.

Myself, I found it difficult to understand a lot of questions about having a science czar, other than one who has line control as a department head does, because I certainly haven't found any difficulty in the last few years that I have been here in achieving the President's strong support for this area and for our proposals, so I think direction should be focused on the question of linking line management with policy development, not so much whether the czar status is in large letters or small letters.

Mr. NELSON. Thank you.
Thank you, Mr. Chairman.
Mr. FUQUA. Thank you. Mr. Lujan.
Mr. LUJAN. Thank you, Mr. Chairman.

I think you have done a marvelous job in the funding and promoting of science within the administration. These last years that you have been there certainly have shown your dedication to it.

You have said in an article that technology and talent are the two competitive advantages that we have over the rest of the world, and following up a little bit on Bill's question on the Department of Science and Technology, you are a member of the President's Committee on Competitiveness, and that group did recommend a Department of Science and Technology, is that correct?

Dr. KEYWORTH. Yes; they did.

Mr. LUJAN. Are you saying that probably nothing will happen?

Dr. KEYWORTH. No; I am certainly not. The decision so far by our administration has been at a time when we are trying to spend our efforts to work on controlling a devastatingly growing deficit is not the time to be coming up here with a proposal on Department of Science and Technology. Let's wait until we are over this hurdle, and then let's talk about it, and we are doing exactly that, talking, now.

The Commission just reported to the President 2 weeks ago, and we simply have not had time to really evaluate the pluses and minuses. It is rather complicated.

Mr. LUJAN. I have two other quick questions. One of the things we discussed before that I am troubled with is the question of energy. We certainly have a surplus of electrical energy right now, but as we look down into the 1990's, that is going to disappear, and we have got to start thinking of ways to meet that need.

Let me just kind of tell you the things that run through my mind. We cannot continue these terribly expensive nuclear powerplants. It looks like we are going in the same direction with fusion, that we are just looking at large, large plants.

It seems to me like we are not really doing anything past the time when we finish the ones that are now in process, and when we are through building all of those, we are just going to be sitting there with our arms folded and say, "Well, what do we do from now on?" It seems to me that we ought to start looking at that problem now.

Can you give us some insight into that?

Dr. KEYWORTH. Yes, we are most certainly looking at this daily right now.

I think we are seeing a change in our overall perspective. If you look back a few years ago, the principal Government role in energy development 10 years ago was to emphasize the long-term opportunities. Fusion, breeder technology, for example, today we are looking at a different challenge. That one too, but we are looking at a near-term challenge.

With the kind of economic growth that the economists I prefer to read are proposing for the next decade, clearly we are going to face a time sooner than 10 years from now when we are going to need to expand our electrical generating capacities. The utilities are accepting the fact that they are going to have to use turbines.

Mr. LUJAN. I was thinking of small things.

Dr. KEYWORTH. I will come to that. The utilities are accepting the fact that they are going to have to use turbines, and I think that is deplorable because it is so terribly inefficient and expensive.

I think it is clear we have two options in the near term, coal and nuclear. What we are doing and have been doing for the last year is to work with utilities and nuclear energy to see if we can't find a way of allowing the utilities to order a nuclear powerplant, say, by the end of this decade, and that means making smaller plants, higher quality, best of technology incorporated, and it means streamlining and making more rational the regulatory process.

We have some work before us. I think the utilities are ready. I also think, incidentally, they have introduced an example that anyone who has not looked at it I think might do so. It was very valuable to me. INPO, the Institute for Nuclear Power Operation, a step that the utilities took following the Three Mile Island incident, to simply elevate the quality of nuclear plant operation in America, it is one of the most outstanding efforts I have ever seen in my life. It is absolutely superb. It is a mechanism for self regulation.

Now, as far as fusion goes, and I believe that model can be carried over and I believe they are pushing, in fusion we have reached a stalemate. It is very difficult to justify a $2 billion experiment if it is just the next step along a long line of fusion developments.

On the other hand, there are some very interesting opportunities to explore smaller fusion device concepts focusing upon high density and upon getting burn to the extent that we have the so-called ash or alpha particles disturbing the plasma. And I think it is time to take a careful new look. I think we had the wrong kind of momentum in the program, and I think we are taking a careful look in terms of the science and new experimental facility options.

Mr. LUJAN. Thank you very much.

Mr. FUQUA. Thank you. Mr. Monson.

Mr. MONSON. Thank you, Mr. Chairman.

