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ABSTRACT

This report on a hearing held in Denver, Colorado, focuses on the development and impact of the electronics, computer, and telecommunications industries on the United States economy and the role of the federal government in developing these industries, including the relationship between technology and educated individuals. An opening statement by Representative Timothy E. Wirth, Chairman of the Subcommittee, addresses the health and competitiveness of these industries. A statement by Tom Lindblom, vice president of Mountain Bell, includes a summary of major Mountain Bell training and development programs, a survey report entitled, "Non-traditional Approaches to the Training/Education Needs of Present and Future Mountain Bell Employees," and an article, "Looking Ahead in Continuing Training and Education," by W. J. Benham. Additional statments are included from Dale H. Hatfield, president, Hatfield Associates; Michael Hickey, president, Biox Technology, Inc.; Allen Meiklejohn, Colorado Senate Committee on Education; Don Weiderecht, Chairman, Colorado Advanced Technology Institute; A. Richard Seebass, Dean, Engineering and Applied Science, University of Colorado; Trenton Gary and John Pigler, on behalf of Communications Workers of America; and Michael Massarotti, Deputy Superintendent of Schools, Adams County District 50. (LMM)

ECONOMIC DEVELOPMENT IN TELECOMMUNICATIONS, COMPUTERS, AND ELECTRONICS: THE EDUCATIONAL COMPONENT

HEARING

BEFORE THE

SUBCOMMITTEE ON TELECOMMUNICATIONS, CONSUMER PROTECTION, AND FINANCE

OF THE

COMMITTEE ON ENERGY AND COMMERCE HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

FIRST SESSION

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ECONOMIC DEVELOPMENT IN TELECOMMUNICATIONS, COMPUTERS, AND ELECTRONICS: THE EDUCATIONAL COMPONENT

THURSDAY, DECEMBER 8, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ENERGY AND COMMERCE,
SUBCOMMITTEE ON TELECOMMUNICATIONS, CONSUMER PROTECTION, AND FINANCE,
Denver, Colo.

The subcommittee met, pursuant to call, at 9:25 a.m., in the gold room, Executive Tower Inn, Denver, Colo., Hon. Timothy E. Wirth (chairman) presiding.

Mr. WIRTH. If the subcommittee could come to order, we'll move ahead on a very ambitious and, I think, terribly interesting morning.

Today we're having another in a series of field hearings by the Subcommittee on Telecommunications, Consumer Protection, and Finance, focused on the industries in our jurisdiction.

The subcommittee has been particularly concerned about the development and impact of the electronics, computer and telecommunications industries on the U.S. economy. And on doing everything the Congress can to encourage and nurture the role of the Federal Government and to define the role that the Federal Government ought to play in developing these industries.

Many of you are familiar with the activities of the subcommittee in assuring universal telephone service. The subcommittee is also involved right now in development of national cable legislation.

We've been working very closely with the U.S. Department of Commerce and U.S. Trade Representative in opening up the Japanese telecommunications market to U.S. goods, and have been involved in a whole variety of other activities of special importance to the industries.

One of the areas that many members of the subcommittee have been concerned about is the relationship between technology and educated individuals and the kinds of investments that we have to be making for the future of the country. That is the focus of this morning's hearing.

I have a rather detailed opening statement which I would, without objections, include in the record.

[The opening statement of Mr. Wirth follows:]

U.S. HOUSE OF REPRESENTATIVES

SUBCOMMITTEE ON TELECOMMUNICATIONS, CONSUMER PROTECTION, AND FINANCE

OF THE

COMMITTEE ON ENERGY AND COMMERCE

WASHINGTON, D.C. 20515

Opening Statement of Rep. Timothy E. Wirth

Chairman, Subcommittee Telecommunications, Consumer Protection

and Finance

Economic Development in Telecommunications, Computers,

and Electronics: The Educational Component

December 8, 1983

Today, the Subcommittee on Telecommunications, Consumer Protection and Finance continues its focus on the continued health and competitiveness of the telecommunications, computer and advanced electronics industries.

As recently as a decade ago, our companies in these fields almost completely dominated both the domestic and international markets. Recently, however, the Japanese and the Europeans have made enormous strides. In several critical technologies we have either already fallen behind or are in danger of doing so. Given the structural weaknesses of so many of our basic industries, like steel and autos, we cannot afford to lose the edge in high technology fields as well.

The rising success of our competitors cannot be ascribed to a single factor, but they all have one attribute in common: an active, positive, government role cooperatively supporting the efforts of private industry.

The single most important factor of our success thus far has been education. We have the most educated workforce in the world, and our teaching and research universities are still unparalleled. Yet, we are facing a crisis in education. A series of distinguished recent reports have documented the failures of our educational system, particularly in those areas most relevant to high technology: science and mathematics. For the first time, we are graduating a generation of children which is less literate than its parents.

Over the course of the last three years, this Subcommittee has

devoted a significant amount of time and resources to investigating ways to maintain the competitive strength of these high technology industries. For example, we continue to play a role in trying to force open the Japanese market for fair competition by American suppliers like AT&T, and to begin telecommunications trade with China. We have supported a strengthened federal commitment to basic research and development. We are currently engaged in an in-depth survey of all federal policies affecting the competitiveness of telecommunications, computers, and electronics.

This morning the Subcommittee will explore the educational policies needed to enhance the future strength of these industries. What must be done to train the tens of thousands of first class engineers, scientists, teachers, and workers who will be the lifeblood of our future success? What role can the federal government play, working closely with state and local government, with educators, and with business? These questions will be our focus today. Without swift and effective action on the part of government, industry and the academic community, we cannot hope or expect to maintain our technological leadership in an increasingly competitive international marketplace.

The availability of an adequate supply of highly trained and qualified scientific and technical personnel is widely recognized as a fundamental contributor to the competitive strength of the telecommunications, computer, electronics and other technology-intensive industries. Perhaps more than any other sector of our economy, the future growth and competitiveness of these industries are dependent on a highly trained and specialized workforce. In terms of world leadership in technological innovation and development, these are as important economic inputs as are capital outlays in plant and equipment or investment in research and development.

The inability of America's educational system to provide the fundamental skills necessary to ensure the future prosperity of a modern, technologically advanced economy is a cause for deep concern in government, industry and the educational community.

The evidence of U.S. weakness in technical education and training is strong and continuing to mount. The best people and the best educational institutions in the U.S. are probably stronger than at any time in the past, but the breadth of capability has receded; in other words, the foundations of achievement are beginning to erode. For example:

> The average mid. school or college graduate has only the most rudimentary knowledge of mathematics or science. Only one in six high school students study science or math beyond the tenth grade.
>
> Recent state statistics indicate an insufficient number of qualified science and mathematics teachers. During the

1970s, the number of mathematics teachers being trained declined 77 percent, and the number of science teachers being trained declined 65 percent.

In our universities the problems are equally disturbing:

> Laboratory facilities in almost all U.S. engineering schools are inadequate to provide a quality engineering education. Equipment is often obsolete and the availability of state-of-the-art instrumentation to teach new and emerging technologies and applications is limited. It is estimated that modernizing university scientific equipment alone would require a minimum investment of $1 billion.
>
> Our 290 engineering schools require an estimated 1000 new faculty members each year. However, the U.S. produces well under 500 annually. Currently, 10 percent of all engineering faculty positions are vacant.

The problems in our educational system place constraints on the ability of the telecommunications, electronics and computer industries to expand and meet foreign competition. The continued shortage of electrical engineers, computer scientists and other technical personnel can only serve to cripple one of the most vibrant sectors of our economy.

These industries are increasingly important and dynamic components of our national and local economies. These industries make significant contributions to our overall productivity increases, real economic growth and world trade performance. What's more, these industries and the high technology sector in general play an increasingly important role in providing new employment opportunities.

During the past decade, high technology industries as a group enjoyed a rate of growth of real output which was more than twice that of the total U.S. industrial output. Nine of the ten fastest growing U.S. industries in recent years have been high technology industries. High technology product trade has contributed large surpluses to our balance of trade -- out performing by far any other sector of the economy. And, average labor productivity of industries in the high technology sector grew six times faster than that of total U.S. business.

In recent years, here in Colorado, high technology companies have mushroomed along the Front Range, creating a "silicon mountain" economy. Just a few short years ago, there were less than 200 high technology industries located in Colorado. Today, however, Colorado has over 700 high technology companies employing nearly 60,000 people. Clearly, these industries are important to both the national and Colorado economies.

But the true significance of these industries goes far beyond what any statistical analysis would show. The new technologies and processes pioneered in these industries not only contribute to the strength of our overall industrial base, but improve the productivity and competitiveness of many of our more traditional industries that face strong international competition. In a very real sense, the future health and competitiveness of traditional industries, such as autos and steel, are tied to the new ideas and cost saving technologies born in the laboratories of high technology industries.

I look forward to hearing the testimony of the Colorado business community, state government officials, Colorado's educational community, and labor representatives on the prospects for improving the educational resources available to these high technology industries.

Mr. WIRTH. We are delighted to have with us this morning from the State of Texas, Congressman John Bryant. Congressman John Bryant, who was elected in 1982, is a member of the subcommittee, and has had a particularly distinguished record on the subcommittee working in the areas of competition in telecommunications, leading a variety of initiatives on that front. As a new member of the subcommittee, Congressman Bryant has had a very significant and quite unprecedented impact.

John, we're delighted to have you here. Any thoughts or comments that you might like to make before we begin?

Mr. BRYANT. I'm very pleased to be in Denver and I appreciate the change in the weather that greeted me.

Mr. WIRTH. There was that. You could have been here a week ago, and it would have been a real change in the weather.

Our first panel this morning includes three witnesses: Mr. Thomas Lindblom, vice president of Mountain Bell; Mr. Dale Hatfield, president of Hatfield Associates and a former Deputy Assistant Secretary of Commerce; and Mr. Michael Hickey, president of Biox Technology in Boulder, Colo.

Gentlemen, thank you very much for being with us. I think it's clear to you the thrust of the hearing today.

There are a number of budgetary initiatives, a number of directions that a lot of the committees in the Congress want to pursue in terms of the basic education investments. For example, in engineering, in higher education, in development of faculty and training at the university/college level and at the secondary school level in the teaching of science, mathematics, computer science, and so on. The subcommittee is trying to help develop a consensus among as many people as possible as to what directions we ought to be pursuing. It's into that initiative that this morning's hearing fits.

The procedures of the subcommittee, I think, are familiar to at least Mr. Lindblom and Mr. Hatfield. Mr. Hickey, we ask you to summarize your comments in 5 minutes or so, then ask each of you to react to what the others on the panel have said. We will include whatever longer statements and longer background you might want to include in full in the record.

So, Mr. Lindblom, perhaps we might start with you and Mountain Bell.

STATEMENTS OF TOM LINDBLOM, VICE PRESIDENT, MOUNTAIN BELL; DALE H. HATFIELD, PRESIDENT, HATFIELD ASSOCIATES; AND MICHAEL HICKEY, PRESIDENT, BIOX TECHNOLOGY, INC.

Mr. LINDBLOM. Thank you, Congressman Wirth.

Ladies and gentlemen. Well, I'm not here to talk about change, and that's probably hard to believe when you consider that 23 days from now Mountain Bell will play a key role in a drama of unprecedented proportions, the biggest corporate restructuring in business history, the breakup of the Bell System, but that is not my topic today.

Instead, I'm here to talk about something so basic to Mountain Bell's success, and I think to the success of all high-technology business, that it will not change, even with divestiture.

It is Mountain Bell's need for talented, educated, skilled people at all levels of our organization, people who can adapt, grow, who are anxious to be able to embrace new information age technologies; people willing to challenge traditions, exercise their curiosity to solve problems, take risks, find a better way, and never stop learning.

We take pride in the fact that people like this are already on our payroll, and they are clearly our greatest asset. In the future, we will need even more employees who match this description. They are crucial to Mountain Bell's future, a future which is intimately linked to the use of high technology.

In the few minutes I have today, I'd like to briefly describe the kinds of skills which Mountain Bell employees, those who already work for us and any new employees we hire, will need to succeed. Then I'll offer my answer to this question: How do we assure that the skills available in the work force, the skills of people graduating from our public educational institutions, match the needs of an increasingly technical business world?

All of us in this room are involved in making that match. We all share responsibilities, whether we represent private industry, organized labor, the educational community, or Federal or State government. We must all continue to invest our time and energy and tax dollars in preparing workers for a high-technology future.

As the U.S. Department of Labor reports indicate, there is a significant trend away from smokestack industries, heavy manufacturing and production, and toward service and information industries. A case in point is that today more people work for McDonald's than for United States Steel.

Labor statistics also indicate that the information age is already here. Right now, about one-half of the Nation's jobs involve handling information in some way. That percentage is expected to grow substantially during the next few years. Government predictions are that the boom areas, measured by sheer growth in numbers of jobs, will be computer programing and software writing.

Mountain Bell's requirements match this overall trend. In fact, we are affected by it in two important ways. First, like many other businesses, we use computers in our own internal operations to keep track of our customer and employee records, to help directory assistance operators find telephone numbers faster, to produce telephone bills each month, and so on.

Second, more and more of our customers want their computer to talk to someone else's computer over our transmission lines, and they want to do so at higher and higher speeds. To keep up with the customer demand, we're upgrading our facilities from analog to high-speed digital capability wherever possible. I'm sure most of you have heard about many of these upgrades: Our electronic central offices, for example, which are really giant computers; or lightwave transmission systems which carry high-speed data on beams of light produced by a laser. One such lightwave system is already operating between Mountain Bell offices in southeast Denver to Longmont and Boulder, and several more will be up and running soon.

The future promises continued computerization in virtually every area of our business. This means that employees willing to

become computer friendly will have a decided advantage. In fact, those who broaden their technical skills in general will find opportunities in our company. A few examples: Central office technicians who can work with electronic switching equipment; cable splicers who learn to work with fiber optics; service representatives who learn to input information into business office data bases.

For the managers of our business, a balance of skills will be required. We still need people with strong liberal arts backgrounds, people who can fill general employment and supervisory jobs. But we also anticipate an increased need for those who have a technical background, especially engineering and computer science, in addition to the people skills. We need managers who can work on team projects, motivate others, and demonstrate technical know-how.

But where will we get people with these qualifications? It's clear that we must find them and not develop them from scratch, as we once did. Traditionally, Mountain Bell hired employees with basic work skills but little or no telecommunications specialty. Then we enrolled them in company training courses to give them the specialized skills needed to do their jobs. In essence, instead of hiring already qualified individuals, we grew our own.

But times have changed. Our environment becomes less stable and more competitive. The cost of training employees in specialized areas has skyrocketed. We no longer can afford to spend either the time nor the money. Still, our need for qualified employees remains.

An industry trade publication, Telephone Engineer and Management, commissioned a study on this subject. It included:

> The traditional on-the-job training concept as the primary source of an employee education is obsolete in the new market. The communications industry is fast approaching a position where new workers must come to the job with the basic tools to be productive immediately.

Of course, this does not mean that we intend to abandon our on-the-job training efforts. Mountain Bell's Training and Education Center offers a wide range of on-the-job courses, both for managers and nonmanagers, and we will continue to do so in the future. In fact, more than 100 Training and Education Center courses have been accredited for degree programs in post-secondary educational institutions.

But that's still not enough, not when our objective is to help build a labor pool whose qualifications keep pace with our industry's changing needs. We need to do more, all of us.

First, the business and educational communities need to work together more closely. More productive programs have already resulted from a close working relationship between Mountain Bell and educational institutions in its territory. Let me give you a couple examples:

The Auraria campus about two blocks from here in Denver now offers a degree communications technician program which teaches the basic technical skills of our industry. This degree program was initiated by the Communications Workers of America and Mountain Bell working together.

Metro State College offers a course in electronic switching equipment, a course that's directly related to our real world needs. So

far, all 22 Mountain Bell employees who have successfully completed this course have also qualified to work in Mountain Bell's electronic offices. In other words, if they can pass this course, they have the skills to do this job.

The University of Colorado at Boulder soon plans to offer an engineering degree program in telecommunications. Graduates of this program will have many of the technical skills necessary to qualify for a good job in the industry.

In addition, colleges and universities in many States, including Colorado, are using Mountain Bell managers as curriculum advisers. Based on these managers' recommendations, several new telecommunications courses are planned for the 1984 school year. Among them are courses in telecommunications technology and in fiber optics.

Mountain Bell will reimburse employees who take advantage of courses like these for their tuition costs through our tuition aid program, provided, of course, that they satisfactorily complete such a course. The tuition aid program provides payoffs for both the company and the employee, and we'll recommend it highly to other businesses interested in encouraging employee educational development. These programs are definitely on the right track, but they are just the beginning. We need many more.

Mountain Bell is committed to working with the educational community to see that more programs are developed. In return, we need your continued commitment to work with us, listen to us, and keep on responding to our needs.

We also need a commitment from those in the State legislature. We need to know that you'll continue to closely monitor the effectiveness of Colorado's publicly funded educational institutions and that, if necessary, you'll push for improvements. Colorado benefits when its schools produce graduates qualified to work in high tech industries. By the same token, Colorado loses if employers must look elsewhere for candidates with the right knowledge and skills.

