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INSTRUMENTATION AND AUTOMATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON ECONOMIC STABILIZATION

OF THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

EIGHTY-FOURTH CONGRESS

SECOND SESSION

PURSUANT TO

SEC. 5 (a) OF PUBLIC LAW 304
79TH CONGRESS

DECEMBER 12, 13, AND 14, 1956

Printed for the use of the Joint Economic Committee

UNITED STATES
GOVERNMENT PRINTING OFFICE
85561 WASHINGTON : 1957

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 75 cents

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INSTRUMENTATION AND AUTOMATION

WEDNESDAY, DECEMBER 12, 1956

CONGRESS OF THE UNITED STATES,
SUBCOMMITTEE ON ECONOMIC STABILIZATION OF THE
JOINT ECONOMIC COMMITTEE,
Washington, D. C.

The subcommittee met, pursuant to notice, at 10:10 a. m., in the Old Supreme Court Chamber, United States Capitol Building, Washington, D. C., Hon. Wright Patman (chairman) presiding.

Present: Representative Patman.

Also present: John W. Lehman, clerk, and William H. Moore, staff economist.

Chairman PATMAN. The subcommittee will please come to order.

Somewhat over a year ago, this subcommittee held an extensive set of hearings on the subject of automation and technological change.

At the close of the hearings, we concluded that the great benefits of an accelerated pace of technological change could be realized for the Nation without substantial social costs by way of lost jobs or excessive personal suffering by reason of displacements.

The subcommittee was convinced, however, that the problems of automation are by no means negligible or settled. If it were not for our present high-level employment, prosperous economic situation, we might be faced with some painful adjustments as a result of the great rush of technological change.

For this reason the Subcommittee on Economic Stabilization feels that it is desirable to review regularly the role being played by this potent force in our economy.

Automation and technology are bringing us new and better products at lower costs. As a Nation we welcome the fruits of this advancing technology, being at the same time watchful that it does not cause personal hardships for displaced workers.

In a sense these hearings are a continuation of those of last year and may well become another in a series of more or less annual occasions for checking up on our progress in this field.

While it is impossible to anticipate at this time what the evidence presented at these hearings may be, it does not now seem likely that any special report to the Congress will be called for.

The proceedings of these hearings will, of course, be given full consideration by the Joint Economic Committee in connection with its March 1 report.

In this particular series of hearings, we are stressing the role of "instrumentation." For those of us who are not engineers or technicians in the field, the word may sound rather formidable and the field one which is rather remote to our daily lives and concerns.

I am sure the witnesses who will appear appreciate the fact that they are talking about a field in which we know little, but are anxious to, and I am sure will, learn a great deal more.

The first witness this morning is Robert Sheen, president of the Milton Roy Co., and retiring president of the Instrument Society of America.

Since Mr. Sheen wears those two hats, he is going to divide his presentation of materials to the subcommittee into two parts—speaking this morning primarily as an officer of the Instrument Society of America, and at a later point in the hearings coming back to tell us some of the special problems of small business in the field and in more detail about the place of instruments in the broad, growing fields of automatic processes.

Mr. Sheen, we are delighted to have you this morning to start these hearings. And you may proceed in your own way. Do you have a prepared statement?

STATEMENT OF ROBERT T. SHEEN, 1955–56 PRESIDENT OF THE INSTRUMENT SOCIETY OF AMERICA, PHILADELPHIA, PA.

Mr. SHEEN. Mr. Chairman, members of the committee, my name is Robert T. Sheen, 1955–56 president of the Instrument Society of America. In the hearings before this subcommittee a year ago, considerable interest was expressed by the subcommittee in instrumentation and automatic controls—as the tools of automation.

It will be my purpose to present to you data and information on the specific growth of this field and more particularly and specifically on the role of the Instrument Society of America and its programs of service and education.

I will make several specific recommendations as to actions the Instrument Society of America believes can be taken by the Congress to avoid a possible technical recession.

Our economy is in danger of a technical slowdown due to shortages of skilled manpower. Only a year ago your committee heard testimony on this subject and then expressed concern that the United States was falling behind in the education of scientists, skilled technicians, and skilled labor.

That critical deficiency is in even sharper focus today despite much good work that has been accomplished and plans that have been made through a number of agencies, including the government, to improve the national situation.

Simply recognizing the fact that thousands and thousands of engineers and technical personnel are required on the industrial front is not good enough.