Dr. Keyworth, many States, at least my own in Utah has a similar position within the State government of a science adviser to yourself in the Federal Government. I am just wondering how these entities relate to each other, your entity and those entities with States that have similar positions, and if we do proceed in terms of centralizing that, you spoke of how you would see that relationship continuing to develop.

Dr. KEYWORTH. That is an interesting question and one that is certainly in a state of change. When I first came here 4 years ago, there was a formal mechanism that was used to deal with people in my position in States as well as others involved throughout the State in advisement of science and technology. It is primarily communication exchange, literally written words.

As the country has become more and more competitive in the last few years, I find that I simply know more and more people in each and every State who are working exactly the same problems that we are, especially the problem of how to couple better industry with universities and how to bring advances in technology into their own State for literally new jobs.

And I find that we have a good but informal link with many States in the Union, probably half the States, and I think it is working very well. But I suspect that I could come here next year and raise that number half to probably 85 percent because I think it is moving at that rate. I think it is very exciting, and the way it occurs in a somewhat spontaneous fashion is exciting.

Mr. MONSON. Are you saying that there is some duplication that exists right now between the Federal Government and State governments in that regard?

Dr. KEYWORTH. I wouldn't call it duplication. I would say that there is execution on the State level and amplification of a lot of the thrusts that we are trying to respond to, and the point is, and we are both responding to the same thing. I don't think it is a question of Federal Government leading as much as responding to a trend and encouraging it.

I don't think there is any redundancy at all. I think it is just plain reinforcement.

Mr. MONSON. And if we do proceed to centralize, as I believe you called it, do you see that the need for those offices will diminish, or will they be of equal importance or perhaps even higher?

Dr. KEYWORTH. I don't think we should look at centralizing that concept. All we have been talking about is the fact that we support the Federal R&D role in about a dozen different agencies and departments. What we are really saying is that it is very difficult to maintain a coherent policy, especially as you try to effect more and more change. So it is simply centralization in terms of the Government role.

As far as the states' role, I think that that role will simply expand more rapidly than the Federal Government role does because it responds more rapidly to increasing public expectations and dependence upon science and technology. I think they go very much hand in hand.

Mr. MONSON. In terms of the different agencies and the R&D role that they have that you have oversight over, have you summarized the Grace Commission recommendations as it pertained to those various agencies in the R&D role in the dollar amount that they concluded was available in savings?

Dr. KEYWORTH. Not specifically. They emphasize two particular thrusts in R&D. One is emphasize basic research, especially universities. Secondly, take a hard look at the Federal laboratories and see if we can't make them even more effective than they have been. Both of those are areas of clear commonality and parallelism.

We have been doing that, and as far as detailed agency-by-agency efficiencies, it is hard to extract the R&D from the agency mission in their recommendations.

Mr. MONSON. Thank you.

Mr. FUQUA. Mrs. Meyers.

Ms. MEYERS. I have three questions, Mr. Chairman, a couple that I would like to ask and one that I would like to ask for another committee members whose time ran out. Let me just say the three questions quickly and then let Dr. Keyworth answer them.

One, from your remarks, you have indicated that we have frozen nondefense R&D and basic research. We know what is happening with student loans. What can we as a government do to encourage

our talent? You have said that we have two things that will keep us ahead in industry, technology and talent. What can we as a government do to continue encouraging our talent?

The second question is, What is happening? What are we as a government doing to encourage basic research in the area of the disposal of nuclear waste?

And then the third question, the Defense Department has been quite outspoken in their requirement for expendable launch vehicles as a backup for the shuttle. Does this undermine the shuttle program?

Dr. KEYWORTH. What can we do to encourage talent first and foremost. I think there is nothing we can do more important than emphasizing basic research and emphasizing particularly the most important basic research. So certainly emphasizing creativity, if you wish, is the strongest attraction we can provide, I believe.

Second, basic research and nuclear waste. First of all, I really think we know how to deal with the nuclear waste problem technically. There is certainly an interesting question of ceramics or vitrification as far as the optimum means of disposal, but I think most of the research is done. The question now is if you wish a sociopolitical question of how to accommodate this, regulate it and individual States' roles and decisions, but I don't think that is at this point a scientifically challenging task.

As far as the ELV's go, as you know, the President has very much encouraged the Department of Defense to develop and maintain the ELV [expendable launch vehicle], capability, and I think it represents no threat at all. In fact, I would go so far as I think it represents a support for space and for the shuttle specifically.