From Congress, especially from Congressman Wirth and fellow members of his House Telecommunications Subcommittee, we need a commitment to continue asking the kinds of questions being raised in this field hearing. The fact that you're all here today is a clear indication that you are concerned, and it's much appreciated.

We certainly hope you'll continue to investigate the issue of high tech education, because it is a key to the competitive success of America's technology firms in a worldwide market.

We also hope you'll continue to support federally financed education loans for promising students. In the future, our industry will need all the bright, talented, qualified people available. We can't afford to miss out on the abilities of some simply because they cannot afford a college education.

Well, my time is running short and I have not yet said everything; however, my written testimony includes more detail, plus some background materials on the points I've discussed.

Congressman Wirth, I thank you for the opportunity to be at this hearing and express my views on the issue. It is an important one, and it is the right group to be discussing it. As Governor Lamm of Colorado said in a recent meeting with Colorado educators, "This is

the year of education. We must strike while the iron is hot. America is expecting great things from us."

Thank you again for this opportunity.

[Testimony resumes on p. 41.]

[Attachments to Mr. Lindblom's prepared statement follow:]

Summary of major Mountain Bell training and development programs

Mountain Bell Training and Education Center

- Located in Lakewood, Colorado
- Completed in 1977
- Serves employees in all seven states in Mountain Bell service territory
- Self-contained learning and living environment, featuring "dorm" rooms and classroom facilities
- Over 700 courses available, including technical and management development
- Specialized facilities available -- for example, pole-climbing school, simulated central offices
- During first quarter 1983, provided 666,473 training hours

Internship Program

- Individual departments and segments within the company offer internships which provide college students with practical business experience

Career Resource Centers

. Total of 6 in company

. Provide career information, counseling services for employees and their supervisors

. Provide employees with tools for assessing their likes, dislikes, skills, and career options

. Assist employees in developing individual career paths

. Provides recommendations for training and development activities, both inside and outside the company, in keeping with career objectives

. Sponsor special interest seminars and workshops on career issues -- how to take tests, conduct interviews

. Training/retraining programs for employees whose jobs are affected by mechanization or centralization of company operations

Training and Education Assistance Program (Tuition Aid)

. Provides financial assistance to all regular employees for continuing education and college credit -- either on-campus or on company premises

. To receive reimbursement for registration and tuition costs, employee must meet following criteria:

-- Must be in academic or technical field which provides knowledge and skills of benefit to both the company and the employee (related to industry)

-- Must be for college credit, related to degree program

-- Must receive grade of "C" or better

. Cost of program borne by company shareowners

NON-TRADITIONAL APPROACHES TO THE TRAINING/EDUCATION NEEDS OF PRESENT AND FUTURE MOUNTAIN BELL EMPLOYEES

- A SURVEY -

EXECUTIVE SUMMARY

Introduction

This survey presents information for consideration in meeting training and education requirements outside the traditional, normal training program. It was conducted as part of a continuing effort of the leadership of Mountain Bell to develop innovative, effective, contemporary and non-traditional approaches and modes which might be used to meet the training/education needs of present and prospective Mountain Bell employees beyond the existing program. In this survey, "non-traditional" refers to training/education approaches and modes other than those which constitute the present Mountain Bell training program.

The changing competitive environment in which Mountain Bell operates dictates rethinking and re-evaluation of the training/education program that serves the mutual interests of the company and its employees. The non-traditional approach will be necessary to maintain the high quality of the work force vital to success in an expanding competitive environment. The purpose of the survey was to develop proposals and commendations for meeting these needs.

To examine training/education requirements outside the traditional training program and ways these needs or requirements could be met, representatives of the following groups were surveyed:

1. Individuals in top leadership positions,

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2. Persons at the Corporate or State Level, who have special knowledge and experience related to employee or organizational needs in the field of training/education,
3. AT&T, Bell Laboratories, and Bell Operating Companies,
4. Other industries and
5. Continuing education organizations.

In the survey, the primary method utilized in data gathering was the interview.

The development of training opportunities in Mountain Bell along with a review of the literature provided background data for the survey.

Mountain Bell Training Opportunities

The development of training opportunities in Mountain Bell has been characterized by increasing emphasis being given training and the centralization and professionalism of training efforts. Initially, each of the original Mountain Bell departments: Plant, Commercial, Traffic, Engineering and Accounting developed and carried out a training program for its employees. Each state had its own training organization.

The Plant Department provides an illustration of how this began to change. In the late 1950's and early 1960's a centralized training facility was established in Denver. In the late 1960's a training center was operated in Denver which enabled Mountain Bell to provide a formalized type of training and to fulfill its fair share commitment to develop courses for use throughout the Bell System.

The Mountain Bell Training Center began operation in 1978. It consolidated training which had been done in the different departments at several locations. It is used as a training center for Mountain Bell personnel from throughout the company's eight-state region. The immense research and planning which preceded the construction of the center made it a truly unique complex designed to enhance learning which, combined with modern, effective, developmental and instructional techniques, is used in conjunction with the training facility to produce the very best learning environment for the student. Because of the effectiveness of this approach other regional resident training facilities are being considered.

A Training Department was established in Mountain Bell in 1979. Training activities formerly reporting to state organizations now report to the Assistant Vice President-Training. The Mountain Bell Training Department has been described as one of the premier training organizations in the Bell System. The commitment to maintaining this position is illustrated by the existence of this Task Force to study training requirements outside the traditional training programs.

Review of the Literature*

Regarding the future, AT&T Chairman C. L. Brown has described the services available from the Bell System as not just the telephone business but also the moving of information and enhancing the ability to manage data in any form. President R. K. Timothy felt that Mountain Bell entered the

*Sources of References are shown in the body of the report.

80's in a favorable position to take advantage of the opportunities present in a competitive environment. According to recent projections, communications will be the fastest growing sector of all national industries. This indicates a need for examination of the effect the expansion will have on training efforts, future job requirements, and the supply of qualified manpower.

Concerning the manpower picture now and in the future, the management of human resources will be of particular importance to the success of the Company. Some feel the traditional on-the-job training concept as the primary source of training is obsolete. New workers must come to the job with the basic tools to be productive immediately. This appears an important consideration since it is estimated the Bell System will require about 50,000 new workers annually for the next 7 to 10 years. Other industries are competing for the same qualified workers with some offering a "bounty" or "reward" to employees for successful recruiting efforts.

Due to zero population growth, there will be an approximate 16% decline in the 16 - 24 year olds entering the job market between 1982 - 1990. Women will continue to increase in the work force. By 1990, it is expected that 53% of all women will be in the work force with 70% of the work force being made up of people between the ages of 25 and 44. Two-wage-earner families in the United States is also an increasing trend. This shows the need for providing child care during working hours, alternate hours and places of work to suit family needs, providing more training and education opportunities, and other moves to accommodate and make use of the changing work force.

There is a general recognition of the need for basic skill training and a growing appreciation that the development of such skills be profitable for a corporation. There are growing rates of unemployment among youth. Committed cooperation between business and academia to establish a work experience program linked to the working world is seen as a feasible approach to the solution of this problem.

There is a growing wave among the workers in American business and industry involving job satisfaction issues. Surveyed workers felt under-utilized, over-educated, and complained of a lack of control over their jobs. A large number would be receptive to attempts to improve job satisfaction which include flexible scheduling, involvement in job-related decisions, and the opportunity and the tools to assure self-development, growth and advancement. The Communications Workers of America have launched a giant campaign to combat job stress for the Bell System employees they represent. Quality-of-life issues will be addressed in the 1980 bargaining negotiations.

Conversely, it has been found that the employees of today are more highly motivated by needs, values and attitudes. They are more career oriented which affects job satisfaction and motivation. Friction is anticipated between these new workers and their supervisors who are steeped in authoritarian tradition. There is an increased desire to work in environments which enhance one's self esteem as measured by one's own values.

There are numerous examples of programs in operation which enhance job satisfaction. In one career development program, if the career development

path requires on-job training, the employee works beside another employee on his or her own time either before or after his or her own shift in order to learn the new job. The Department of Labor ruled that pay was not necessary as long as the employee was voluntarily training and not performing productive work.

Other companies are taking or have taken the following innovative actions based on a comprehensive review of corporate training and education:

1. One company developed self-improvement courses taken on the employees' own time with consultations and examinations permitted on company time. The learning center staff works with colleges in developing courses.

2. More and more workers are given the responsibility and resources to pursue their own development.

3. A new look is being taken at assessment. Emphasis is being placed on employee development rather than the selection outcomes.

4. One corporation is accredited to grant doctorates, another offers a bachelor's degree, another offers college level courses.

5. One college developed and instructs a fully certified electronics terminology program for an international firm.

6. Business and industry have moved to provide their own training and education programs. Seventy-five percent offer in-house courses which

serve about one-eighth of all employees who participate mostly during working hours, 74% authorize employees to take outside courses during working hours at company expense, and 89% have tuition aid programs.

Concerning specific companies, the following opportunities are noted:

A. General Motors operates a fully accredited college of engineering and business.

B. Sandia Corporation offers one of the widest varieties of educational opportunities.

C. Holiday Inn has established its own training "university".

D. International Business Machines has increased the use of self-study material and computer assisted instruction.

E. Bankers use colleges and universities to provide an intellectual, theoretical foundation and to teach generic skills; the American Institute of Banking furnishes the technical training and professional development in varied areas.

F. Xerox Corporation operates an international center for training and development.

G. Kimberly - Clark has an Educational Opportunities Plan (EOP); the plan features liberal eligibility requirements, an amount of money allotted to each employee for educational opportunities, and a yearly deposit by the company to an account to be used for future educational expense for employees and their families.

Many conclusions may be drawn from the literature about other companies, namely:

- college credit for in-house courses provide greater motivation for employees to continue their education

- 300 major corporations will have degree granting units by 1984

- the promotion rate for non-management employees with a degree will increase to several times greater than for non-management employees without a degree

- jobs requiring a college degree (AT&T Study) will increase 20 to 30 percent by 1985

- the interdependence of the Company and the employees is increasingly recognized with the success of one contingent upon the success of the other. Objectives of both must be merged or integrated for a needed entrepreneurial spirit

- the growing tendency to view employees as a resource makes money spent on training and development an investment rather than an expense

There are examples of existing telecommunications training programs outside the Bell operating companies. This includes the University of Colorado in Boulder, Colorado, which offers a Master of Science Degree and that seeks to give an understanding of the Technology of Communications. Texas A&M University, College Station, Texas, has pioneered telecommunications for the undergraduate with a program which began in

1975 as a cooperative effort between Texas A&M and the Texas Telephone Association.

The aim of the Mitchell Vo-Tech School in Mitchell, South Dakota is to prepare prospective telephone company employees, not only in basic job entry skills, but in the entire scope of the technical occupation of telephony and the necessary knowledge required by operating companies. Alabama Technical College in East Gadsden, Alabama, has established a telephone plant-personnel training program with funds supplied by the Southern Independent Telephone Exposition. Fort Wayne Indiana High School has established a one-year "Electricity-Electronics" course in cooperation with the General Telephone Company of Indiana.

A new directory shows even more telephone training being developed. The Senior Technical Editor of Telephony Magazine feels that the telephone industry now realizes that it is necessary to encourage and assist vocational and trade schools to perform the preliminary instructions prior to the assignment of personnel for future and more specialized training. John Brady, of California Polytechnic University and Pacific Bell, feels that the telecommunications industry must develop alternative approaches to personnel development if it is to keep pace with manpower requirements.

With the world moving into a third industrial revolution called the "information age", there are several means in existence that are alternatives to face-to-face communications. There are some newer technologies which can be used for education and training. This includes teleconferencing which brings people together without the problems imposed by distance and time; the Gemini 100 electronic blackboard which requires

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no special skills, training or transmission facilities to operate; and slow-scan video.

Golden Gate University takes its MBA Program into industrial plants by means of television. Firefighters in Rockford, Illinois, receive instructions on pre-fire planning over a regular cable TV hookup, and respond to questions by pressing the appropriate button on a small console which is transmitted to the control point of the TV training system.

In the 1960's the University of Illinois in cooperation with Control Data Corporation created PLATO, a computer based instruction program. Programmed Instruction, Individually Prescribed Instruction, and Criterion Referenced Instruction are other training modes which have been developed.

The PicturePhone Meeting Service is a Bell System audio/visual communications medium which enables groups in different cities to interact through special meeting rooms located in most major cities in the country. Programmed Audio-Cassette Training (PACT) is a self-instruction method of training involving the combined use of student workbook, cassette tape, and tape recorder.

Several studies conducted over the years concerning retention measurements by type of instructional media show that presentation of material by means of two-sense modalities is more effective than either visual or oral presentation alone.

Some Interview Results

The survey revealed a commitment to training and education at all levels, combined with the belief that changes must be made if the challenge of the 1980's is to be met. These challenges include Mountain Bell's commitment to maintaining high quality service on a competitive basis while assuring a profit.

The changes identified covered a wide range of employee development and training and education approaches, including the following:

It was believed that training and education must be mutually beneficial to both Mountain Bell and the employee. To achieve this it was believed that the focus must shift to the individual for the responsibility for his or her own growth. In this, the role of Mountain Bell is to assist in developing training and education opportunities which assure profitability and competitiveness.

The need for non-traditional training and education was recognized. The advantages of utilizing institutions of higher learning and other outside sources were also recognized. This included the desirability of college credit for "in-house" courses and liberalization of the Tuition Aid Plan. Courses like that of Service Representative could be provided to local institutions on a pre-employment and after-hours basis.

Employee turnover and changes in the employment situation accents the need for training and education. The present system of incentives for self-development was felt to be inadequate. Some changes suggested which

would increase the incentives for self-development were flexible hours, sabbaticals for educational pursuits, the need to recognize individuals who obtain degrees while employed, counting self-development as an "added factor," and an incentive pay system. It was felt that the assessment centers do not contribute to employee development.

It was generally felt that Mountain Bell training facilities should be open at night and on weekends for training purposes with members of employee's families eligible to enroll in courses. The provision of child care facilities was urged.

The expansion and administration changes of correspondence courses and the Tuition Aid Plan were suggested.

Pre-employment and after-hours programs are in operation in some states. An "Educational Training Council" was suggested for each state composed of district managers who have labor force needs. The head of Human Resources in each state would chair the Council. The Council would work with the appropriate local training and education institutions in meeting its needs; the Corporate Training and Education Department would provide direction, expertise, monitoring and evaluation.

The need for career counseling was widely emphasized as a means of providing job satisfaction and other quality-of-work-life issues.

The survey revealed that the offerings in colleges, universities, vocational-technical and other schools are extensive. Utilization of these opportunities and cooperative relationships was believed desirable.

Experience in the states indicates that such institutions are seeking arrangements with business and industry which are mutually advantageous. With tax-supported institutions, the Company contribution involves providing courses, equipment, expertise, and tuition aid when employees are involved. Operating telephone companies and other industries are also using outside sources for training.

The main theme which seemed to pervade the literature and interviews is that the 1980's will indeed be a time of change. Non-traditional approaches of all types in training and education will be required to keep pace with the demands of the age. Another theme which seemed to persist was that inflation and other economic factors demand that less expensive, non-traditional approaches be used.

Recommendations and Proposals for Consideration

The Task Force Recommendations and Proposals for Consideration are given for long term solutions with measures identified which the Task Force believes should be taken immediately. Within this context, the following general and specific recommendations are made:

I. Develop a Company policy of training and education in context with the mutual benefits to be gained by the company and the employees.

Training and education are an integral part of an Employee Development Program. Such development, including training and education, should be based on a policy which recognizes the dignity and worth of a individual and the importance of each individual to the organization as it endeavors to fulfill its mission.

Such development and training should acknowledge that only the individual can assume responsibility for his or her growth. It should further recognize the competitive environment in which the organization operates, the requirement for service of the highest quality to its clientele, and the necessity for an adequate return to investors in the organization. While the individual has responsibility for his or her growth, the organization has a responsibility for assisting the individual. This assistance can take many forms ranging from encouragement and financial assistance to helping in the development of training/education opportunities, both inside and outside the organization.

Also, this policy should rest on a solid foundation of commitment to employee growth and development on the part of the organization and its managers. In final context, mutual benefits will be gained by the Company and the individual employee.

Immediate steps toward attainment of such a goal are not limited to but include:

1) Develop a comprehensive career development/counseling program.

2) Establish incentive policies regarding self-development activities.

3) Survey all employees for their input on the kinds of programs in which they would like to participate.

II. Change the name of the Mountain Bell Training Department to the Mountain Bell Training and Education Department.

This change would accurately portray an enlarged function of Mountain Bell training as generally envisioned by Corporate and State personnel to meet the challenge of the 80's. Contacts and research data uncovered by the Task Force involving what other companies are doing support this concept. Specifically "at stake" are the needs uncovered for pre-employment and continuing non-traditional training and education both during and after hours that would result in the interests of the Company being served.