We of the Instrument Society of America believe that our Nation today is at the crossroads of our destiny. Each of us is concerned with the matters that affect the welfare of our Nation.

The Instrument Society of America submits that the need for scientific and engineering personnel is particularly pressing in the field serviced by ISA, namely, instrument-automation users and manufacturers.

This urgency grows out of the fact that instrumentation-automation is indispensable to our economy and to our defense; that increasing needs for instrumentation-automation demand more adequately trained personnel at all levels of instrumentation design and application.

We submit, and want to bring into clear focus, an irrefutable fact—that our progress as a Nation is tied closely to advancing techniques in instrumentation-automation; that we desperately need more trained manpower to continue our progress, and that unless this challenge is met now we will face an increasing technological slowdown which will seriously threaten our economy and our security.

First, let me emphasize as strongly as possible that the road to automation is not a quick one—but it is an essential one and an inevitable one.

Most important of all, gentlemen, automation—its effect on American industry and on American economy—is not a subject for controversy between management and labor. Both have a definite common objective in doing everything possible to accelerate the understanding, the education for, and the achievement of automation and what automation can do to give us a strong national domestic economy and a military preparedness so essential in our world of today.

What is the relationship of instruments and instrumentation to automation? Instruments are the devices and tools that make automation possible.

As a simple example, consider temperate, its measurement and control. The thermometer is a temperature-measuring instrument. The thermostat is the instrument that responds to temperature as a controlling device for fuel, steam, or the heating or cooling medium.

Other types of instruments are used to measure and control physical, chemical, and electrical variables. Still more complex instruments are the computers, frequently tied directly into the accounting system of the plants. Later witnesses will discuss specific types of instruments and their applications.

What is the role of the Instrument Society of America in instrumentation-automation? The Instrument Society of America was formed in 1946 with 11 local sections. Today there are 86 sections throughout the United States and Canada, and a membership of approximately 10,000.

In structure, it is a technical society and the membership is open to all with an interest in this subject. It is not a society of "nuts and bolts mechanics," nor is it a society of "long-haired college professors."

It is the only technical society in America devoted exclusively and completely to the interests and problems of instrumentation and automation. It embraces the long-haired college professor, the design engineer, the operating engineer, and the technician. It includes the medical scientist, the biological scientist, and trained instrument mechanics.

Present membership comprises approximately 43 percent as engineers, 4 percent as technicians, 10 percent as mechanics, 7 percent as educators and the remaining miscellaneous interests, and 30 percent in financial, business, sales, and production management.

The organization of the society is shown on chart I. You will note that its interests embrace virtually all the fundamental industrial areas of our economy.

And here I will refer you to the charts that are appended to the testimony that you have in front of you.

In these particular charts you will see the fact that the society for example has a number of district vice presidents, serving various areas of the country to bring us close to our various sections.

There are several technical divisions as such headed by operating vice presidents.

Then under the second portion of the chart, that is labeled as table 1–A, you will find a typical industrial division shown as a nuclear division, where the director is Dean Joseph Weil of the University of Florida chairmaning that particular division.

To give you a further idea of how this society cuts across the various fields of interest in the divisions, you will note aeronautical, chemical and petroleum, food, heating and air conditioning, medical and biological, metal and ceramics, nuclear power, transportation, administrative automation, machinery, instruments equipment manufacture, rubber, paper, scientific laboratories and so forth.

(The charts are as follows:)