First of all, the shuttle is a manned, highly flexible vehicle. It is our flagship, no question. But I think the ELV's represent a means to carry out expanding defense needs, an opportunity to have multiple fleet, if you wish, more than one vehicle in the garage, so to speak, and also, maybe most importantly of all, it represents a means by which the private sector can ultimately get involved in providing competitive launch services to compete with the area on.

So I think the Defense Department's step to meet their own needs is one that is extremely healthy for our overall space program and to look at it as a threat to the shuttle I think is to bring back the days of the 1970's. I don't think the shuttle is the least bit threatened. It is our flagship. It works. We are proud of it, and it is well funded.

Ms. MEYERS. If I have another minute, Mr. Chairman, I will do one followup question.

You say that in disposal of nuclear waste that the research is done. Has it been proven? In other words, where has it been or where do we have an example of the fact that this truly works?

Dr. KEYWORTH. Your question goes really to the heart of the matter. We have an enormous amount of data, for example, from a Nevada test site and years of monitoring flow in known geology. That is important.

But one of the difficulties in dealing with the potential hazards of nuclear waste is the fact that we are worried about effects hundreds, even thousands of years from now, and it cannot be proven, if you wish, except in a scientific sense until we wait that length of

time. I believe there is extremely high confidence that we can handle the problem of nuclear waste. Other countries are doing it and are doing it successfully, and I simply do not think the problems are scientific and technical any more.

Mr. FUQUA. Mr. Walgren.

Mr. WALGREN. Thank you, Mr. Chairman.

Dr. Keyworth, as you know, OMB has directed the NIH to forward fund a number of biomedical research grants that will result in less than 6,500 grants that were expected by the Congress, as I am sure you know, and as I understand it was endorsed by the administration prior to election.

They have ordered OMB to forward fund those so that the money that is available will not cover 6,500 but will only cover 5,000. My question is, What is their power to do that?

Dr. KEYWORTH. First of all, I don't think this was done by OMB in an arbitrary fashion. Certainly from our perspective and involvement in this, we are looking forward at the ability to attract the best talent in America in the biomedical sciences.

Mr. WALGREN. You say it wasn't done in an arbitrary fashion. Could I just ask what the raw power, what the structural authority is of OMB to make that determination, and then when does your office review their decision?

Dr. KEYWORTH. We are a relatively small operation compared to the rest of Government and the White House. Our formal structures are few, fortunately. We have many, many mechanisms for, if you wish, hearings. Ultimately in the budget process, as you know, we have a budget review process that ultimately goes to the President. We interface with OMB in the most informal fashion on an almost day-to-day basis. I talked to David Stockman, for example, or other members of OMB and our staffs constantly interplay. There were no surprises here.

Mr. WALGREN. Now, OMB made this decision, and I gather when they came to you and knew they were coming to somebody who believes that you can only liken the present potential of biomedical research to the brink that Einstein saw in his physics in 1905, they came to somebody who would not like to see those 6,500 grants reduced.

Now, assuming OMB made that decision, what are your remedies then? Did you, at that point, support David Stockman in his decision, or were you able to express a reservation to any other level of the administration other than OMB?

Dr. KEYWORTH. Mr. Congressman, I can't answer that question without you allowing me to go back to the answer that you truncated at the outset. The objective here is to maintain the field of science, not to measure its quality simply in terms of the number of grants. We said that an increase of nearly 2,000 grants in 1 year, nearly a 35-percent increase, simply represented roller-coaster funding, and if we could maintain that steady increase from 1985 into 1986, then we would be able to attract better scientists and maintain a healthier field.

Mr. WALGREN. So I take that to mean that you then agreed with the OMB decision on the grounds that you wanted to maintain a steady level of funding in biomedical research.

Dr. KEYWORTH. It is not a steady level of grants, it is an increase. We started in 1984 with 4,200 grants.

Mr. WALGREN. Is it your view of the past that there has been any diminution of support for biomedical research?

Dr. KEYWORTH. I certainly am worried about—

Mr. WALGREN. And if there has been none in the past, would you reasonably anticipate the Congress withdrawing from that level of support for bio——

Dr. KEYWORTH. Would you like me to answer the question? Now the question to me addresses diminution of support for the biomedical sciences and the implications that we are going to lose leadership in this field. I don't think that is the case at all.

I do think we have some fundamental problems. I think NIH has not been treated over the last 10 or 20 years the way other areas of science have. It has been treated differently by the executive branch and differently by the legislative branch. Most of the changes in funding that have occurred have occurred here in the legislative branch of Government.