This will require implementing procedural requirements for organizational name chan s and notification to AT&T, other Bell Operating Companies, continuing training and education institutions, and others of the name change and the reasons for it.

III. **Issue new mission and policy statements to reflect the guidelines, operational requirements, and limits to be followed in expanding the concepts of training and education.**

This is acutely important for all Company-assisted or Company-sponsored training and education activities that involve the employee in on-the-job and after-hours activities. This should include maximum use of the Mountain Bell Training Center, other training facilities, and cooperative assistance with outside colleges, universities, and technical institutions under cost-effective arrangements. It is recognized that unique courses involving proprietary aspects of Mountain Bell and the Bell System operations cannot be divulged or given to outside institutions.

The Task Force believes and recommends that the family of the employee and retired employees be considered and provided for, particularly for weekend or after-hours activities at Mountain Bell facilities with provision made for child care.

Consideration should be given to providing or arranging for college credit as appropriate for in-house courses and as an additional motivation for self-development.

Steps to be taken in achieving these goals include:

1) Negotiate with the American Council on Education for accreditation of in-house training courses.

2) Open the MBTC for after-hours instruction to employees, their families, potential employees, and retired persons.

3) Offer existing courses, workshops, and courses from outside training organizations on-site and after-hours at any Company location where there is demand.

4) Explore the feasibility of training at home or "cottage" training locations.

5) Develop formalized Co-op programs in all States.

6) Develop formalized work/experience programs in all States.

7) Develop self-paced non-proprietary training for Service Representatives, Computer Technicians, and other job titles to be instructed by continuing education organizations or made available through the Company "Independent Study Unit".

IV. Enlarge the functions of the Mountain Bell Training and Education Department for implementing training and education requirements both in and outside the Company to achieve greater centralization of training and educational management.

The establishment of the Mountain Bell Training Department was a giant step toward the centralization of training resulting in greater efficiency at less cost. As the scope of training and education may be enlarged to include non-traditional training and education and greater utilization

of programs and facilities inside and outside the Company, a more appropriate definition of departmental functions would be in order.

The data in this Task Force Report suggest many non-traditional approaches such as self-paced modules for many courses for use on a pre-employment or after-hours basis. Use of PicturePhone, computer based instruction, and other technology should be given very careful study under the enlarged function of the Department of Education and Training.

The Tuition Aid Plan and an enlarged Correspondence Course Unit should be included in this. The Task Force believes and recommends that the responsibility for tuition aid and correspondence course units should be lodged in a new Division which would also have responsibility for all outside sources of learning, relationships with accreditation agencies, and liaison with state officers. Also, a regular relationship should be maintained by this Division with representatives of other industry and educational councils to keep abreast of new developments.

Some immediate steps to be taken to attain these objectives include:

1) Expand and update the Tuition Aid Plan.

2) Expand and update Correspondence Course Unit and course offerings.

3) Explore the use of other media to be incorporated into new and existing training programs.

V. Give special consideration to the establishment of and participation in State Training and Education Councils.

These councils would assure the active participation of the state organizations in the training and education process. The Council would be composed of district managers who have force needs, and would be chaired by the head of Human Resources for each state. The Council would make determinations of future job vacancies, skills needed to fill them, and work with appropriate local institutions in meeting these needs either at the institution or on Mountain Bell premises. Courses would be open to all with or without guarantee of employment for non-employees. Indications are that Company contributions in regard to tax-supported institutions could be expertise, equipment, and facilities, combined with tuition aid for employees who participate.

The role of Corporate Training and Education would be overall direction, basic research, training and educational expertise, monitoring, and evaluation.

Because this would get participation and involvement of state offices and enlarge training and education opportunities, the Task Force believes and recommends that this be instituted immediately in each state. There should be careful documentation of the Council's work to determine the range of possibilities open for each state. Regular liaison would be maintained as part of the function of the new Division created.

Immediate steps to take in establishing such Councils are:

1) A meeting with the Heads of HRD in each state should be held.

2) General guidelines should be developed for the operation of the Council which would allow for differences in the states.

3) An inventory should be made of outside training opportunities available in each state.

LOOKING AHEAD IN CONTINUING TRAINING AND EDUCATION

W. J. Benham

November 24, 1981

An examination of the history of Mountain Bell reflects a long standing interest in training and an unceasing commitment to the extension and improvement of training opportunities. Beginning in the 1950's, a concentrated effort has been underway to achieve centralization and professionalism in training. These efforts reached fruition in the mid 1970's when the Mountain Bell Training Center was constructed, staffed and equipped to provide each person receiving training an opportunity for maximum growth and development.

In 1980, a survey was made of non-traditional approaches to the training and education of Mountain Bell employees. From the study both philosophical and operational changes were made. This began with the name of the department changed to Training and Education.

The Human Resource Guide was revised to reflect an enlarged concept of training and education. Within this concept, the responsibility of the individual employee for his or her own development was identified with the role of the company being that of assistance in providing opportunities whenever possible. The Human Resource Guide also emphasizes the importance of both pre-employment and after-hours programs which are of mutual benefit to the company and its employees. Most of these programs are provided by colleges, universities, vocational and other schools.

Pilot programs were developed in these schools to meet both employee and company needs. The programs ranged from basic installation, to outside plant work, to service representative training and education. Also, the programs met Bell System standards, allowed both present and prospective employees to demonstrate initiative, and were of benefit not only to the employee but to Mountain Bell and the schools as well. The projects demonstrated that significant financial savings could result to Mountain Bell and its clients as a consequence of such training and education efforts.

After-hours, on-site degree programs at both the master's and bachelor's levels were developed.

The Mountain Bell approach to training and education now and for the future is supported amply by research involving the projected rapid changes in industry. John A. Brady [1] says

> "The traditional on-the-job training concept as the primary source of employee education in the new market is obsolete. The communications industry is fast approaching a position where new workers must come to the job with the basic 'tools' to be productive immediately."

He estimates, with the need for skilled manpower to maintain and develop EDP, voice, image, written office communications, etc., that the Bell System will require approximately 50,000 new employees annually for the next 7 to 10 years. [2]

[1] John A. Brady, "Help Wanted: Professionals for the 80's and Beyond" . Telephone Engineer and Management, September 1, 1979, P. 112

[2] Ibid, P. 113

The Bell System is not the only industry seeking skilled communications workers, as classified advertisements in trade journals and industry publications indicate. In a recent Wall Street Journal article, a story was printed on the "bounty-hunter spirit." Goodyear Tire and Rubber Co. is offering its active and retired employees a $1,000 reward for recruiting workers for two of its facilities. Goodyear needs people with special skills and started the program because of a "critical shortage of electronic and scientific computer people in industry."[3]

According to Dr. Seymour L. Wolfbein, Professor of Business Administration and Economics at Temple University in Philadelphia and a leading economist, the business world will not only be "scrambling for the hands we need from the point of sheer numbers, the problem will be compounded by serious deficiencies in the education of those diminishing numbers. This is attested by the lack of competency among young graduates in such basics as reading, writing and numbers."[4]

Based on the foregoing, the Bell System will not only be competing for business, but for qualified workers as well.

It is from this base that the plans for Continuing Training and Education Services are identified and projected.

[3]Goodyear Unit Offering Bounty For Technicians," The Wall Street Journal, April 28, 1950, P. 12

[4]Dr. Seymour L. Wolfbein, "View From The Top - Forecast' 80: Prepare for Dramatic Changes in the Workforce" Management World, January 1980, P. 1

1982 goals for continuing training and education services are:

To evaluate existing programs which served as pilot projects in developing non-traditional training and education opportunities both within and without Mountain Bell.

To replicate programs in non-traditional training and education which have proven successful when a similar need exists.

To initiate new programs in training and education which show promise of being cost-effective and of mutual benefit to Mountain Bell and its present and prospective employees.

In pursuing these goals, first attention will be given to those programs and projects which develop training and education opportunities, now provided by Mountain Bell, but which could be provided by colleges, universities, vocational and trade schools.

Because of organizational changes due to restructuring it will be necessary to vary the approach to accommodate these changes. In the past, the Mountain Bell state organizations have been the prime movers in initiating and carrying out projects. Now it will be vital that segments also be involved in the process of identifying need and planning and initiating programs to meet these needs. It would appear that district operating councils which have responsibility for a particular area must also be involved. Thus, in the role of catalyst or change agent, the Continuing Training and Education Services Team (CTEST) will have to operate in concert with the segments, states and district operating councils in program planning, initiation, and evaluation.

Plans For Accomplishing Goals

1. Evaluation of existing programs is made to establish their cost-effectiveness as compared to standard or traditional training and education. Programs or projects in this category are those which have been underway on a pilot basis. To establish consideration for other projects of this nature in the future, information will be developed to reflect base data for the programs showing need, problems encountered, solutions developed, and outcomes of the programs including training and education benefits, financial savings and potentially reduced turnover. Also included will be the feasibility of the programs in other situations.

To assure a degree of uniformity in the evaluation process, the guidelines developed for non-traditional programs will be used.

The following are the programs which have been evaluated or scheduled for evaluation:

-Introduction to Outside Plant	completed
-Basic Installation	completed
-Service Representative	completed
-Personal Growth Seminar	completed
-Customer Clerk (old version)	

The results of the completed evaluations augur well for non-traditional training and education programs or projects. To illustrate, an evaluation of the Introduction to Outside Plant program at the Albuquerque

Technical - Vocational Institute revealed that considerable savings could occur in after-hours programs for employees. In a single course with a beginning enrollment of 24 only 5 submitted transfer applications and will receive in-depth training for outside work. Training costs on the 19 who did not submit transfer requests could have totaled over $72,000.

It was the consensus of the task force that evaluated the Pima Junior College trial project that it was successful in terms of:

1. reduced travel expense for training
2. reduced tuition and salary expenses for training
3. reduced training days
4. more productive employees as result of the training program.

The course has been duplicated at Phoenix Junior College.

Future classes at both Pima and Phoenix Colleges will enroll 14 trainees. Based on the assumption that Mountain Bell will hire or transfer 50% (7) of each class, the task force found that Mountain Bell could realize substantial savings in training expenses. For 6 classes at both colleges, it is estimated these savings will be $114,526.44 in 1981. For 10 classes at these colleges it is estimated the savings will be $187,747.14 in 1982.

Based on the same hiring rate, the task force reported that using the average savings in productivity for students completing the trial course, potential savings in productivity would be $91,392 in 1981 and $152,320 in 1982.

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These combine for a total potential savings in 1981 of $205,918.44 and in 1982 of $340, 067 for the Basic Installation Projects at Pima and Phoenix College.

2. Programs or projects should be duplicated at other locations when it has been determined that they can meet the needs present. To illustrate, the Basic Installation course at Pima Junior College in Tucson was expanded to Phoenix College because many of the same needs were present in Phoenix. It was the consensus of the task force that the Basic Installation program could be duplicated at any college or vocational/technical institution. Furthermore, it was recommended that the course be duplicated in all Mountain Bell states where there is a demand for installer training. Similarly, it is planned that the Introduction to Outside Plant course at Albuquerque Technical Vocational Institute will be expanded to Farmington, New Mexico .

A need exists to determine other locations in Mountain Bell where proven programs could be utilized. This is a matter which requires early contact with states, segments and district operating councils.

A means to help identify a location of a project could be the utilization of forecasted openings for a particular job as indicated by the jobs report.

3. Needs have been identified which call for the initiation of new programs. Generally, these needs have emerged from contacts with state personnel and efforts must be made to involve segments and district operating councils in the need determination process.

The following programs in this category (along with other needs emerging almost weekly) include:

Customer Clerk: In this program, senior high students will earn credit toward graduation while taking the course and working part-time in a phone center. Interest in this has been expressed by Colorado, New Mexico, Utah, and Montana.

Telecommunications/ Telephone Technology: This program is provided in colleges or vocational schools and generally offers two options. The Outside Plant Technician option is two semesters in length and is designed to give a theoretical and practical knowledge in telephone construction, cable splicing, station installation and repair techniques, as well as DC-AC theory, mathematics, physics, human relations and technical writing. The Telecommunications Technician option is four semesters in length and includes the Outside Plant option the first two semesters, with the third and fourth semesters, offering theoretical and practical knowledge in advanced telephone devices and key systems, as well as electro-mechanical and electronic central office systems. There is interest in this program in Arizona and Colorado.

Management Training: In this program, initial management training courses would be available to Mountain Bell employees through higher education institutions. The interest in and need for this program exists in all states.

Operator Services Training:	Such training would be provided as part of high school or vocational/technical school curriculum. It would be one semester in length. It would result in operators being trained on a pre-employment basis. There is similar program in Pacific Bell which has markedly reduced the rate of turnover. Interest exists in all states.
Public Contact Curriculum:	Such a program would be provided in community colleges. The goal would be to reduce in-house training time for potential service representatives through a core curriculum on interpersonal skills, combined with business subjects.
Electronic Switching System-Central Office Technician: (ESS-COT)	This program is being considered for Colorado Metropolitan State College and has a two-fold purpose: To recruit students who have completed their sophomore year in the school of Engineering Technology and to provide after-hours courses for employees.
ESS-COT Candidate Orientation:	This program is planned to provide applicants for ESS-COT positions with a familiarity with what is required for successful performance. It is designed to help them determine their interest in such positions. There is interest in this in Colorado.

It is also planned to make a survey of telecommunications/telephone schools nationally to determine other programs which might be provided in the area served by Mountain Bell.

Thus, the long standing interest in training and the commitment to the extension and improvement of training opportunities in Mountain Bell continues. The charge is to place a main emphasis on programs and projects to develop cost-effective training and education opportunities, now provided by Mountain Bell, in colleges, universities, and vocational and trade schools.

Mr. WIRTH. Thank you very much, Mr. Lindblom, and your full testimony and the attachments will be included in the record. We look forward to continuing to work with you, Mountain Bell and U.S. West, not only in December but in the new year with your new independence.

Mr. Hatfield.

STATEMENT OF DALE N. HATFIELD

Mr. HATFIELD. Thank you, Mr. Chairman. I appreciate being invited to testify before you today on economic development in communications, computers, and electronics.

As a former Government official with responsibilities in the communications and information policy area and now as a consultant and part-time educator in this field, I have a very strong interest in the topic of this hearing.

You, Mr. Chairman, and the other members of your subcommittee are to be commended for investigating an area that is so crucial to our future economic and social well-being.

In this brief statement, I would like to cover just three things. First, I would like to stress the importance of this sector of the economy. Second, I would like to convey some personal experiences that I have had recently with firms that are trying to recruit technical and management personnel in this field. Third, and finally, I would like to offer a few observations based on my affiliation with the graduate program in communications at the University of Colorado.

First, while it is becoming almost a cliche to point it out, our economy has shifted in a fundamental way over time from an emphasis on agriculture to a concentration on the production of goods to, beginning in the 1960's, an emphasis on the production of services.

Because the production of services is so dependent on information, the current period has often been called the information age. Since about 1960, it is estimated that information workers of all types have comprised the largest single group of the U.S. work force.

Thus, if we are going to continue to enhance our productivity and our standard of living as a nation, it follows that the productivity improvements must increasingly come from the information sector of the economy.

In the industrial age, the emphasis was on achieving greater productivity by amplifying our muscle power. To increase productivity in this new age, the emphasis must be on amplifying our mental power and, of course, the tools for achieving that amplification are precisely the computer, telecommunications, and electronic office-place technologies that you are dealing with here today.

In my opinion, there is only one conclusion that can be drawn from these observations, and that is that the development of these tools is indeed vital to our national well-being. We should also keep in mind that while the information-intensive industries are vital in their own right, maintaining a strong position in these same technologies can be of major importance in maintaining the competitiveness of our more traditional U.S. products in the world market-

place. The better job we do of that, the easier it becomes for us to make the transition into this new era.

Turning to my second point, I must say that I am troubled by the difficulties that some firms are having in attracting highly qualified people in this field. My evidence is obviously anecdotal, but I hope informative no less.

I have been doing some consulting work with a small firm in Boulder which has been trying unsuccessfully for over 6 months to hire a skilled radio frequency, or what we call RF, design engineer. The product my client wants to produce is a large volume item with important commercial applications. It is a market that could easily go off shore if American manufacturers are unable to capitalize on some very recent FCC decisions.

Another example is some work I recently did involving a very large, established U.S. manufacturing firm. While the firm recognized that some advanced communication techniques could potentially increase their productivity, a shortage of experienced communications managers, coupled with rapid changes occurring in the common carrier field, held them back. They felt that about all they could do was maintain their existing services on an effective level.

Still another example is a client of mine who is in the financial services industry. In my opinion, this particular firm has done a really outstanding job in increasing their productivity by making extensive use of advanced communications and computer systems. They have shown considerable interest in building on these capabilities and providing certain services to others. One of the reasons that they have held back, however, is that they cannot recruit the experienced people they need to both sell services to others and continue to advance their own system.

Briefly stated, we as a nation cannot afford to have such shortages hold us back in this important sector of the economy.