I S A ANNUAL CONFERENCE AND EXHIBIT ATTENDANCE

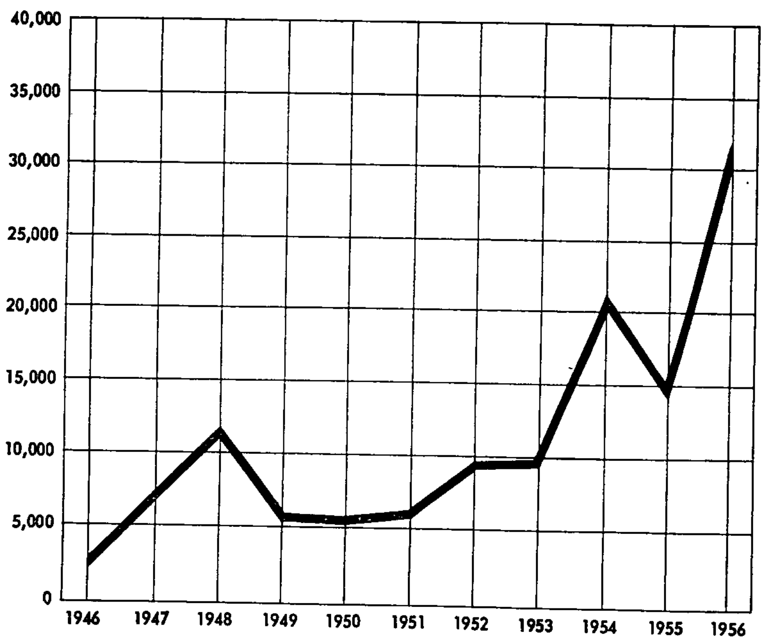
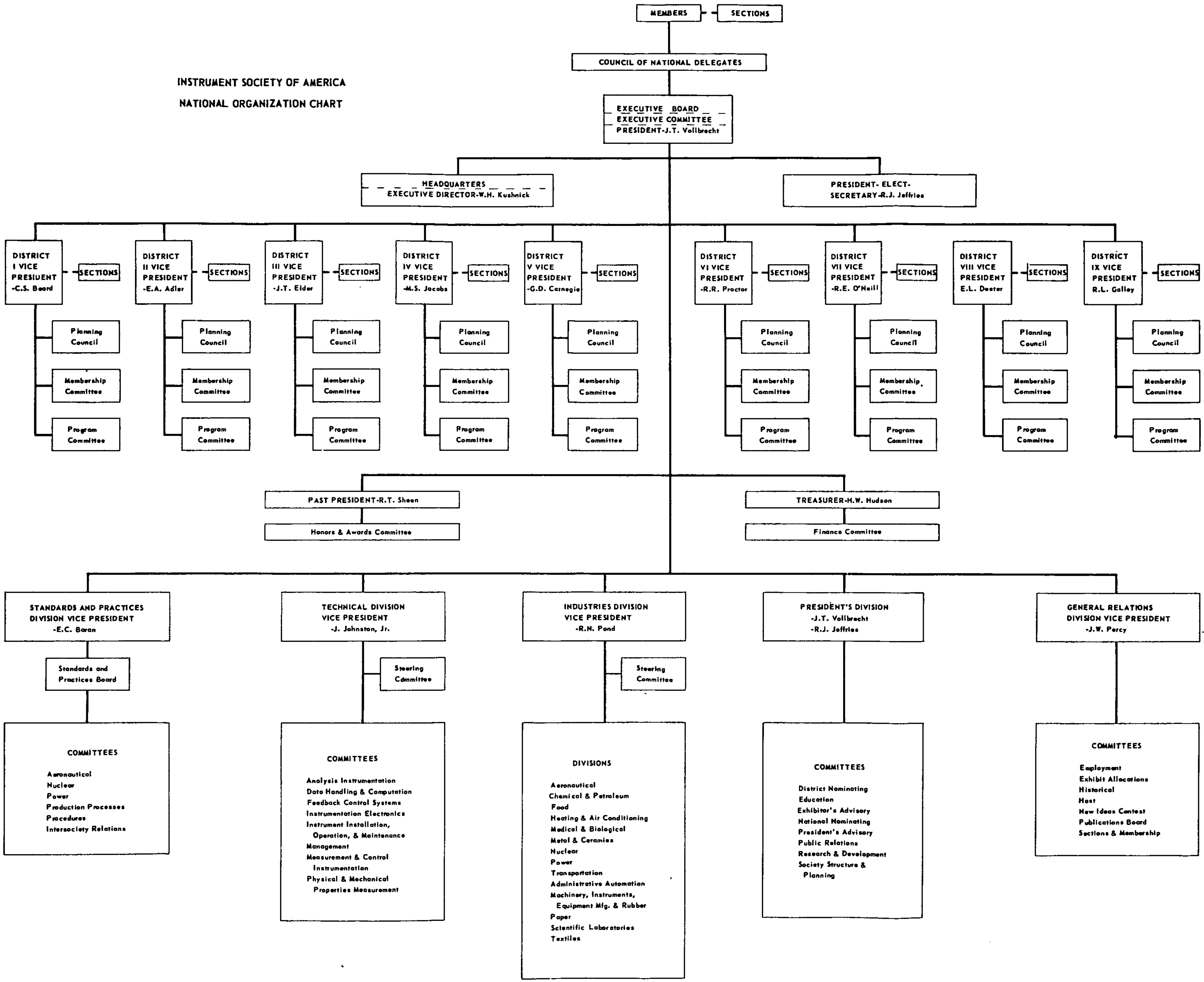


Table 1b.