One of our concerns is the difficulty in establishing priorities. If I want to emphasize, for example, immunology or microbiology, how do we do it? The problem, Mr. Congressman, is much bigger than counting grants, and that is the challenge we have got to cope with.

Mr. WALGREN. Thank you, Mr. Chairman.

Mr. FUQUA. Dr. Keyworth, we have a Democratic caucus, and we are going to have to break for it. Mr. Lujan is going to take over the committee. We have three members, Mr. Hall and Mr. Traficant and Mr. McCurdy. Do you have questions that you can submit in writing?

Mr. HALL. I have a very brief question, 5 or 10 minutes.

Mr. FUQUA. Make it brief.

Mr. HALL. Dr. Keyworth, I think you are doing an excellent job of overcoming your Yale background. If I understood your statement, the college presidents reflect the real thinking of the world, you are spending too much time with Stockman or something.

Seriously, did I understand that out of context, were you referring only to the tuition?

Dr. KEYWORTH. Only to the world of tuition. I think college presidents are as far away from the real world, in general, as any group I know.

Mr. HALL. As we are from the scholarly world.

Dr. KEYWORTH. Farther. Farther.

Mr. HALL. Let me ask you. McArthur told the Japanese after World War II that they could no longer make war, and they said, "OK, we will make radios, we will make televisions, we will make automobiles," and now they are looking skyward. Seriously, what are we doing with regard to aeronautics, NASA, or DOD to keep us competitive, technical aspects and the field of research? Because if they are the threat to us from aircraft manufacturing that they have been in the very successful ventures in the automotive field, we are in real trouble. Are we doing anything to combat that, and if so, what?

Dr. KEYWORTH. I think we are responding very much so. We established about 3 years ago in our office an aeronautics review

panel to look forward and give us a strength of strategic recommendations, and they are now concluding to me it is a very important report, and they are pointing out three major steps that will logically occur.

One is the all composite aircraft. The second is, if you wish, the supersonic transport, and by the way that situation is very much changed from the early 1970's because of East-West trade—excuse me—because of trade with a specific base enhancing so greatly. And, third, is very much farther in time, is the so-called space plane and our flight to Tokyo, for example, suborbital.

Mr. HALL. You have a study that you can refer me to, and I won't take any more of your time.

Dr. KEYWORTH. Jack Steiner, the architect of the 727, chairs it, and it is just about completed.

Along with that, we have supported strong aeronautic research and technology in NASA, and that is in this budget.

Second, there is a very aggressive program in the Department of Defense in many corners to support leading edge research in aeronautics for their own needs, but that doesn't mean I am so confident that we are going to win. We have a lot of work to do.

Mr. HALL. Thank you, Doctor.

Mr. FUQUA. Mr. Traficant.

Mr. TRAFICANT. I have a question relative to coal gasification. What is the policy now, and what pursuits are we taking to perhaps utilize coal more aggressively in our energy needs in the future?

Dr. KEYWORTH. Our principal approach to the near-term technology, coal gasification, for example, have been to let the marketplace create the demands that will drive the technology and develop the utilization. We have continued to do some of the more fundamental research that could support increased dependence upon coal for gasification and liquification.

But our basic policy has very much been to reintroduce the market forces that we feel were diminished in a devastating way in the 1970's.

Mr. TRAFICANT. Very good.

One other thing is to the best of your knowlege, where are we now buying our high-performance computers and parts now on a percentage? What percentage of our purchases, the U.S. Government, are made from foreign entities?

Dr. KEYWORTH. The percentage right now of truly high-performance computers is almost entirely the United States. The concern about Japanese supercomputers is one that has preceded supply, but it is now justified. Several Japanese companies are making highly competitive leading edge supercomputers. So I am not sure what my answer would be to you a year or two from now.

Mr. TRAFICANT. Finally, in the research and development area, the Japanese have certainly put a lot more of their money to that purpose. Do you particularly feel that that is one of the reasons why they are ahead and, second of all, maybe in line with that, is the administration's view on the high tech aspects into the private sector perhaps with industry in helping to modernize, for example, the steel industry, which seems to fall behind some of the foreign

competitors? What are the policies there, and what are the programs and targets?

Dr. KEYWORTH. Your first question, what about the huge Japanese investments? Japanese investments are centralized and easy to identify; it is a bit more awkward for us to try to find exactly what the investments that are being made are because it is hard, for example, to fractionate IBM's overall R&D investment. I think we are investing enough money to stay ahead.