My final point concerns education. I mentioned earlier that I teach part time in the graduate program in telecommunications at the University of Colorado at Boulder. It is the oldest multidisciplinary program of its type in the country, and we are quite proud of it. It is aimed, on the one hand, at giving the nontechnical student a firm grasp of telecommunications technology and, on the other hand, giving the engineering student a solid background in economics, public policy, and social aspects of this field. Over the last decade, we have graduated several hundred communications professionals.

My point is not the success of the program, but rather the fact that it is an excellent example of what the Federal Government can affirmatively do in cooperation with the States and industry.

The program was started with a relatively modest grant from the National Science Foundation. It was continued with support from the university and the private sector—including, I might add, Mountain Bell—and today similar programs have been started all over the United States. We like to think that one of the reasons so many other colleges and universities have added such programs is the example we have set. In short, a little seed money can go a long way.

As a closing thought, I would like to say that my work with students has taught me that we should not confuse effective use of

these information tools with the creation of the tools themselves. We should not confuse computer literacy with computer science. The great majority of our information workers do not need to be experts in how computers work or how to write software. They do need to be expert in how to use the telecommunications, computers, and electronics technology we are addressing today. In a sentence, we need educated consumers and producers.

Mr. Chairman, that concludes my remarks and, again, I appreciate the opportunity to appear before you here today.

Mr. WIRTH. Thank you again, Mr. Hatfield. I might add that both you and Mr. Lindblom have been before this subcommittee on a number of occasions and we, as always, appreciate your perspective and input which has been very valuable now and will be, I'm sure, in the future.

Our third witness is new to the subcommittee. Mr. Michael Hickey is president of Biox Technology, founded, as I understand it in 1979 with two employees?

Mr. HICKEY. That's correct.

Mr. WIRTH. And now it's 60 employees?

Mr. HICKEY. That's correct.

Mr. WIRTH. Give us a quick picture of what Biox Technology does; can you?

Mr. HICKEY. Yes; I will.

STATEMENT OF MICHAEL HICKEY

Mr. HICKEY. I think in terms of the testimony, it might be important for me to show you what the effect of some of these high technology education issues can have. Biox Technology makes a device called the noninvasive oximeter.

Mr. WIRTH. A what?

Mr. HICKEY. Noninvasive oximeter. What that device does——

Mr. WIRTH. Do you compete with U.S. West in making that?

Mr. HICKEY. Our device basically measures oxygen levels in the blood without taking blood out of the body. It shines light through the tissue and measures signals coming from the probe that we have, which basically goes through your earlobe and takes this information and processes it through several microprocessors and tells you the oxygen level in your blood.

It used to be that you had to take blood out arterially through a long stick that you placed into your wrist. So it's a great advancement in terms of both the pain that a person has to go through and the cost, because the cost factor in a hospital used to be approximately $50 to get this information, and you essentially can get it for almost no cost now once you purchase the piece of equipment.

But I think more importantly, I'd like to talk about the effect of some of this education has in terms of employees and competition and things like that. We started with two employees back in 1979, and we had a total salary for that year of approximately $20,000. Currently, we have 60 employees; our salary levels are going to be annualizing this year close to $2 million. So the effect of high technology innovation went from $20,000 to $2 million.

One of the concerns that this country has is the competition concern with the Japanese. One of the ways, I believe, that we can get

out of that is through not only technology but technological innovation.

If you look at our product, there was a major competitor that we had prior to, oh, several months ago, was a company called Minolta, which used to make an oximeter but no longer makes an oximeter, because they couldn't really compete with the Biox oximeter.

So the Japanese competition, when it comes down to innovation, is really less of a threat. I think that the Japanese have outproduced us, but this country has the ability, if it can innovate, to compete very effectively against any country in this world, and it's a matter of getting these creative, innovative technical people out of the educational institutions.

In terms of just gross money, if we can talk about that for a minute. Biox Technology back in 1979 was losing at a rate of about $500,000 per year. This year, we should go over the $10 million level in sales and next year we intend to double and continue to double that in the out years.

So you can see, again, the effect of a couple of people getting together in an innovative, technical environment, can produce a lot of good economic results. It can produce employment, it can produce taxes, it can produce substantial gross sales.

If you look at Biox Technology in terms of the out years, currently we are looking to hire 13 additional people. If we could hire 13 additional people today, we would. Our basic problem is finding them. Eight of those people are—all 13 of those people are technical people. Eight of those people would be electrical engineers that we're looking for.

At this point, our plan, our short-term plan is to begin in January going out of the State of Colorado to look for engineers. We have consistently advertised within the State and have looked all over the State for qualified engineers and can no longer find them, so we're going to be going to California and to Texas and to Massachusetts looking for technical people there. We can no longer find them here.

I think if you look at the process of technical innovation, basically that's what Biox is, that you can see the enormous potential of employment and of very strong competitive effort that this country can make through small businesses. And I believe that the essence of that is going to be the technical education in the future. Increasingly, we are looking to the universities to give us technical people, and we are having a difficult time finding them.

That's pretty much my testimony.

Mr. WIRTH. Thank you very much, Mr. Hickey.

Would any of you like to react to statements made by other members of the panel?

Mr. LINDBLOM. I wrote a note to myself. Where did you get the 60 people from 2, and he's practically answered that. When you built from 2 to 60, did the numbers that included the 60 come from Colorado?

Mr. HICKEY. Yes, most everybody came from Colorado. We got a lot of people from agencies that were being phased out, space agencies in the Boulder area that were phasing out. There was a phasing-out period where there seemed to be a lot of Government

grants that were phasing out, and we were picking up people from those agencies.

We also have a lot of technical people who are almost self-trained, software people and electrical engineers who primarily have trained themselves. But most of them came from the Boulder area.

Mr. LINDBLOM. I think his example points out the fact that there is such a great demand all over the country for these skills that the States that are really, I think, beginning to produce more are where he is going—to your State, Congressman—looking for the skills that he can't find here, which is, I hope, being heard by the right people.

Mr. WIRTH. If that's the case, if, in fact, we are seeing Mr. Hickey going to California or going to Texas or Illinois to find the people you need, maybe you're going to have that same experience with Mountain Bell, or already are——

Mr. LINDBLOM. Somewhat.

Mr. WIRTH [continuing]. What does that tell us about where some of the responsibility for this technical education lies?

Mr. HICKEY. If you look at these major centers of technology, most of them revolve around a university. You're looking at Stanford and MIT, and a strong university will create spinoffs over and over again. And where we're going to find ourselves going is to Palo Alto and to start advertising there and sit in hotels and interview people. They've got a headstart, because they started several years—they've been in this a longer period of time, and that's where we're going to find people, I believe.

In the future, however, I think that if you have a strong central university, highly technical, although not solely technical, I think you're talking about a good, strong university system as a whole, you're going to find spinoff people coming out of those universities who, in this new day and age of the entrepreneur, are going to be starting businesses and the Bioxes—there's going to be many Bioxes, I believe, in the future, if you can get that good core of a university.

Certainly, University of Colorado is a start in that direction, but I think there could be great improvements there.

Mr. WIRTH. The assumption is that the need for the highly trained individuals in the kind of enterprises that the three of you are involved with are directly related to a strong university system training those individuals. We all agree with that. That's where they come from.

Mr. LINDBLOM. I think it also cuts to the nonuniversity trained, those who are willing to produce some of the nonengineering skills. We still look to the technician side, and I think—so we have both requirements, the highly trained, skilled, educated, college educated, as well as those who can develop technical skills to run these machines if they don't choose to go on and get the developmental skills. So we have a need for both, really.

Mr. WIRTH. Who provides the predominant amount of funding for the University of Colorado's efforts in this area or University of Texas at Austin or Stanford or MIT or other institutions around the country? Where does most of that money come from?

Mr. HICKEY. I think it's primarily government responsibility.

Mr. WIRTH. Which government?

Mr. HICKEY. I think, from my point of view, it's probably an equal responsibility of State and Federal Government, and that isn't as if—in a small business case, we rarely ever look for government money. We don't get any. But what we get from the government is this talent.

And in our case, the engineers we've had, most of their educations have been subsidized by both Federal grants and State grants. Yet when Biox started, Biox never got a cent of any government money. We didn't need it.

Mr. LINDBLOM. It can't all come from government. I think we've got to create the incentives in individuals who want to pursue these skills, although maybe some of the initial thrust has to come from the levels of government, and the things we're doing in Colorado, I think the bill that came out of last session, Senate bill 1, is in the right direction. I think Michael is on the right track that we're behind. How do we catch up? What's it going to take to catch up? Is it a lot of infusion of Federal money or just an enthusiasm among our population that there are opportunities here and we've got to create within our own State the ability to get that education.

Mr. HATFIELD. I'd just comment that the fact that one region of the country is stealing high talent people from another region of the country may be robbing Peter to pay Paul, as the expression goes, but I think that tends to make it a little more of a Federal problem when you have to continually go outside. It creates inefficiencies in the whole system by continually people stealing people back and forth across the country. On the other hand, I think a certain amount of competition between regions to attract qualified technical people is probably good, as well. But certainly, I think the fact that you get so much movement between regions, it tends to make it something that the Federal Government should be responsible for and take an interest in, certainly.

Mr. WIRTH. Well, certainly the Federal Government has always been involved in this kind of technology and technical training and got deeply involved, particularly after sputnik—you'll all remember—and after the Second World War there was an influx of trained individuals. But in terms of the development of laboratories and the support of professors and the development of the whole training infrastructure, we as a country made that investment very significantly in the late 1950's and early 1960's. And I'm not sure that very many people begrudge that investment, and that was the type of investment that, I think, has paid off handsomely.

What the three of you are talking about here would suggest that that was a good investment and one that ought to be continued. Our problem is in terms of setting priorities. There are some who write budgets today in the Office of Management and Budget who would suggest, leave it all to the private sector or leave it to State governments to do. And the question is, Is it possible for the private sector or for State governments or for both to pick up the slack and to make the investments that are necessary to do the kind of training that you've talked about, Mr. Hickey; to provide the kind of technical individuals that you've talked about, Mr. Lindblom, particularly as you are looking to the outside rather than doing a lot of your training inside. And that seems to be a

trend at Mountain Bell and, I would assume, with Bell companies present and future all across the country.

How much can the Federal Government do? Should the Federal Government maintain its commitment, or can we leave it to the private sector and to State governments to do the job?

Mr. HICKEY. From a small business point of view, when you have a small business that's in competition with a company like Minolta, we don't have extra capital to put in training our own people, and most of the growth in business, as I understand it, is in small business. So if you expect small business to have extensive training programs, you are going to weaken our capital structures to the point that we are not going to be competitive with the other world companies.

So from a small business point of view, to expect us to have massive training programs, one, we don't have them and, two, we can't afford them. And if we did put our money into that, we wouldn't have enough to compete throughout the world.

Mr. HATFIELD. There is some things that a small company can do; for example, hire students part time. That gives you some fairly good talent that's fairly far along in the educational process, gives them a little bit of income to be able to stay in school. So I think that some of the smaller businesses, and I consider myself that now too, can help a little bit in that way. It's a very limited way, but I think it can be productive.

Mr. LINDBLOM. I think just as important from an industry education standpoint is not—yes, the dollars are important, but we've certainly got to communicate with our educators of our needs, and then they need to change to match the requirements of industry. I think maybe our educators will have an opportunity to speak about this, but it seems to me we're so slow sometimes in changing the curriculum to match the needs of the community. You get locked into something and, this is the way I taught it, the way I've taught this course, and it continues forever. I think the education industry has to be changed more rapidly to match the needs of the communities.

Mr. WIRTH. Mr. Bryant.

Mr. BRYANT. It seems apparent to me that, in view of the problems that have been outlined by the staff in preparation for the hearing and by you in your testimony, that this would not be the time in history for us to be cutting back on Federal or State funding for public education. I think that's the flat-out question I'd like to ask, Is it fair to conclude from your remarks that you would oppose cutting back on Federal funding for public education?

Mr. HICKEY. I would absolutely. I think you're going to find the out years could be fairly dismal if you have a group of uneducated people 10 years from now. You're going to find you'll get this technology rolling out, and then drop if you lose your talent pool. We lose our talent pool 5, 10 years out if we cut back on education At least, that's my belief.

Mr. BRYANT. Mr. Lindblom.

Mr. LINDBLOM. I know it's a delicate problem to balance any budget, but I think education needs have to be high on any priority list for consideration. We've all identified the need, and it isn't going to go away. Industry is changing rapidly, and we all know of

the competition from other countries for these skills. If we don't provide the skills from within our own country, the products are going to come from somewhere else that we still need to run our businesses. So the education is important.

And as I said, it would be a shame to see someone miss this opportunity who has the intelligence and the desire for lack of funds.

Mr. HATFIELD. Yes, I guess I was in government long enough to know the difficulties. We can't afford to do everything that we would like to do, but my personal feeling is the investment in human capital, investment in education is just absolutely the highest priority. No question in my mind about it.

Mr. BRYANT. A lot of the time I hear people talk about how we need—you touched on it a little bit, it's a recurring theme about how we need to communicate better with the education community and the teachers need to do this and the superintendents need to do that. But stealing information that was provided by the committee staff, if you look and see what's going on in education, the people who are there to talk to are rapidly leaving; we don't have them any more.

During the 1970's, the number of secondary school mathematics teachers being trained declined 77 percent. The number of science teachers being trained declined 55 percent. And you can compare our efforts, from this information, in educating people in engineering and all of the other areas that relate to what you're talking about and they're always, always behind Russia and Japan. It just seems to me impossible to conclude that we have any business discussing cutting back.

I would defer to the chairman of the subcommittee, a member of the Budget Committee, if I recall, Reagan has tried to cut $11 billion, is that right, annually out of our Federal education budget?

Mr. WIRTH. That's correct.

Just on the subject of student loans, the cuts proposed by the administration would—almost 50 percent of the students receiving student loans would no longer be recipients of student loans, which would mean a dramatic dropoff of enrollments in colleges and universities across the country, particularly among people at the bottom end of the income scale.

And if we are concerned about a democratic society in which all have access to opportunity, not just those who have a lot of money, we have a devastating set of priorities in terms of the future of the country. We're going to have an all-white engineering class 10 or 15 or 20 years from now and all-white business school and all-white law school and so on, or very close to it; scarcely a reflection of what I would suspect most of us would like the country to be.

Mr. LINDBLOM. He used the term student loans. I think it's gotten a bad name from the fact that it is a loan and it's not being paid back. I don t know recent statistics, but I know there's a lot of effort to recover those. But a loan sometimes becomes nonrecoverable.

Mr. BRYANT. Are you bidding salarywise for those 13 new employees, or are you just having basically an auction form?

Mr. HICKEY. Salary levels are going up considerably. We have to pay competitive—small business has to pay as good a salary with as good a fringe benefit package as a major company does.

I think if we're talking about the investment in education, Biox Technology alone this year is going to pay over a million dollars in taxes. To me, that's a return on investment that's fairly high. It would be interesting to go back and calculate the investment that was made in our engineering staff and see what that produced in terms of taxes. I don't know what that number would be, but that would an interesting figure to actually look at.

Mr. WIRTH. A couple of themes have come out that I had not thought about and we've had a lot of discussion of this particular issue. One, the discretionary money available to small business is limited—you can't expect small businesses who are putting their money into new ventures, new plant, new equipment to take whatever discretionary money they have into a lot of training or retraining of individuals. That is just not the best priority that we ought to have for the country.

If we take the next step from that and look at where the job creation is in this country, you're absolutely right that the new jobs are being created primarily in companies of 50 employees or fewer. That's where the future of the country seems to be. That's where the new ideas are, and we certainly are surrounded by that here in the State of Colorado. Which would again argue from the perspective of business development, small business development, innovation and maintaining the idea capital in the United States for those investments to be made publicly or made someplace else and not asking you or asking you, Tom, as you are going more and more into the public marketplace for employees rather than training them yourself.

Here we have a very large company and a very small company saying essentially the same thing.

Mr. LINDBLOM. Part of our problem in looking for these people, if we brought them up with just basic skills without any technical training, we spend between $15,000 and $20,000 over a 6- to 8-month period to bring them up to speed so they can work with our computers and, frankly, we just don't—it's expensive, we don't have the dollars available like we'd like to, and the time element. We need them now to protect our product, which is telephone service.

So we've just got to get the point across, I think, that we need people coming to us with better skills to get into the productive workplace quicker. That's one of our problems.

Mr. WIRTH. So one of the themes that has come out of this discussion is job development, job creation. The other that all three of you mentioned is the trade dimension. I think all of you touched on it in one way, shape or form. If we do not make these kinds of investments, we are going to see these markets or the technologies move overseas and we will lose what are potentially great opportunities for the United States. Noting that today, I believe, 1 job in 5 or 6 in the United States is dependent directly or indirectly on international trade. We view ourselves as being a relatively insular market; not the case at all. We are moving more and more into an international economy, and to stay competitive these investments have to be made.

Gentlemen, thank you very much. Do any of you have any closing words for the good of the order that you might like to add?