The question is whether we are spending that money in a redundant fashion or not, and I think that the sense of competition that I have seen creeping in in the last 4 years is driving a lot of cooperative ventures to prevent exactly that redundancy. So if we can keep this up, I have no doubts that we will remain in the lead. But that should not be taken as a complacency.

Mr. TRAFICANT. In the steel industry, what can we do there?

Dr. KEYWORTH. The steel industry is something else. My own efforts have been to try to couple the talent in the U.S. science and technology base to a troubled industry whose own research and development capability has diminished. The steel industry is an exciting one to me because there really does appear to be an opportunity to make a leapfrog advance in technology, to manufacture steel and manufacture chemicals, raw material on the one end and product out the other end.

As we looked, we found that in the Federal laboratories resided most of the real expertise in trying to address this problem, and so we tried to bring the steel companies, via a cooperative mechanism, the Iron & Steel Institute together with the national labs to try to, if you wish, jointly address those problems, and that is an effort that is continuing. It is a fine line because such an effort could easily become a disaster in my opinion if we had Government program managers deciding what is good for the steel industry.

On the other hand, in this case, the steel industry is serving as the program manager, and what we are using from the Federal laboratories is the talent, and I think it is an excellent partnership that we need to look at carefully in the future.

Mr. TRAFICANT. Thank you, Doctor.

Mr. LUJAN [presiding]. Mr. Lewis.

Mr. LEWIS. Thank you, Mr. Chairman.

Dr. Keyworth, what is being done for the implementation of the 1984 National Critical Materials Act?

Dr. KEYWORTH. We have, as you know, established a Committee on Materials, the Interagency Coordinating Committee. I recently placed as chairman of that group Dr. McTague, a new deputy in my office, who is one of the most distinguished materials scientists in the country. It is now a vigorous, active effort to try to draw upon advances in technology to address our national materials needs and opportunities. I think it is working very well.

Now, you know we have had some very drastic changes in underlying science in the last 5 years. Today the prospects for ceramics, literally structural materials, are extremely exciting. They were almost nonexistent just a few years ago, so the science has been very much changing, and I think I can say to you now I think we are structured in a way to carry out our responsibility effectively.

Mr. LEWIS. Since this calls for a collaboration between OSTP and OMB, what is the best way to structure that collaboration?

Dr. KEYWORTH. As a Cabinet Council group and as COMAD, we work very closely with OMB and in a very constructive way.

I must admit that the Council, itself, has not at this time been established, but I would certainly claim that the process we have in place is meeting the needs requirements and the objectives that a lot was demanded.

Mr. LEWIS. Following up on a previous question on aeronautics, can you explain why NASA zeroed out the composite primary structures in the budget and that sort of thing?

Dr. KEYWORTH. I am not certain why NASA chose to do it, but let me offer you my own view on why that was not inappropriate.

This is an enormous effort in the Department of Defense, larger than appears in the development of composite technologies and large structures, and I think within the priority setting in NASA it was clear that DOD was really driving the leading edge in that area, and NASA could play a better role in other areas.

Mr. LEWIS. I would like to also follow up on one of Mrs. Meyer's primary questions on exercising our talent in the areas of science. What do you think the Government can do to promote science and math in our educational system? You did work on this last year, and you did come around and work with us on the science and math bill. I would like you to elaborate, if you will.

Dr. KEYWORTH. Certainly. As we look back over the last four years, nothing any of us could have done will have had as much impact as I believe that National Commission on Excellence in Education had in simply elevating education in public priority. I think that was monumental. In a sense, we are responding to that elevated priority now.

In the National Science Foundation particularly, we have very much strengthened the effort, top national talent, and we are trying to continue to devise new means. One of the ones that I am most excited about is a program of centers and institutes with industrial universities and secondary school teachers, high school teachers, to improve teaching and curricula, but most importantly develop a feedback loop where new ideas will be developed with representatives of each of those.

Teachers go back and try them and come back a year and speak to the successes and failures. We want to build some institutes that would repesent major educational research facilities and then have centers around the country to hopefully benefit from that experience.

But no, I don't think any Federal agency is going to have a very large overall dollar role in improving science and math education. We are trying to use the NSF's relatively small dollars as a very, very high level, and I am quite excited about some of the opportunities that are emerging.

Mr. LEWIS. Thank you.

One final note, Mr. Chairman. I have no problem with the supercomputer in Florida State.

Thank you.

Mr. LUJAN. Mr. Morrison.

Mr. MORRISON. Dr. Keyworth, I appreciate the interest of your office in the beneficial uses of nuclear technology, particularly one that I am interested in, food irradiation. You established a committee on interagency policy coordination, and I understand from some of their initial efforts that food irradiation came out on a list of 10 at about No. 6, which is fine.

I just wondered if you could give the committee an update on whether this particular committee, your interagency committee, happens to be; how it is working and any views that you might have on the opportunity to advance the cause of food irradiation as a technology?

Dr. KEYWORTH. I think the coordinating mechanism is working quite well in this case, and I think a lot of the participants and the Food and Drug Administration, for example, and regulatory agencies have been elevating their priorities here.

As you well know, Mr. Morrison, there has been really some red herrings in our understanding of food irradiation, the particular one being the interpretation that there is some toxic byproduct that is produced by food irradiation and that simply is not the case as we now know. I think we can look forward to—I guess, what I am trying to say is that the risk assessment of this problem is becoming scientifically based, more rational and will lead in an orderly fashion to a more orderly process of FDA's allowing more and more products to be preserved by this important technology.

I think we are coming out of sort of a middle age treatment of a rather sophisticated technology into some maturity. Other countries, as you know, even some undeveloped countries have bought technology from the West to preservation of seeds, for example, through irradiation.

Mr. MORRISON. Thank you. I agree this is one arena where we have let some sort of phobia keep us from using the technology that we developed ourselves. In the same regard, it appears that there is a substantial shortfall of available source materials for irradiation programs.

Canada controls the supplies of cobalt 60 and even if we released all the cesium 137 that we have separated out from our defense nuclear wastes that would only last about a year. The question is, Do you foresee this country in the near future pursuing efforts to extract new source byproduct material such as cesium form the nuclear fuel cycle?

Dr. KEYWORTH. I have had, albeit small, but a number of people seeking either to expand small industries or develop new ones to develop new source technologies. And I have listened to both their own assessment of the market and to their own perception of the impediments in government, because this is an area that is extremely tightly regulated as it should be.

I think there are some interesting opportunities and I am not sure they are going to directly confront the advantages that Canada has in cobalt 60, but certainly you mentioned a very exciting one, cesium 137 as an option.

I think we in Government have got to do everything to encourage these entrepreneural efforts to take new aproaches to a lot of resources along with meeting the obvious, but scientifically well-understood regulatory necessities.

Mr. MORRISON. I would just like to share with you that private enterprise is very enthusiastic about getting into irradiation and now are irradiating, of course, a tremendous volume of the medical supplies that are used. We are very frustrated because we are looking to the use of cesium, which we own as taxpayers, but we find—the latest list finds that it is oversubscribed.

We have about 50 million curies available and 128 million curies have been requested by private enterprise. So there is a need in this area, and I look forward to working with your agency committee in this regard.

Mr. Chairman, I would like to ask permission to submit one other question in writing and would also comment that you look very good in the chairman's seat.

Mr. LUJAN. We have our job cut out for us in the next session of Congress. I enjoy this seat.

My colleague from New Mexico, Joe Skeen, we will make it an all New Mexico panel here.

Mr. SKEEN. This is New Mexico day here, Jay.

Before I begin, Mr. Chairman, I would like to say I appreciate very much the courtesy that the chairman and you, the new chairman, have extended to me, and I would ask your indulgence. I would like to ask Jay one question.

Dr. Keyworth, it is always a pleasure to hear you testify up here, and I think it is a testament to your expertise that you wore out all the majority, and they had to leave. You have done a fine job.

The question I would like to ask you about is the Very Long Baseline Array. We have authorized some $15 million in fiscal year 1985. Also, Mr. Chairman, before I forget it, I have no less interest since I have scooted over to appropriations. And I want to assure you that you have a great advocate here, and that is one of the reasons I am here today, because I wanted to hear Dr. Keyworth's testimony on the proposed budget and items.

And I certainly intend to be an advocate for this committee. Speaking about the $15 million that was authorized in fiscal year 1985, and the National Academy of Science still holds this as probably the highest priority major new program for ground-based astronomy in the eighties. We have expended $2 million, and I would like your opinion.

Has this had any adverse effect on the program itself, or do you see any adversity because of the slow promotion of this particular program?

Dr. KEYWORTH. I think the VLBA could have gone ahead faster than it has. There has been delay. On the other hand, there is no question that the VLBA is going to be built, and it is going to be a leading facility, I would emphasize in support of the Academy's observations. I know of no new facilities that represent the kind of leverage per dollar that this does.