Mr. LINDBLOM. I think balancing industry and education and government in the same subject is going to be very interesting.

Mr. WIRTH. That's what we're trying to figure out—where that cooperation can be. Some people call it an industrial policy to balance all of those together. Other people call it simply economic cooperation, which I suspect is a better way of putting it. Where are all those three pieces? How do they all fit together? And that's the job that we have, rather than being behind the barricade somewhere hurling brick bats at each other from different perspectives.

Thank you, all three of you, very much for coming, and we look forward to working with you in the future.

Our second panel this morning includes a number of distinguished witnesses. Mr. Don Wiederecht chairman of the Colorado Advanced Technology Institute in Golden; Senator Al Meiklejohn, with a very distinguished record in the State legislature, among other things as Chairman of the State Senate Committee on Education; Mr. John Pigler, director of education, and Mr. Trenton Gary, director of business and industry relations for the Colorado Training Foundation, both representing the Communications Workers of America, Local 8412; Dr. Michael Massarotti, deputy superintendent of schools in Adams County; and Dr. Richard Seebass, dean of the University of Colorado College of Engineering and Applied Science.

Gentlemen, thank you all very much for being with us. I think you all are familiar with the rules and procedures of the subcommittee. We would ask each of you to summarize your statements; they will be included in full in the record. Then I will ask you to comment, each of you if you would like to, on what other panelists have said and then get into exchange with Congressman Bryant and me.

Perhaps by way of starting we could start and recognize both distinction and legislative seniority and recognize you, Senator Meiklejohn.

Thank you all very much for being here.

STATEMENTS OF ALLEN MEIKLEJOHN, COLORADO SENATE COMMITTEE ON EDUCATION; DR. DON WEIDERECHT, CHAIRMAN, COLORADO ADVANCED TECHNOLOGY INSTITUTE; A. RICHARD SEEBASS, DEAN, ENGINEERING AND APPLIED SCIENCE, UNIVERSITY OF COLORADO; TRENTON GARY AND JOHN PIGLER, ON BEHALF OF COMMUNICATIONS WORKERS OF AMERICA; AND MICHAEL MASSAROTTI, DEPUTY SUPERINTENDENT OF SCHOOLS, ADAMS COUNTY DISTRICT 50

Mr. MEIKLEJOHN. Well, Mr. Chairman, Congressman, thank you very much for inviting me to come down. I appreciate that courtesy. I have to tell you that I have not been well and I didn't prepare formal remarks.

Mr. WIRTH I'm sorry. You're very good to be with us today. You probably, unprepared, are better than most with preparation.

Mr. MEIKLEJOHN. You know, there's room for great concern in the area that this committee is holding these hearings. I also serve as a member of the Western Technical Manpower Council, and if I could summarize, Congressman, we are falling behind substantially

in the area of Ph.D. scientists and engineers. Talking now just about the area of the responsibility of this committee. There are other problems in education than what we're talking about here, but certainly this is a great one. The projections I see are that in my lifetime we will not have equilibrium between supply and demand in Ph.D. scientists and engineers.

We are falling behind in the area of research. The training of technical employees, undergraduate persons and the like, is certainly a difficult area, but I don't think it has the calamitous consequences, as I envision, in the nature of our need for Ph.D. scientists and engineers and advanced research.

In a partial effort to meet some of that, within this State, for 2 years a number of us tried to get something adopted in this State along the lines of the Colorado Advanced Technology Institute which would be an education establishment, of course, without any faculty or any walls, which is a place where industry, education, and Government can come together to try to start solving and coordinating some of these problems of training, both technician level, undergraduate, graduate level, Ph.D. level and in the area of research.

And as you know, earlier this year we did adopt in Colorado Senate bill 1, which established the Colorado Advanced Technology Institute. I'm very pleased that Dr. Wiederecht could be with us today to tell us what that agency is doing. It's starting on less than a shoestring, and hopefully the State will see fit to fund it in the way it should be. It's a very good cooperative effort between industry and the government.

The other thing, you know, is how to move the postsecondary education establishment sometimes in a direction more toward what the needs of the present society and economy are. And I'll tell you, that's not easy. You go to our universities and you meet these brilliant men and women, utterly brilliant people, dedicated men and women of credibility and integrity But try to shift some of those resources from one area in a comprehensive area of a university to another— I know that you're going to hear from Dean Seebass, for example, his struggle in the engineering school, and what he's going to tell you is the absolute truth, but how to shift resources in a massive education establishment from one area of construction to another.

Mr. WIRTH. Do you think that's more difficult than shifting jurisdictions within committees of a legislative body?

Mr. MEIKLEJOHN. I would say about the same, Congressman, you just can't get the job done. It's just glacial, just elephantine in making these movements.

Colorado has made a very strong commitment to advanced technology education and research. As disappointed as I've been with some of our funding in this State, I went to a meeting, a national meeting, about a month ago. To my dismay, Colorado got a gold star. I say to my dismay. Imagine what's going on elsewhere.

These funding problems are a mess. I would suggest to you, Congressman, I know you know that I think the less the Federal Government intrudes in some of these areas the better off we all are, but I think there are some real areas that this committee needs to consider and that the Federal Government needs to consider and,

in particular, in the vein of this day's hearing, I would commend your attention to continuing efforts in research, which I think the Federal Government alone can do by way of funding, and some kind of new support for postgraduate work in engineering and sciences, where I think there is a critical need. If we don't respond to this need soon, we're not going to have universities.

Those are my remarks, Congressman. I'm delighted to be here. Thank you so much for inviting me.

Mr. WIRTH. Thank you very much, and we'll be getting back with you.

Don, may we move from that introduction to you and the Institute.

STATEMENT OF DR. DON WIEDERECHT, CHAIRMAN

Dr. WIEDERECHT. Congressman Wirth and Congressman Bryant, ladies and gentlemen, it is an honor and a pleasure to be here today with your panel members and colleagues to discuss this vital issue of education and its relationship with the growth of desirable high technology industry.

As Congressman Wirth so aptly stated in his invitation letter, we as a nation are indeed facing formidable challenges to our economy and to our society from increasingly stiff competition from abroad. Not so long ago, domestic companies such as General Electric competed primarily with similar domestic concerns, such as Westinghouse or RCA. Today, the toughest competition GE, RCA, and Westinghouse face, at home as well as overseas, comes from companies with names like Phillips, Siemens, Sony, Hitachi.

A recent Booze Allen Hamilton report stated that in the past two decades, the United States did not gain market position in one major industry area and, in fact, lost position in 12. Japan, on the other hand, increased its position in eight industries, while losing ground in none. Small wonder that Honda, Datsun, Toyota, Subaru have become names familiar to every household.

If the challenge and market confrontation has been an agonizing one for our traditional industries, it could be even more so for our exciting new high tech industries which have evolved so quickly from the accelerating technological discoveries in our modern world.

These dynamic companies, whose existence and profit depend on maintaining a state of the art competitive edge, have become increasingly important to the economy of the country, and particularly to our State. In fact, one of the brightest spots in Colorado's economic strength and stability has been the explosive growth of these high tech and related industries.

High tech firms have often been described as mind intensive rather than capital intensive, meaning that these businesses employ a higher percentage of well-educated, professional, technically skilled personnel. Hence, there is a very critical and essential link between excellence in education and continued growth of the advanced technology which, in turn, nurtures these state of the art companies.

But the resources are simply not available to provide the educational output needed for competitiveness in our emerging informa-

tion era. Shortages exist in faculty, equipment, and facilities, and there are limitations on the numbers of students.

As a consequence, the enormous potential for future growth of advanced technology industries may be stifled by this crisis in education.

A recent report from the Western Interstate Commission on Higher Education and Colorado Commission on Higher Education indicated that the demand for trained engineers and scientists in Colorado exceeds by 40 percent the State universities' current and projected capabilities to provide manpower. It is, therefore, critical to substantially improve our efficiency and our productivity of available resources.

The means to do this are really threefold, we believe. One is to have clearly defined goals that are shared by industry and education alike, that are understood by all facets of these organizations, institutions, and are agreed upon. These goals must answer the questions of: Where can technology go? What can business market profitably with this technology? What are the educational and research needs needed to support this technology?

A second means is to share capability. We must complement, not duplicate, our capabilities and resources. This must include capabilities in talent and equipment and in facilities.

Third, we need collaborative joint participation. Team efforts are an important way to go, and the leadership of those teams to achieve synergism is essential. What is needed is a partnership of industry, education, and government. Within this partnership, Government can provide help with finances, with policies, and with priorities. Government, in return, can obtain the economic growth, development, and stability that we all seek.

To function this partnership required a forum and an organization. In Colorado, the answer has been the Colorado Advanced Technology Institute or CATI, which was established by State law in June of this current year. The overall purpose of CATI is to promote, support, and enhance education and research programs in the fields of advanced technology.

It is governed by an 11-member commission; 4 of these are the presidents of the academic research institutions in the State, both public and private; one is the executive director of the Colorado Commission on Higher Education, who represents the State and the community colleges; and 6 are key executives from advanced technology industries, both small and large, to represent all the important facets of our State economy.

The commission has identified four technology thrust areas for the State. These are microelectronics, telecommunications, material science, and biological sciences. These represent the industries that are existing in the State of Colorado. They also represent thrust areas where we have existing educational strengths at the present time and, third, they represent areas where we have a potential for obtaining more qualified grads in needed areas, more qualified faculty from active research, and, third, more high tech business for the State.

At the present time, we are developing plans that will strengthen our excellence in education in these areas, that will extend the

availability of this education, and that will expand research in these areas.

We seek matching public and private funds, and at the present plans are being formulated to develop these. An example of a project that's being considered by the CATI commission is one that uses the technology itself that we're talking about to help achieve our goals. Specifically, I refer to a potential establishment of a telecommunications network statewide that would use the best teachers, wherever they may be, that would extend to all regions of the State, that would not require duplication, that would have a lower cost rather than having multiple facilities and staff, and that would have multiple uses in education, such as computer-aided engineering, libraries, for continuing education, and for software development.

This would eventually, ultimately link all educational centers in the State with the cutting edge of technology that's being developed in Colorado's high tech industrial laboratories, and it can serve continuing education as well as new grads.

This is but one of several initial projects that are being considered by CATI that will become a part of our strategic plan to address major, long-range programs that will impact and benefit all sectors of the State.

The CATI commission seeks broad based support for its far-reaching goals, and the Federal Government will, indeed, play a role of significance, I am confident. The optimum potential role for the Federal Government needs to be defined, along with the specific technical and educational aspects of our strategic plan.

We are looking forward to working with you, Congressman Wirth, and your staff in the future with regard to CATI, and I will endeavor to keep your staff informed of our institute's progress in the coming months.

I would like to close my thoughts this morning on this subject of excellence in education and its vital link to maintaining the health of our high tech industry by stating that my company and those represented here today are examples of our commitment and involvement to help the educational process in our State and our Nation serve the need it must in order to keep America competitive.

Thank you for the opportunity to be here this morning and to share these thoughts with you.

Mr. WIRTH. Don, thank you very much.

Our next panelist is Dr. Richard Seebass, dean of the College of Engineering at the University of Colorado, and I think, as we've talked about stealing talent from California and Texas, this is an example of stealing talent from Princeton and Cornell. Is that right, Dick?

Mr. SEEBASS. That's right, if you include my most recent academic home, the University of Arizona.

STATEMENT OF A. RICHARD SEEBASS

Mr. SEEBASS. Thank you very much, Chairman Wirth and Congressman Bryant, for the opportunity to testify today.

I've entitled my remarks "Engineering our Economic Recovery," as they are somewhat broader than just remarks on engineering education.

Four years ago, I participated in a very comprehensive review of the appropriate role of NASA in the first A of NASA, that is, in aeronautics. That led to a substantial interest on my part of the role of the Federal Government in furthering the economic health of a given industry and, beyond that, the economic health of the country as a whole.

I've also become specifically concerned with the responsibilities that we in engineering education have, but that's been more recent, since I've only been a dean for 2 years. Too often I've heard myself and other deans speaking on the subject without doing the homework we really need to do to understand the broad picture. We've been complaining about our overloads without really understanding what we need to do to contribute the best we can.

I have managed to do the homework I needed to convince myself I understand these issues reasonably well for an engineer. I have read more than seven books and probably a dozen research articles on the subject, including the best sellers such as "In search of Excellence."

If you read all this material, the findings you arrive at are no different than the findings that a group of us came to last February. I served then on the National Research Council's Commission on Engineering and Technical Systems as the chairman of the Aeronautics and Space Engineering Board.

That Commission reviewed more than 100 National Research Council programs that were then under way in a "crosscut" exercise to identify their common themes. The main thrust of that study and, of course, of what I read, is that we are succumbing to the economic challenge of the Japanese, and also the European Common Market as exemplified by airbus industries. This isn't as perilous as our military competition, to be sure. We should look at it as fun, exciting, rewarding, especially if we succeed in winning this competition.

There are four principal ingredients in what I see is our failure to keep pace with Japan and, in selected technologies with Europe.

We do not have a coherent national industrial policy for the express purpose of maintaining our economic well-being. The current, albeit robust, laissez-faire approach alone isn't going to provide the competitive advantage we need. What you heard from Michael Hickey was very exciting, and that's part of this laissez-faire response. But it is not enough!

Second, the current focus on short-term improvements in the bottom line, profit, by corporate management and the willingness of CEO's to tie up corporate resources needed for R&D and plant improvement in the acquisition of other corporations has markedly decreased our long-term competitive strength.

Third, the inadequate educational preparation of our children from birth through high school has resulted in an intellectual deficit that the universities and the colleges of this country cannot overcome.

And, finally, the engineering and technical manpower needs of our corporations are now being met by talented graduates, but as

you've heard over and over again, these graduates are in short supply and, hence, command high salaries, and that makes them expensive. In addition, their education has not been especially appropriate to the problems industry faces today. This is especially noticeable in the lack of programs and student interest in manufacturing and their lack of familiarity with contemporary computer capabilities.

I'd like to address each of these points very briefly, with more extensive remarks on engineering education, and still keep my remarks to 5 minutes.

INDUSTRIAL POLICY HEADING

Our industrial leaders are divided on this issue of industrial policy, because some see it as subsidies, trade barriers, support for failing industries. But more enlightened industrial leaders see it as liberalized antitrust laws, appropriate tax incentives, and enlightened and coherent and continuing government policies.

We do have two long-standing successful industrial policies in this country. In the first of these, aeronautics, the government has been both a provider of not only procurement-related R&D, but more specifically and more importantly, generic technology R&D. In the latter, agriculture, the government has not only supported technology development, it has also engaged in client-oriented and very applied R&D through its agricultural experiment stations. It's no accident that for several decades those two industries have been the principal contributors to the positive side of what has now become an overall negative trade balance.

We've got to derive from our experiences in these industries the models for our future. We need a policy that draws on the governments role in agriculture and aeronautics, encourages enterprises like the Microelectronics Computer Consortium [MCC], which has recently been formed and decided, unfortunately for us, to locate in Austin, Tex.

Let me note here that from my point of view, the MCC decided not to locate here in Colorado because they felt the State was not providing its major institutions the support they required to be national leaders in the high tech enterprise, despite the gold star, Senator Meiklejohn accords us in this area.

Japanese industry, the Japanese banks the Japanese Government together have an industrial policy. This is public knowledge. You can, for example read it in an advertisement in the November Scientific American that's 30 pages long. They're very clear about what they're doing and why.

FOCUS ON SHORT-TERM PROFITABILITY

Let me turn to the second point. There is no doubt that the current focus on short-term profitability is causing us trouble. The Martin Marietta-Allied-Bendix waltz took money from R&D and capital formation and put it into paper. United States Steel's decision to acquire Marathon for tax writeoffs rather than rebuilding their steel-producing enterprise is a national tragedy. Such nonproductive endeavors need to be discouraged, while at the same time

providing legislative enhancements to encourage capital formation. We suffer very badly from poor capital formation in this country.

HUMAN RESOURCES

Before I turn to the final point, engineering education, let me just note that with regard to the third point, human resources, the Japanese long ago realized that their principal asset on that small island was human intelligence, and they have invested very heavily in developing and furthering their own intellectual capabilities. This has a remarkable impact, not only on economic health, but you can even see it, not surprisingly, ever in their standardizing test scores.

ENGINEERING EDUCATION

Let me turn now to the major points I want to make about engineering education. For more than a decade industry has been seeking academe's help in the manufacturing enterprise. As Senator Meiklejohn noted, trying to turn an academic institution around in a short period of time, even a decade, is very, very hard. Colleges of engineering have been slow to respond to national needs.

Robotic devices for manufacturing were developed in this country with support from the Federal Government by unimation. They are now principally manufactured and principally employed in Japan. Part of the responsibility for this tragedy lies with our engineering colleges. Computer-aided design has been pioneered and advanced by industry with little help from academe. Too few engineering colleges have kept pace with developments in computer technology, and too seldom are we providing the advanced education our students need to participate in our high tech endeavors.