I think this, along with the space telescope and now the very exciting large telescope that actually is going to be built with private funds in California, some $75 million, I think, clearly shows that here is an area of science that the United States will be in the lead of until beyond the end of the century. There is no question.

I think it is unfortunate when the VLBA has gotten tied up in other considerations and used as a lever in other areas. I think it is a gem and should remain a gem by itself.

Mr. SKEEN. Thank you. Mr. Chairman, I just hope that the testimony and responses are as absorbing over on appropriations as they were here today. You did very well, Jay. It is good to see you both and look forward to a further visit.

Thank you very much, Mr. Chairman and members of the committee, I appreciate your indulgence.

Mr. LUJAN. Thank you very much for being with us. We know you have been a leader in promoting all of the science programs and technology programs. And we are glad you are because you will keep this country in the forefront of technology.

Dr. KEYWORTH. Thank you so much.

Mr. RITTER. Mr. Chairman, could I just quote, Dr. Keyworth, from an article that he has written for "Technology Review."

Mr. LUJAN. All right.

Mr. RITTER. I think it is very important and perhaps summarizes some of the things that we have been talking about today. In an article that appeared in an issue of MIT's alumni publication, "Technology Review," there is a comment of yours that I think is very instructive.

> We are in real danger of letting other countries assume the industrial lead in profitable new fields of technology that American scientists have done most to establish, and that American taxpayers have underwritten. We continue to be the world leader in big science and other nations take advantage of that big science to apply to technologies that we see in industry after industry, a loss of America's industrial competitiveness.

My colleague from Washington State, I think, made an excellent comment when he said in certain areas, phobias are keeping us from using technologies that we have developed ourselves, and that other countries are using these. And I guess my point is that this committee and the science community has an obligation beyond just the fomenting of the science establishment and part of that is an industrial competitiveness.

Part of that is in a better science base to our regulatory process, and frankly, if we continue simply along the path which has led us to many Nobel Prizes—Britain also has many Nobel Prizes per capita—we are going to continue to lose that industrial competitiveness in industry after industry. And we are going to continue to see major industries and technologies that we have developed go unused, underused, and exempt outside of the world competitive arena if we don't get our act together on this regulatory side of the program.

Mr. LUJAN. Thank you very much.

By unanimous consent, I would put into the record my opening statement following the chairman's. Thank you very much.

Dr. KEYWORTH. Thank you.

[Whereupon, at 11:25 a.m., the hearing was adjourned.]

Questions and answers submitted for the record follow:]

STEEL INDUSTRY

QUESTION: What is the Federal role going to be with regard to research, development, and modernization in the steel industry?

a. What is the steel budget and mission of DOE and its national laboratories?

b. What is NSF's budget and mission for steel research?

c. What is NBS's budget and mission for steel research?

d. How will these and other Federal efforts be coordinated?

ANSWER: a. DOE has obligated or expended about $37M on steel research (since about FY'84). The work is cooperative with the steel industry, including participation by U.S. Steel, Bethlehem, Westinghouse, Armco, and the American Iron and Steel Institute, and includes cost sharing by industry. Several DOE labs are involved in the work, including Los Alamos, Idaho National Engineering Lab, and Pacific Northwest Lab.

The projects funded include work in direct reduction of iron, oxygen production, thin strip casting, sensors, and high temperature recuperators.

Most of DOE's steel research work is aimed at improving the energy efficiency of the steelmaking process.

b. NSF's current budget for steel research is about $2.4M. About $1.5M of this is in basic research in the physical metallurgy of steel. About $900K is in process engineering research, including the support of two industry-university cooperative research centers--one in iron and steelmaking at Carnegie-Mellon University, and one (not yet awarded) in steel processing at Colorado School of Mines. NSF's mission in steel research is to fund basic scientific and engineering research of the highest quality.

c. NBS is spending about $1M/year to assist in the development of standards and measuring techniques for the steel industry. Much of NBS's activities in steel consist of cooperative research programs with the steel industry.

d. Federal research efforts in steel will be coordinated through the Committee on Materials (COMAT) which reports to the Federal Coordinating Council on Science and Engineering Technology.

STEEL INITIATIVES

QUESTION: What are the ultimate end products you expect from the current steel initiatives? Will the Federal role be limited to new technologies for the processing of steel?

ANSWER: The end products expected from the ongoing and proposed cooperative research programs in steel technology are two:

1. The development of steelmaking and forming technology which will enable the steel industry to improve its competitive posture in world markets, and
2. The formation of an enduring partnership in research between the Federal laboratories and the steel industry which will benefit the Nation and serve as a prototype for future cooperative research programs which will make the Federal labs more responsive to national needs.

The Federal role in the steel initiatives is to harness the extraordinary technical capabilities of the Federal laboratories to the national benefit. As the White House Science Council Federal Laboratory Review Panel Report (The "Packard" Report) noted, "The United States can no longer afford the luxury of isolating its government laboratories from university and industry laboratories."

STEEL ADVISORY COMMITTEE

QUESTION: What does the Administration plan to do with the work of the Steel Advisory Committee? Who in the Administration will take the lead in assuring the implementation of those Committee recommendations which both are worthwhile and require Federal action?

ANSWER: The report of the Steel Advisory Committee was approved by the full committee on 11/28/84 and was submitted in early December to the newly formed Interagency Working Group on Domestic Steel Issues, which reports to the Cabinet Council on Commerce and Trade. The Working Group is using the Advisory Committee's report as the basis to develop more specific recommendations to the Cabinet Council in the area of taxation, regulation, and trade. The final report will be submitted to the Cabinet Council in early May.

JOINT OPERATING COMMISSION ON FOOD IRRADIATION

QUESTION: A bill was recently reintroduced (H.R. 696) which also attempts to coordinate the federal decision-making role in food irradiation by statutorily creating a Joint Operating Commission on Food Irradiation. Do you believe that the Commission created in my legislation duplicates the intended purpose of your Committee on Interagency Radiation Research and Policy Coordination?

ANSWER: No. The Committee on Interagency Radiation Research and Policy Coordination is an interagency advisory committee which addresses a broad range of radiation issues. It serves to bring together all federal agencies that have jurisdiction over radiation and provide a means for discussion deliberation, and coordination of overlapping policy decisions, as well as a central mechanism for scientific review of specific questions related to radiation issues. The scientific data on food irradiation will be discussed in CIRRPC as one of several items. If the Joint Operating Commission on food irradiation is established the ongoing efforts of CIRRPC should complement its activities.

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NOAA RESEARCH PROGRAMS

QUESTION: According to SCIENCE magazine and other sources, you recently told a group of journalists that NOAA's research is characterized by "poor quality work" and "pork barrel programs".

a. Are these attributions accurate?

b. If so, please elaborate on your view of: NOAA's research quality; the appropriate role for NOAA research; and steps that should be taken to improve NOAA's research programs.

ANSWER: NOAA's mission covers a broad range of scientific and technical disciplines and issues. I have criticized the non-uniform quality of the overall NOAA program, for example, many of the fisheries laboratories seem to be politically motivated and are simply not first-rate facilities. NOAA's research programs and laboratories (in the Office of Oceanic and Atmospheric Research), though of higher quality, are still a mixed bag. Some, like the Aeronomy Laboratory (in Boulder) and Geophysical Fluid Dynamics Laboratory (in Princeton) are first-rate, world-class facilities. However, some of the other laboratories have problems. The Great Lakes Environmental Research Laboratory (in Ann Arbor) seems to me to have a more regional justification and therefore should not be funded so completely by the Federal government. The Space Environment Laboratory (in Boulder) performs a fine service function for NASA and DOD and, therefore, probably should be funded by these other agencies.

Finally the SEA GRANT program needs to be reoriented away from development projects more appropriate to private industry (e.g., developing techniques for cold smoking of salmon) towards long-range basic research in the marine resources (e.g., marine biotechnology).

NUCLEAR WINTER

QUESTION: The U.S. Government is accelerating a multi-agency program aimed at assessing the "nuclear winter" hypothesis. Our understanding is that FY 1986 funding will be approximately $5.5 million, with program management residing at OSTP.

a. Why was OSTP chosen as manager of the nuclear winter research programs?

b. What experiencedoes OSTP have in management of large multi-agency, multi-disciplinary research programs?

c. What will be the role of the Department of Defense with respect to program funding and management?

d. Why was the decision made not to place management of the program with NOAA, which has considerable, on-going experience in managing interagency scientific programs (i.e., National Ocean Pollution Program; National Climate Program; National Acid Precipitation Assessment Program)?

ANSWER: The Program management and management of funds to support the various research projects will remain with the respective agencies. There will be a coordinating committee, made up of the participating agencies with OSTP as the chair, as an advisory body to facilitate the flow of information between the agencies and to recommend research. This coordinating committee will be the focal point for communicating with interested parties outside the participating agencies.