Let me note here that I subscribe to something that was said earlier. We not only have to retain our lead in high tech endeavors, we also have to revive the smokestack industries, and I'm going to claim that we can do that, because there's a natural synergism there between them.

We currently have the lead, although a decreasing one, in computer hardware. No doubt about it. We also have an even larger lead in computer software. The management of the manufacturing enterprise, from computer-aided design for economic manufacture through product distribution, can now be orchestrated through computer management and the manufacturing process control. We can regain our historic lead in some of these smokestack industries by capitalizing on the lead we have in computers and software.

To retain our lead in the industries that we're now strong in and to regain a competitive posture in others will require a national policy to further develop engineering research and education, as engineering education is truly in a crisis. Without a return to the national programs that you alluded to, Congressman Wirth, that lifted this country out of the doldrums in engineering education in the post-Sputnik era, I feel we are truly lost.

For every lawyer that Japan graduates, we graduate 10 lawyers—my apologies to the lawyers. For every engineer we graduate, they graduate an engineer. They have half the population base we do We do not have the appropriate base of ability—trained stu-

dents within our high schools, nor do we have, as Senator Meiklejohn has carefully noted a sufficient number of well-trained Ph.D.s in engineers to really further expand our engineering educational programs. Our enrollments have doubled in the last decade, while engineering faculty have increased 10 to 15 percent.

Mr. BRYANT. Would you repeat that?

Mr. SEEBASS. The number of students in engineering—the engineering enrollment—has doubled in the last decade. Engineering faculty members have increased 10 to 15 percent in the last decade. The supply of additional faculty is simply not there. It's going to be a decade before the supply of Ph.D's increases, and only then if Government programs are put in place to insure this development.

In the short term, we have to make much more productive use of our engineers. We can't produce engineers in our colleges of engineering that require 2 years of education when they get to industry to be brought up to speed. We must not only teach them the theory, we've got to also teach them the practice, and we don't have the resources to do that.

NATIONAL SCIENCE FOUNDATION

Let me just comment on where I stand with regard to funds for the National Science Foundation. The National Science Foundation budget is about $1.2 billion. Ten percent of that budget is directed toward engineering research at the universities, that is $123 million.

If you take the funds from the DOD, DOE, and the NASA that's directed to engineering research in our colleges of engineering, it comes out to be less than half of the NSF expenditures on science.

Now, there's no doubt that the NSF expenditures on science are not more than needed. You cannot cut those for they provide the base for engineering developments. What has to be done is to increase the NSF expenditures on engineering research and engineering education. You've got to increase that budget in the next year or two from 123 million to something like $260 million a year, and that's basically what's needed in terms of the educational component of an industrial plicy.

That is essentially what Senator Meiklejohn was noting when he said that you've got to support Ph.D. training in the colleges of engineering with Federal programs, and you've got to support engineering education with federal programs.

There is much to be done, from my point of view. The time for studies, hearings, expressions of dismay is past. Now is the time for action. The principal ingredients of that action are clear. All that is needed is the determination to act.

Thank you.

[The statement of Mr. Seebass follows:]

CONGRESSIONAL TESTIMONY
DECEMBER 7, 1983

ENGINEERING OUR ECONOMIC RECOVERY

RICHARD SEEBASS, DEAN
ENGINEERING AND APPLIED SCIENCE
UNIVERSITY OF COLORADO

FOUR YEARS AGO I PARTICIPATED IN A VERY COMPREHENSIVE STUDY OF THE APPROPRIATE ROLES FOR THE NASA IN THE FIRST "A" OF NASA, THAT IS, IN AERONAUTICS. THIS LED TO AN INTEREST ON MY PART IN THE ROLE OF THE FEDERAL GOVERNMENT IN FURTHERING THE ECONOMIC HEALTH OF GIVEN SECTORS OF OUR INDUSTRY THROUGH ITS SUPPORT OF RESEARCH AND DEVELOPMENT ACTIVITIES, BOTH IN INDUSTRY AND AT UNIVERSITIES. I HAVE ALSO BECOME SPECIFICALLY CONCERNED WITH THE RESPONSIBILITIES THAT WE IN ENGINEERING EDUCATION HAVE. TOO OFTEN I HAVE HEARD MYSELF, AND OTHER DEANS TOO, COMPLAIN ABOUT OUR WELL BEING AND HOW THE CURRENT ILLS OF ENGINEERING EDUCATION SPELL DISASTER FOR THIS NATION WHEN, AT BEST, ONLY A FEW OF US HAVE RESEARCHED THE SUBJECT WELL ENOUGH TO UNDERSTAND IT.

I HAVE MANAGED TO DO THE HOMEWORK NEEDED TO ANSWER MY OWN PERSONAL CONCERNS ABOUT MY RESPONSIBILITY AS AN ENGINEERING DEAN. TO THIS END, I HAVE READ, SKIMMED, OR READ THE RELEVANT EXCERPTS FROM SEVEN BOOKS AND MORE THAN SEVEN POSITION PAPERS. THESE STUDIES INCLUDE: IN SEARCH OF EXCELLENCE BY PETERS AND WATERMAN, MEGATRENDS BY NAISBITT, GLOBAL STAKES BY BOTKIN,

DIMANCESCU, AND STATA, THEORY Z BY OUCHU, THE NEXT AMERICAN FRONTIER BY REICH, AND GOVERNMENT AND TECHNICAL CHANGE EDITED BY NELSON.

MY FINDINGS FROM THESE READINGS ARE NOT MUCH DIFFERENT FROM THOSE THAT I ARRIVED AT AFTER A MEETING LAST FEBRUARY OF THE NATIONAL RESEARCH COUNCIL'S COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS. I SERVED ON THIS COMMISSION, WHICH IS COMPOSED OF SOME SEVENTEEN INDIVIDUAL BOARDS, AS THE CHAIRMAN OF THE AERONAUTICS AND SPACE ENGINEERING BOARD. IN WHAT WE CALL A "CROSS-CUT" EXERCISE, WE REVIEWED MORE THAN 100 INDIVIDUAL STUDIES IN PROGRESS UNDER THE VARIOUS BOARDS FOR THEIR COMMON THEMES. WE IDENTIFIED SEVEN OF THESE AS WORTHY OF INDEPENDENT STUDY BY THE COMMISSION. THE PRINCIPAL THEME THAT EMERGED FROM THIS EXERCISE WAS A RECURRENT CONCERN WITH THIS COUNTRY'S WEAKENING ECONOMIC POSITION.

THE MAIN THRUST OF WHAT I HAVE READ, AND WHAT WE DISCUSSED AT THE CETS MEETING, CAN BE SUMMARIZED AS FOLLOWS: THIS COUNTRY IS NOT ONLY FACING, IT MAY BE SUCCUMBING TO, THE ECONOMIC CHALLENGES OF JAPAN, AND THE EUROPEAN COMMON MARKET AS EXEMPLIFIED BY AIRBUS INDUSTRIES. THE CAUSE OF THIS EROSION IN OUR ECONOMIC POSITION HAS FOUR PRINCIPAL INGREDIENTS:

1. WE DO NOT HAVE A COHERENT NATIONAL INDUSTRIAL POLICY FOR THE EXPRESS PURPOSE OF MAINTAINING OUR ECONOMIC WELL BEING. THE CURRENT, ALBEIT ROBUST, LAISSEZ-FAIRE RESPONSE ALONE IS NOT GOING TO PROVIDE THE ADVANTAGE WE NEED TO SURMOUNT OUR ECONOMIC COMPETITION.

2. THE CURRENT FOCUS ON SHORT-TERM IMPROVEMENTS IN THE BOTTOM LINE -- PROFIT -- BY CORPORATE MANAGEMENT AND THE WILLINGNESS OF CHIEF EXECUTIVE OFFICERS TO TIE UP THE CAPITAL NEEDED FOR R&D AND PLANT IMPROVEMENT AND THE ACQUISITION OF OTHER CORPORATIONS HAS MARKEDLY DECREASED THE LONG-TERM COMPETITIVE STRENGTH OF OUR CORPORATIONS.

3. THE INADEQUATE EDUCATIONAL PREPARATION OF OUR CHILDREN FROM BIRTH THROUGH HIGH SCHOOL HAS RESULTED IN AN INTELLECTUAL DEFICIT THAT OUR COLLEGES AND UNIVERSITIES CANNOT REMEDY.

4. THE ENGINEERING AND TECHNICAL MANPOWER NEEDS OF OUR CORPORATIONS ARE NOW BEING MET BY TALENTED GRADUATES, BUT THESE GRADUATES ARE IN SHORT SUPPLY AND HENCE COMMAND HIGH SALARIES. IN ADDITION, THEIR EDUCATION HAS NOT BEEN ESPECIALLY APPROPRIATE TO THE PROBLEMS INDUSTRY FACES. THIS IS ESPECIALLY NOTICEABLE IN THE LACK OF PROGRAMS AND STUDENT INTEREST IN MANUFACTURING AND THEIR LACK OF FAMILIARITY WITH CONTEMPORARY COMPUTER HARDWARE AND SOFTWARE.

LET ME ADDRESS EACH OF THESE POINTS BRIEFLY.

OUR INDUSTRIAL LEADERS ARE VERY MUCH DIVIDED ON THE ISSUE OF A NEED FOR NATIONAL INDUSTRIAL POLICY. TO SOME SUCH A POLICY MEANS TRADE BARRIERS, SUPPORT FOR FAILING INDUSTRIES, AND OTHER GOVERNMENT STRATEGIES THAT MANY OF US BELIEVE ARE DOOMED TO FAILURE. TO OTHER, MORE THOUGHTFUL INDUSTRIAL LEADERS, IT MEANS LIBERALIZED ANTI-TRUST LAWS, APPROPRIATE TAX INCENTIVES, AND ENLIGHTENED, COHERENT, GOVERNMENT POLICIES. LET ME POINT OUT THAT WE HAVE HAD SUCCESSFUL INDUSTRIAL POLICIES IN TWO INDUSTRIES, NAMELY AERONAUTICS AND AGRICULTURE. IN THE FIRST OF THESE, AERONAUTICS, THE GOVERNMENT HAS BEEN BOTH A PROVIDER OF NOT ONLY PROCUREMENT-RELATED R&D, BUT MORE SPECIFICALLY AND MORE IMPORTANTLY, GENERIC TECHNOLOGY R&D. IN THE LATTER, AGRICULTURE, THE GOVERNMENT HAS NOT ONLY SUPPORTED TECHNOLOGY DEVELOPMENT, IT HAS ALSO ENGAGED IN CLIENT-ORIENTED AND VERY APPLIED R&D THROUGH ITS AGRICULTURAL EXPERIMENT STATIONS. AGRICULTURAL RESEARCH BEGAN WITH THE HATCH ACT OF 1887; AERONAUTICAL RESEARCH BEGAN IN 1915 WITH THE FORMATION OF THE NACA, THE NATIONAL ADVISORY COMMITTEE ON AERONAUTICS, WHICH HAD ITS MISSION BROADENED TO INCLUDE SPACE IN 1958. THESE TWO INDUSTRIES HAVE, OF COURSE, BEEN TWO MAJOR CONTRIBUTORS TO THE POSITIVE SIDE OF OUR TRADE BALANCE FOR MANY YEARS.

WE MUST DERIVE FROM THIS EXPERIENCE THE NECESSARY MODELS FOR A BROADER ATTACK BY THE FEDERAL GOVERNMENT ON THE R&D NEEDS OF OUR CORPORATIONS. SUCH AN INDUSTRIAL POLICY SHOULD ENCOURAGE COLLABORATIVE ENTERPRISES AMONG VARIOUS COMPETITORS IN THE R&D

ARENA, SUCH AS THE RECENTLY FORMED MICROELECTRONICS COMPUTER CONSORTIUM (MCC). AND IT SHOULD ALSO FOSTER INDUSTRIAL-UNIVERSITY COLLABORATION. LET ME NOTE IN PASSING THAT FROM MY POINT OF VIEW MCC DECIDED NOT TO LOCATE IN COLORADO BECAUSE IT FELT THE STATE WAS NOT PROVIDING ITS MAJOR INSTITUTIONS THE SUPPORT THEY REQUIRED TO BE NATIONAL LEADERS IN THE HIGH TECH ENTERPRISE.

THE WATCHES WE WEAR, THE TELEVISIONS WE WATCH, THE STEREOS WE LISTEN TO, THE MICROWAVES WE COOK WITH, AND NOT INFREQUENTLY THE CARS WE DRIVE, NOW COME FROM JAPAN. THIS SUCCESS OF THE JAPANESE DERIVES PRINCIPALLY FROM THEIR MITI LEAD INDUSTRIAL POLICY AND THE RECOGNITION THAT QUALITY AND COST ARE DETERMINED BY CAREFULLY MANAGING THE MANUFACTURING ENTERPRISE. FORTUNATELY, FOR THE MOMENT AT LEAST, THE AIRPLANES WE FLY AND THE COMPUTERS WE USE COME PRINCIPALLY FROM THIS COUNTRY.

TURNING NOW TO THE SECOND POINT, THERE IS NO DOUBT THAT THE CURRENT FOCUS ON SHORT-TERM PROFITABILITY IS TYING UP CAPITAL NEEDED TO SUPPORT R&D ENDEAVORS. NO ONE CAN VIEW THE BENDIX - MARTIN MARIETTA - ALLIED WALTZ AS ANYTHING BUT A DISASTER. RATHER THAN INVEST IN NEW EQUIPMENT, U.S. STEEL DECIDED TO ACQUIRE MARATHON, AND BY LIQUIDATING CERTAIN PORTIONS OF MARATHON, GAIN ACCESS TO A RENEWAL OF THE DEPLETION ALLOWANCE PROVIDED FOR NON-RENEWABLE NATURAL RESOURCES. THIS SHORT-TERM FOCUS DERIVES FROM THE HYPE OF THE STOCKBROKER AND THE GULLIBILITY OR GAMBLING INSTINCT OF THE AMERICAN INVESTOR. PEOPLE USED TO BUY GENERAL MOTORS STOCK FOR RETIREMENT. NOW THEY "BET" THEY CAN GUESS THE SHORT-TERM PSYCHOLOGY OF OTHER INVESTORS BETTER THAN THOSE OTHER INVESTORS CAN GUESS THEIR OWN

PSYCHOLOGICAL MAKEUP. WE SURELY MUST PROVIDE MORE SUBSTANTIAL TAX INCENTIVES FOR THE LONG-TERM INVESTOR VIS-A-VIS THE SHORT-TERM SPECULATOR WHILE SIMILARLY ENCOURAGING CAPITAL FORMATION.

BEFORE I TURN TO ENGINEERING EDUCATION, LET ME JUST NOTE THAT, WITH REGARD TO THE THIRD POINT -- THE EDUCATIONAL PREPARATION OF OUR CHILDREN FROM BIRTH THROUGH HIGH SCHOOL -- THAT THE JAPANESE LONG AGO REALIZED THAT THEIR PRINCIPAL RESOURCE WAS THE HUMAN INTELLECT. THUS THEY HAVE INVESTED HEAVILY IN DEVELOPING AND FURTHERING THEIR OWN INTELLECTUAL CAPABILITIES, AND THIS HAS RESULTED IN A REMARKABLE INCREASE IN THEIR COMPARATIVE SCORES ON INTELLIGENCE QUOTIENT AND OTHER TESTS.

LET ME TURN NOW TO ENGINEERING EDUCATION WITH THE OBSERVATION THAT, FOR MORE THAN A DECADE, INDUSTRY HAS BEEN SEEKING ACADEME'S HELP IN THE MANUFACTURING ENTERPRISE. ENGINEERING COLLEGES HAVE BEEN SLOW TO RESPOND TO THIS REQUEST. ROBOTIC DEVICES FOR MANUFACTURING WERE FIRST INTRODUCED BY AMF AND UNIMATION IN THE EARLY '60s, BUT THEY ARE NOW PRINCIPALLY MADE AND EMPLOYED IN JAPAN. INDEED, HALF OF THE PRESENT ROBOTIC WORK FORCE RESIDES IN JAPAN. COMPUTER-AIDED DESIGN WAS PRINCIPALLY PIONEERED AND SUBSEQUENTLY ADVANCED BY INDUSTRY. TOO FEW ENGINEERING COLLEGES HAVE KEPT PACE WITH THESE DEVELOPMENTS AND ONLY RARELY HAS ACADEME PROVIDED IMPORTANT ADVANCES IN THESE ENDEAVORS.

I DO NOT SUBSCRIBE TO THE THESIS THAT HIGH TECH IS WHERE IT'S ALL AT. RATHER I AGREE MORE WITH EDWARD E. DAVID WHO NOTES THAT WE MUST DEVELOP A SMOKESTACK INDUSTRY / HIGH TECH SYNERGISM. FULLY HALF THE DEMAND FOR COMPUTERS, INSTRUMENTS,

ELECTRONICS, AND COMMUNICATIONS STEM FROM OUR SO-CALLED SMOKESTACK INDUSTRIES AND THE ECONOMIC WELL BEING OF A REASONABLE FRACTION OF THIS COUNTRY'S POPULATION DEPENDS ON THESE INDUSTRIES. THIS COUNTRY MUST NOT ONLY RETAIN ITS LEAD IN THE SO-CALLED HIGH TECHNOLOGY INDUSTRIES, BUT WE MUST REGAIN OUR PREVIOUS LEADERSHIP IN SOME OF OUR BASIC MANUFACTURING ENDEAVORS. WE HAVE THE OPPORTUNITY TO DO SO. WE CURRENTLY HAVE THE LEAD, ALBEIT A DECREASING ONE, IN COMPUTER HARDWARE. WE HAVE A SUBSTANTIAL LEAD IN COMPUTER SOFTWARE. THE MANAGEMENT OF THE MANUFACTURING ENTERPRISE -- FROM COMPUTER-AIDED DESIGN FOR ECONOMIC MANUFACTURE THROUGH PRODUCT DISTRIBUTION -- CAN NOW BE ORCHESTRATED THROUGH COMPUTER MANAGEMENT AND THE MANUFACTURING PROCESS IMPLEMENTED THROUGH COMPUTER CONTROL. AND WE CAN REGAIN OUR HISTORIC LEAD IN ECONOMIC MANUFACTURING THROUGH OUR LEADERSHIP IN COMPUTER HARDWARE AND SOFTWARE. TO RETAIN OUR LEAD IN THESE INDUSTRIES AND REGAIN A COMPETITIVE POSTURE IN OTHERS WILL REQUIRE A NATIONAL POLICY TO FURTHER DEVELOP ENGINEERING RESEARCH AND EDUCATION AS ENGINEERING EDUCATION IN THIS COUNTRY IS TRULY IN A CRISIS STATE. WITHOUT A RETURN TO THE NATIONAL PROGRAMS THAT LIFTED THIS COUNTRY OUT OF THE DOLDRUMS IN ENGINEERING EDUCATION IN THE POST-SPUTNIK ERA, I FEEL WE ARE TRULY LOST.

IT IS TRUE THAT FOR EVERY LAWYER JAPAN GRADUATES THIS COUNTRY GRADUATES TEN LAWYERS. IT IS ALSO TRUE THAT FOR EVERY ENGINEER THAT WE GRADUATE, JAPAN GRADUATES AN ENGINEER; YET THEY HAVE HALF THE POPULATION THAT WE HAVE. AT THE MOMENT, HOWEVER, WE DO NOT HAVE AN APPROPRIATELY EDUCATED BASE IN OUR HIGH SCHOOLS

TO DRAMATICALLY EXPAND OUR ENGINEERING PROGRAMS BEYOND THE ENROLLMENTS WE HAVE TODAY. NOR DO WE HAVE THE FACULTY RESOURCES TO SERVICE SUCH AN EXPANSION. RATHER, WE MUST TAKE ADVANTAGE OF THE COMPUTER REVOLUTION THAT IS UPON US TO ENHANCE THE PRODUCTIVITY OF THE ENGINEERS THAT WE ARE TRAINING. WE ARE SIMPLY GOING TO HAVE TO COMPETE THROUGH MORE PRODUCTIVE ENGINEERS AND THE RESPONSIBILITY FOR TRAINING THOSE ENGINEERS RESIDES PRINCIPALLY WITH OUR COLLEGES OF ENGINEERING. UNFORTUNATELY, WE ARE NOT, ON THE WHOLE, ESPECIALLY WELL PREPARED TO TAKE ADVANTAGE OF THIS REVOLUTION. THIS COMPUTER REVOLUTION WILL CONTINUE FOR THE REST OF THIS CENTURY; THOSE THAT CAPITALIZE ON IT BEST WILL GARNER SUBSTANTIAL ECONOMIC RETURNS. WE MUST ENSURE THAT ENGINEERING EDUCATION TAKES FULL ADVANTAGE OF THIS RESOURCE.

THE NATIONAL SCIENCE FOUNDATION BUDGET DEVOTES 10% OF ITS 1.25 BILLION DOLLAR BUDGET TO ENGINEERING. THERE IS NO EXCESS IN THE NSF FUNDS PROVIDED FOR SCIENCE, BUT RATHER A TWO-TO-THREE FOLD SHORTFALL IN NSF FUNDS FOR THE SUPPORT OF ENGINEERING. THE TOTAL DOD, DOE, NASA AND NSF SUPPORT FOR ENGINEERING RESEARCH AT OUR UNIVERSITIES IS LESS THAN HALF THE NSF'S EXPENDITURES ON BASIC SCIENCE.

THE CHARTER FOR THE NSF MUST BE CHANGED TO REFLECT RESPONSIBILITIES FOR ENGINEERING RESEARCH AND EDUCATION. LACK OF SUPPORT FOR OUR UNDERGRADUATE LABORATORIES MEANS THAT WHILE OUR STUDENTS KNOW THE THEORY, THEY AREN'T FAMILIAR ENOUGH WITH ITS APPLICATIONS WHEN THEY GRADUATE, AND HENCE IT TAKES MANY GRADUATES ONE TO TWO YEARS OF INDUSTRIAL EXPERIENCE TO BRING THEM UP TO SPEED. WE LACK THE GRADUATE STUDENT SUPPORT TO ATTRACT THE

BEST OF OUR UNDERGRADUATES TO PH.D. STUDIES TO INCREASE THE POOL OF TALENT AVAILABLE FOR FACULTY POSITIONS. FINALLY, THE SUPPORT FOR UNIVERSITY RESEARCH IN ENGINEERING AND FOR THE FACILITIES TO CONDUCT THIS RESEARCH MUST BE EXPANDED IF WE ARE TO BE EFFECTIVE PARTNERS WITH INDUSTRY IN PROVING THE TECHNICAL ADVANCES THAT ENSURE THIS COUNTRY'S TECHNICAL COMPETITIVENESS. A MINIMUM ADDITION OF 140 MILLION DOLLARS TO THE NSF BUDGET IS NEEDED FOR NEXT FISCAL YEAR IF NSF IS TO DO WHAT NEEDS TO BE DONE FOR ENGINEERING RESEARCH AND ENGINEERING EDUCATION. I SAY THIS AT THE VERY MOMENT THAT NSF IS STUDYING A RETURN TO FY 82 EXPENDITURE LEVELS.

THERE IS MUCH TO BE DONE. THE TIME FOR STUDIES, HEARINGS, EXPRESSIONS OF CONCERN AND DISMAY IS PAST. NOW IS THE TIME FOR ACTION. THE PRINCIPAL INGREDIENTS OF THAT ACTION ARE NOW CLEAR. ALL THAT IS NEEDED IS THE DETERMINATION TO ACT.

Mr. WIRTH. Thank you very much, Mr. Seebass. I not only find myself agreeing almost completely with the substance of what you had to say, I would just like to reflect on when I was first running for office people asked had I ever run for office before, and I said, "No, and I'm not a lawyer, either." That is also parallel to what you're suggesting about the production of lawyers, with all due apologies to my colleague from Dallas.

Mr. SEEBASS. And Senator Meiklejohn, too.

Mr. BRYANT. And half the Congress.

Mr. WIRTH. More than half the Congress, I think.

Our next two witnesses are Mr. John Pigler and Mr. Trenton Gary from Colorado Training Foundation. Mr. Pigler and Mr. Gary represent the CWA, Communication Workers Local 8412, which founded the Training Foundation. The purpose of the training foundation is to address the training and retraining of communication workers in order to head off future displacement and unemployment of those workers. Mr. Gary has been with Mountain Bell ince June of 1981, initially as a directory assistance operator. Mr. Pigler is a circuit analyst with Western Electric and has been with Mountain Bell as a technician.

Gentlemen, we thank you very much for joining us this morning and look forward to hearing from you.

STATEMENT OF TRENTON GARY

Mr. GARY. Mr. Chairman, members of the committee, thank you for the opportunity to testify here today.

My name is Trenton Gary, and I'm a member of the Communications Workers of America, Local 8412, which represents 6,500 Mountain Bell workers in the metro Denver area. I am also the director of business and industry relations for the Colorado Training Foundation, Inc., which, as Congressman Wirth said, is a wholly owned subsidiary of CWA Local 8412.

First of all, I'd like the record to show that I'm speaking in behalf of CWA Local 8412 and the Colorado Training Foundation, and that my statements, opinions, and views may not necessarily reflect those of the CWA International Union or any other CWA local.

In January of 1983, Senator Gary Hart wrote in a draft of the new employment strategy that, and I quote,

> Fundamentally, we need new employment strategy that invests in human assets to obtain the highest and most productive return for the economy, the nation, and the workers themselves. That program is one that requires the combined, sustained efforts of labor, business, and government on all levels. Over the next decade, American workers will face a substantial occupational upheaval. Many of today's occupations will be substantially altered or simply will no longer exist. Workers from the shop floor to the office will need new skills to work with the emerging information technologies.

With the impending Bell System divestiture, we are, indeed, witnessing the beginning of a new era in the communications industry, an era that is bringing with it a flood of new communications companies into the previously Bell-dominated industry. And with them, they are bringing a new competition for the most advanced technologies and the most qualified employees.

The new emphasis on competition is placing an urgent need on the workers to seek higher training and education in order to be able to compete for the better jobs and to maintain employment in the midst of jobs being displaced by new technologies.

Even before the divestiture takes place, this trend is being evidenced by a decline in upward mobility and an overwhelming feeling of insecurity by CWA Mountain Bell employees.

CWA Local 8412 has elected to attack these problems on a local level. In February of this year, the officers of local 8412 commissioned John Pigler and myself to investigate and create a union-initiated training program, and in July of this year we formed the Colorado Training Foundation, Inc., a not-for-profit Colorado corporation for the purpose of offering an accessible, comprehensive, continuing educational program to communications workers that will promote self-pride, career professionalism, and job security through training.

With the spirit of Senator Hart's draft of the new employment strategy in mind, we have designed our program to work in the atmosphere of a joint labor-business-government effort on a local level. By utilizing existing educational institutions and resources that are readily available to us, our primary criterion for determining skill development is, indeed, employment security and we, therefore, will take into account the direction of the employer company, as well as the industry as a whole.

Our joint effort will be taking great strides towards the ultimate goal of personal and career development that will lessen the impact of job displacement and reduce the amount of unemployment due to technological change in the communications industry in our area.

At this point, I would like to introduce John Pigler, and John will explain the program we have established with the Denver Auraria Community College and touch on what we are attempting to establish with Mountain Bell.

STATEMENT OF JOHN PIGLER

Mr. PIGLER. Thank you, Trenton.

The primary purpose of CTF is to provide an education and training program designed to enhance job and career security. The CTF is attempting to head off displacement and unemployment by providing an educational tool which will assist the employability of each individual.

CWA Local 8412 is a local union which represents the majority of the Mountain Bell work force in Denver. It is from this perspective that I speak.

The technological advances and the communications field is changing at such a pace that we cannot stay abreast with them. The Colorado Training Foundation wishes to act instead of react to these changes. We currently have established a curriculum with the Denver Auraria Community College which provides compressed credit courses which lead toward a certificate of achievement or an associate's degree, with an additional option of a baccalaureate degree if the individual so chooses.

The curriculum is designed to provide a broad range of skills which apply not only to the telephone company, but also to the communications industry. The thought behind this concept is that the individual employees should receive courses which elevate his or her possibilities for promotion and security within their current employer and to improve their chances of reemployment in the same career field if technology or company restructure creates displacement or a loss of their job.

The proposal of the CTF submitted to Mountain Bell, the State of Colorado, and an agency of the Federal Government requested joint effort as formated by the CTF to provide training and education and to encourage continual process.

Our issue is local to this city and to this State, even though the concept may have national applications.

It is my opinion that the basic question each educational facility should ask of itself is, am I providing timely education in a dynamic atmosphere which outdates itself before an individual completes his or her education? I do not feel that this issue can be properly addressed at the State level. The lack of scientists, engineers, and skilled workers is of national concern and a national policy should address this issue. However, I feel the governing of this policy should be at the State level.

Perhaps the solution or incentive would be a forgivable loan program for math and science students. Perhaps another solution would be orientation toward math and science at the elementary level of education, math being a division which normally requires several repetitions before absorption. It should have this opportunity for repetition.

I do feel strongly that the graduation requirements from high school as some areas have initiated is, indeed, necessary for more comprehensive youth. However, shouldn't a strong math and science background be instilled before the day of graduation?

A final point which I feel needs to be emphasized is that of continual education and training. Had that point been emphasized in the socialization process 10 to 20 years ago, the need for the program I'm currently involved in wouldn't be necessary today.

Thank you, Mr. Chairman, for this opportunity to express my views.

Mr. WIRTH. Thank you very much, Mr. Gary and Mr. Pigler.

Our final witness on this panel this morning is Dr. Michael Massarotti, the deputy superintendent of schools, Adams County District 50. Mike?

STATEMENT OF MICHAEL MASSAROTTI

Mr. MASSAROTTI. Congressman Wirth and Congressman Bryant, it's an edifying experience to be among such august individuals. I appreciate the opportunity to share some thoughts with you.

My comments are made in light of diminishing and decelerating fiscal resources and the growing criticism of public education. A recent report suggests that the year 1983 will go down as the year of reports, 138 of them.

Mr. WIRTH. If we hurry, we can get in one before the end of the year, or shall we start the new year—we'll do it with you, Al, and start.

Mr. MASSAROTTI. There are certain things that we recognize that I would like to address to the panel and to you, gentlemen, before I make comments about some perspectives and observations we have about this effort.

We recognize that elementary and secondary education happens to be the front end of that big pipe that leads to that graduate research Ph.D. who makes his or her contribution to this total effort of leadership and maintenance of the leadership posture. We recognize that America's greatest resource is our human resource, and I think much of the criticism of public education may be justified, to an extent, because we went through a period that I characterize as rather permissive and low expectations, and I think that trend is changing. We see the period of time with the variables impinging on our operation, we see that adversity as really opportunity in disguise.

We're optimistic because we are living in a marvelous period of human experience, and seldom has a generation been afforded an opportunity to employ the creative energies now available to us as we move in transition from an industrial era to the morning of a technological revolution.

I think we are naive to believe and not recognize that today's marvels are mere primitive forerunners of what is to come, and I believe that not since Galileo's application of telescopic optics in 1610 has man been on the threshold of mindboggling discoveries with the use of the space telescope which will be launched later in this decade.

We know that there is a burgeoning body of knowledge that education must understand, include, and extend to our students.

We recognize that man is playing and will play various roles in the evolution of technology—technologist, developer, manufacturer, sales, and utilitarian user. We recognize that there is an increased opportunity to utilize this technology and information it produces even today in a cost-effective manner.

We were talking yesterday with a company about transmission systems and we were looking at a fiber optic system, and the individual suggested to me that we now have a plastic system that will conduct that light, and I said, "Yes, but only 200 feet with the speed that we want." So I'm encouraged by the options of materials that may allow us to utilize this technology in a more cost-effective manner.

When we talk about education, we talk about change, and I would like you to be aware of certain things that educators are faced with in trying to move people along in a reasonably efficient manner, and one happens to deal with the nature of technology and its influence on man.

Someone argued that the utilization of technology causes man to surrender his freedom to his creations. Michael Crichton in his book, Congo, would suggest that this is a shallow concern. Man began to surrender degrees of freedom when he domesticated animals. We recognize now in retrospect that the labor performed by animals in effect freed man to perform the tasks at hand more ef-

fectively and efficiently and to pursue higher order goals. We must not be so myopic to not transfer this insight into the potential effect of new technology.

We receive people from universities who did not anticipate this revolution and, as a consequence, came to us with old knowledge, and it's not the fault of the professional educator and I don't know whose fault it is. It is not my intention to place blame today, but seek solutions.

The educational programs at the universities must be remodeled. They must be revamped in order to provide skills at a teaching and administrative level for us to do the job that we have to do. It is inconceivable for me as a former university professor that we can prepare a professional classroom teacher with 30 undergraduate hours in education. But I suspect that will be a battle that will be fought and waged for years to come, and I do not expect any significant changes in those programs beyond the undergraduate program in my lifetime.

The problem with the educator, I think, relates to, in part, the nature of man. Man tends to seek stability and certainty. He is within his comfort zone with the predictable and habitual. Yet our potential as higher order animals is our ability to adapt. The previous speaker made that comment, survival will depend on that. And I believe that seemingly rapid technological development will compel man to be more at ease with change.

To recognize and actualize the power of technology will facilitate the achievement of a continuing degree of evolutionary freedom. The extent that we learn to cope with this realization will enhance or retard the freedom that we now have.

As educators, we must not fall in the trap of focusing on the tool, but rather on how the tool can be applied. It is interesting to speculate on what our railroad industry would be like today had the railroad industry focused on transportation rather than trains. It is our opinion that the real issue today is not the computer but its application in the management and promulgation of information.

The potential data bases with user-friendly processing will facilitate the retrieval of information normally not accessible. In addition, the professional educator can be relieved of menial time-consuming labors, not only administratively but in the classroom. The acceptance and mindful use of this tool can revolutionize the manner of human interaction in the classroom. Assuredly, we can improve timely decisionmaking. A teacher could be freed to pursue individualization of instruction, to emphasize changing ends and changing means, to link the present to the future.

We have the concern of declining test scores and academic performance, and the Japanese did, in fact, establish a high level of expectation. With local prerogative in the way schools are set up today, it becomes a task for individual school boards and districts to not compromise a sense of excellence and accept mediocrity, whether it's at an administrative, teaching, or student performance level.

For the most part, our current generation of educators were educated to serve the needs of an industrial society with reasonably fixed limits. Yet we find ourselves with the awesome responsibility of educating the children of today for the predictable uncertainty

of an evolving technological society of tomorrow with no apparent limits.

We perceive it as a magnificent challenge and a magnificent opportunity for educators to model our ability to be lifelong learners and adapt our environment. As we believe that the universe is expanding, so must man expand as an integral element of that condition. We must begin by extending our commitment to continue our learning and mindfully assessing our behavior governing values that have served us in a passing era.

As I said when I began, that adversity is really opportunity in disguise, and much to the chagrin of some of our critics, we are doing something, and I would like to represent some things that can happen in a school district.

We didn't sit around and cry over spilled milk that the university did not provide knowledgeable people in the area of technology to help us develop youngsters. We understood the importance of bringing people along. I have a 92-year-old immigrant father from Italy, and his favorite comment was, "You cannot apply what you do not know," and districts attempting to implement the computer or a computer science department without preparing teachers to implement the expectations of the curriculum are throwing good money after bad.

After a systematic plan that was developed in 1979, we can say today that 95 percent of our teachers have gone through—district-sponsored, no extra money, supported by local funds—a 3-credit hour graduate course in computer awareness with a followup course computer-assisted instruction.

We see students encountering the computers in our curriculum in three ways: First, as an object of instruction; second, as a problem-solving tool; and, third, as an aid to instruction, directly and indirectly, with files and information the teachers can access to promote individualization.

The reeducation of the cadre of professional classroom teachers originally educated in an industrial mentality is critical if we are going to cause the curriculum to move ahead and to provide the kinds of entry skills that the universities need to produce the people to maintain our lead.

We cannot overlook an older citizenry that will be affected by technology. There is a need for adult education courses to provide these people with an opportunity to understand this tool, and the greatest challenge comes in the education of the current generation to possess the entry skills and attitude of an information high tech society.

In the remodeling of our curriculum, our district was one of the first in the United States to implement a 10 semester hour graduate requirement in computer science. And I agree with an earlier speaker who suggested that it is not secondary education's role to produce computer experts, and we understand that. However, we felt, in the design of that curriculum, that high level skills should be made available and the opportunity to develop those skills for those people who wish to continue their education at the university. It also attends to the student who must be impacted by technology and the computer in understanding personal applications and issues related to the consumer end.

A second challenge that we have is the need for more math and science teachers. We find it kind of interesting, we're caught between a rock and a hard place. The people who are capable and who are attracted into engineering and other areas leave us in a dilemma. Who do we get to teach these courses? That's an issue we have to deal with, Mr. Chairman.

We need to develop a system to capture the creative imaginations of people and needs outside the military- industrial complex which can promote new paths of research. We are currently involved with a large corporation at an advisory level. We've been involved at a controlled introduction level. We're hopeful of becoming a beta site for some ideas that we have in this area.

We need to develop models to foster a synergistic relationship between and among government, business, and education. A speaker said it best a minute ago, "I believe that research and development is the lifeblood in the renewal component of front runners and that we must develop ways to pump prime research to assure our leadership."

Districts have to be careful about the mindful acquisition of hardware and software minimizing expense competition with other general fund expenditures. And when the day comes when we have grant moneys made available because of cooperative projects between business and education where both agencies can receive a portion of the funds to support that cooperative research, that we don't fall in the trap that we found ourselves with the NDEA act in the mid-1960's, where there was a proliferation of expenses associated with the administration of those programs, A $50 microscope suddenly became a $100 microscope and our purchasing power was significantly diminished.

I think that there are other creative ways if direct funding is to occur where a structure for review of proposals can be made in cooperation with committees who are not employees on a long-term basis with the Federal Government but who are called together occasionally to represent the different interest groups and to pass on those proposals and support those proposals that have the best merit.

I'm probably overtime, but I would like to conclude by saying that I believe as many, that it is not our manifest destiny to remain leaders in high tech. I don't think that God, if one believes in God, has suddenly decreed that the United States of America is now and for always will be in a leadership role in this area. It will take a commitment of resources and leadership to maintain our lead, and I call for some form of national plan or policy on the magnitude of the plan that put man on the Moon if we're really committed to remain leaders in this area.

And I end by saying that I was always taught to be cognizant that success is a journey, not a destination.

Thank you.

Mr. WIRTH. Thank you very much, Mike. I also note here is Dr. A. Joseph, who is the superintendent of district 50 and recipient of the recent ET-83 award, emerging technologies 1983, on behalf of district 50. We're glad to have you here.

Mr. JOSEPH. Thank you.

Mr. WIRTH. Would any of you like to comment on what other members of the panel have said?

[No response.]

Mr. WIRTH. If not, let me begin. The purpose of what's going on in these umpteen number of reports that have been put together in the last year, the purpose of what we're trying to do with essentially a very technical subcommittee that needs the underpinning of well-trained individuals is to raise that level of consciousness. This window of opportunity, it seems to me, doesn't come along very often. It came on after Sputnik, was open for a while, we took advantage of it, and it shut down and the Nation went on to other things. We now have the window probably for another 2 or 3 years.

Assuming that's the case and we're all in here trying to take advantage of that from various perspectives, one of the questions that we face all the time was said initially by you, Senator Meiklejohn, in your statement, Who does what? At what level of government do various responsibilities reside?

You made the statement, if I can badly paraphrase it, that we want as little interference as possible from the Federal level, but there are certain responsibilities that the Federal Government has that they must fulfill. We are constantly in a position of sometimes justifiably being accused of having eyes that are bigger than our stomachs in terms of what the Federal role ought to be.

Perhaps you might touch on those things that you think, picking up from what your other colleagues on the panel said, the Federal Government should be doing, and maybe we could get reactions from the rest of you as to what we ought to be thinking about rather than what we should be leaving to other levels of government and to the private sector.

Mr. MEIKLEJOHN. Let me answer it this way, Mr. Chairman: I think there are some things that are essentially local, and I think we would all agree, for example, that the management of the university is a local matter and the Federal Government shouldn't try to manage it. Then you start getting into some grayer areas.

I disagree with a remark that you, or perhaps you, Congressman Bryant, that there would sooner or later be an all-white engineering school, all-white law school, so on. I don't think that's the way things are working. I think that the decreasing student aid, which I view as a calamity, has put the aid down in the lower economic strata and that, as a matter of fact, the people who are being excluded from college and university should be the upward mobile, lower middle class. They can't afford it. They don't qualify for aid and they don't have enough money to send their kids to school. But if you're real poor, you can get the money to go to college. I'm not articulating too well.

Mr. WIRTH. No; I understand. That had been my statement. So what you're saying is that the aid—what limited aid there is—gets to those who are most in need and there is a very large group who historically might have——

Mr. MEIKLEJOHN. What I'm trying to say is Colorado is not Mississippi or Alabama. Colorado has a good school system, which certainly can be improved. But one of the problems in it is the area of math and science teachers. Perhaps some of the educators around here could help me with the number, but when the Commissioner

told me the number of math and science teachers that we're going to graduate in the State of Colorado this year, it was simply appalling, and it borders on like 30 or 20, something on that order. I just couldn't believe that that was all the math and science teachers we were graduating in Colorado in a year.

Something has to be done about that. Part of it is legislative in Colorado. But to come back, your question was, What is the Federal role? See, I don't believe that a State can subsidize those young men and women, because we don't have the dough. We simply don't have the money, or at least it's perceived that we don't.

I think the Federal Government alone can implement some kind of tuition or education subsidy for these critically needed skills, which are nationwide in short supply, math and science, in our current context being the problem. It seems to me that those are the areas that the Federal Government can most profitably assist in these very substantial problems. God, I'm glad you're holding these hearings, Tim.

Mr. WIRTH. The first priority would be research and development and the subsidy of the students going through programs; is that——

Mr. MEIKLEJOHN. My first priority for the Federal Government in this area, my first priority would be subsidizing young men and women who are working on Ph.D. level skills in engineering and sciences. That would be my No. 1 priority, because I think we're approaching a disaster in a few years in that area.

Mr. SEEBASS. I can put some price tags on the Federal cost of doing that, if you want. When I say you need to add $140 million to the NSF budget this fiscal year or next, I don't do that lightly. I don't do that without knowing what the components are. But just let me remind the audience here that this only impacts the Federal deficit in the fourth decimal place. The Federal deficit is $200 billion and we're talking about $140 million, a trivial expense, given the expected return on this investment.

You've got to put $30 million into recruiting the best undergraduate engineering students to graduate education, which is just exactly what Senator Meiklejohn would do. And then entice the best of those into academe; this will cost $30 million a year indefinitely.

You need to insure that our laboratories are equipped so that the students that go out don't have to be retrained in industry at their expense for 1 or 2 years. That's another $30 million a year.

You've got to also help us redirect, and as Senator Meiklejohn noted, it's not easy, our efforts toward those areas that are of most current importance. That's roughly a $20-million-a-year expense.

You also need to encourage the States to get involved in this enterprise by subsidizing, through matching dollars from the Federal Government and the State governments, breeding grounds, call them greenhouses, for high-tech enterprises at the universities. New York State has done this especially well. That will cost the Federal Government $55 million each year for several years.

And you need to encourage our undergraduates to get interested in research so that they will go on to this graduate program; that will cost about $5 million a year.

That's a total program of $140 million a year. It's a trivial expense in a Federal budget.

Mr. WIRTH. I think many of those items were included in the House Budget Committee mark last year. I think we worked with your department and with the National Academy in putting together the package for reinstrumentation, for incentives to keep some of the best people in universities so that they were going through as assistant professors and weren't going down the road. I think there was another part of the package which was the retraining of teachers on the assumption that we're not going to attract a large number of people who are going to go into the teaching of math and science.

One of the things we learned how to do pretty well in the late 1960's and early 1970's was retraining teachers out of the NDEA program, and that we ougnt to put a large emphasis on the redevelopment and retraining of existing cadre of teachers. Mike, I think you and I have talked about that.

That seemed to be, from the literature that we were able to sort out last year, the best approach to the 20 to 30 graduates you were talking about, Al, was the retraining rather than assuming that somehow we're going to attract people in.

That package got as far as discussions with the Office of Management and Budget, which they said a flat no and, in fact, we spent our time not trying to provide any increments for these future investments but holding the line against further cuts. So it's not as easy as——

Mr. SEEBASS. I understand, Congressman.

Mr. WIRTH. You will find, I think, an enormous amount of agreement here. I don't think there is any disagreement, and I would suspect no disagreement on the priorities that the two of you set in terms of clearly outlining those areas of Federal responsibility.

Mr. MEIKLEJOHN. Let me put a footnote in, though, if I may, Mr. Chairman, to what Dean Seebass said. He's talking about engineers. I spread that Ph.D. crisis broader than engineers. I say scientists, as well as physicists, biologists, so on.

Mr. SEEBASS. I don't disagree with that. I'm just delineating the engineering component.

Mr. BRYANT. I tend to, perhaps because of being new on the job, reduce it down to more simple political terms when I look at the problem; 11 months ago I was still a member—nearly 12 months ago—of the Texas legislature and the Committee on Education, where I had served for 9 years. I found that year in and year out we had no support in a part-time legislature—and I don't know whether that's what you have here or not—but from the business community and the ones that had the most influence on the direction of our legislature for public education.

The problem in our State simply is that we're about 41st in the Nation in per pupil expenditures and our teachers are quitting because they're not making any money and, of course, the quality of the end product is much poorer than it should be for a State as wealthy as ours.

I don't know how any of those problems translate to Colorado, but I know that, if you read the literature about the Nation, there is a similar problem all over the place.

I just wonder, Dr. Seebass and Dr. Massarotti and also Senator Meiklejohn and anyone else, as well, I hear a lot of discussion

about getting the private sector involved in the problem, we've got to encourage this and that, and we've got to get the private money into it and so forth, I wonder what experience you've had here in Colorado in getting them to participate, not only with grants and so forth from their companies, but participate in encouraging the Colorado legislature or the Congress to order their budgetary priorities in such a way that we place public education in the order, in my opinion at the top of the list, where it should be.

Mr. SEEBASS. I would say in Colorado that we have benefited enormously in our engineering colleges from collaborative enterprises with industry, especially industrial funding of our equipment needs and industrial funding of our research needs, as well as support for development of new faculty. But it's a factor of 10 too small, and I think industry has really gone to the edge of what they can do for us.

Mr. WIRTH. In terms of direct funding. What's the other piece?

Mr. SEEBASS. The other piece, of course, industry's been very helpful in the support of Senate bill 1 introduced by Senator Meiklejohn and championed for industry by Dr. Wiederecht, and their political support has been influential in changing the attitudes in the State, and I think eventually that will result in funding for the Colorado Advanced Technology Institute. But I don't see the money there in the State, at the State level, to do the things that need to be done this year.

Mr. MEIKLEJOHN. Congressman Bryant, our K-12 funding formula was evolved from what was called COED, which was a State organization composed, in large measure, by Colorado Association of Commerce and Industry, the Cattlemen's Association, some of which are the big citizen groups, CACI, Colorado Association of Commerce and Industry being the equivalent of our State chamber of commerce. And it's a workable school finance formula, which if you can say it works, you've said a lot. I don't think anybody thinks any school formula is good, but it works.

And because of that, because of that support, we are above average in Colorado in our expenditures for K-12 education.

As Dean Seebass said, CACI, the higher education council of CACI, supported the establishment of CATI. The industry itself has agreed to fund CATI. That's embarrassing to say that the State of Colorado couldn't fund an agency as important as the Colorado Advanced Technology Institute, but that's exactly, you know, the short pockets that I ran up against.

Dr. Wiederecht and some of his colleagues in industry undertook, along with CACI, to fund it for the first year with volunteer contributions.

The Governor just convened a small business conference within the last month, and the fifth and sixth priorities of small business industry were the adequate funding of K-12 education and postsecondary education. So I can say I think that the business community in this state understands it. What I don't think is happening is that the general assembly is not understanding what business and the people are saying. I think it's just sad, but that's the case.

Mr. WIEDERECHT. Congressman Bryant, if I may add some comments to this also. Speaking both from the association with CATI and a large corporation, I think what Dean Seebass said is true,

many companies have addressed their civic responsibilities in terms of grants of funds for fellowships, for equipment, and for various innovative programs; however, the number of such requests far exceeds the ability of those companies to really meet the need. Therefore, that is what has underlay the concept of CATI, whereby we seek to find means whereby we can have challenges by matching funds from the public sector which will encourage industry, provide incentives to industry to give additional funds by, at the same time, complementing what those funds are that are coming from the private sector. That way we would hope to be able to more closely approach the total funds that are really needed to do the job.

With regard to the funding of CATI, indeed, we recognize the State of Colorado had a fiscal problem in this past fiscal year, and it was for that reason that, because the timing was right for the formation of our institute, that we felt we had to go forward with it and accept the fact that there were no funds to be allocated at the start. So industry's contribution was a show of further interest and an attempt to help defray administrative expenses for that first period of time.

However, we will need to, indeed, find public support, both from the State and Federal governmental agencies in the time ahead.

I might add that one more facet to this, there seems to be possibly a need for increased public awareness. I think that can help the public to put their priorities more properly before their representatives at the State and Federal level.

It strikes me that in many cases the communications and meetings and written and various other forms is amongst a group of people who are relatively small in number who really know and share the sense of crisis and want to do something about it, but there is a need to extend that awareness and set a national priority on a much broader scale so that you can get the kind of consensus support that we need in order to do this job.

Mr. WIRTH. Gentlemen, thank you very much. We greatly appreciate your willingness to join us and help us.

Let me just put this in the context of what we're doing is attempting to reach out as broadly as we can to as diverse communities as Dallas, Albuquerque, San Diego, Portland, Minneapolis, Nashville, Chicago, Cleveland, Boston, New York, to name some of the communities in which this subcommittee and other members of the full committee are having hearings focused in a very, very similar way, trying to reach out and develop more broadly the support for precisely the kinds of investments and priorities that I think we all share.

It's an undertaking that is difficult at a time with a $200 billion deficit and all of those priorities we're aware of, but it's a matter of, I think, being much clearer in terms of setting priorities. These things do get lost in the rounding, but you round a whole lot of programs and after a while, as Everett Dirksen said, "A billion here and a billion there and pretty soon you're talking about real money."

Thank you all very much for being with us, gentlemen. We appreciate it. We could spend a great deal more time on the retrain-

ing and on elementary and secondary education, and we hope to have another opportunity to do that and to work with all of you.

Thank you very much.

[Whereupon, at 11:20 a.m., the hearing was adjourned.]