INSTRUMENT SOCIETY OF AMERICA
NATIONAL ORGANIZATION CHART

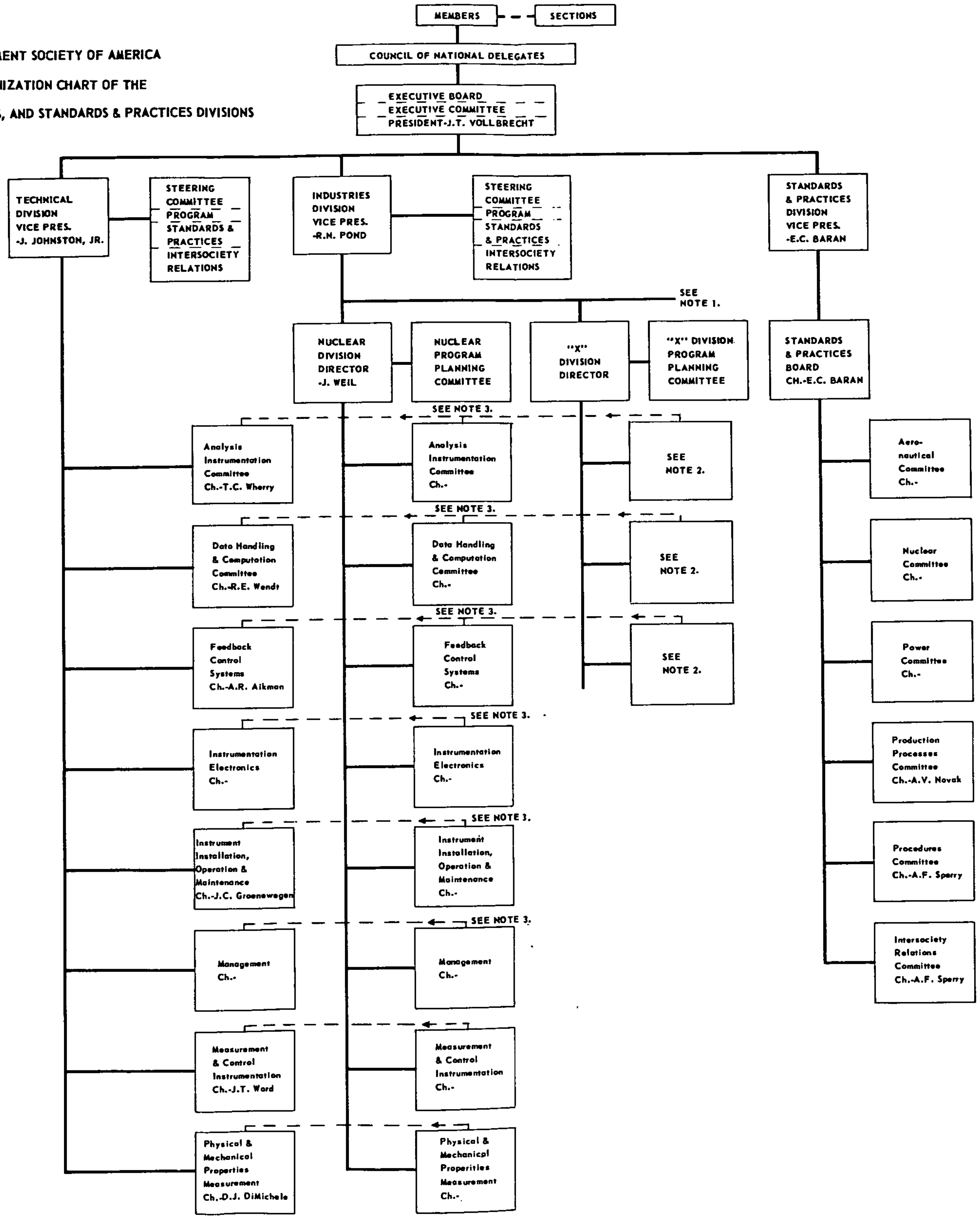


85561 O-57 (Face p. 4) No. 1

INSTRUMENT SOCIETY OF AMERICA

ORGANIZATION CHART OF THE

TECHNICAL, INDUSTRIES, AND STANDARDS & PRACTICES DIVISIONS



NOTES:

1. While only the Nuclear Industry Division is shown for illustrative purposes, other Industry Divisions represented by "X" are: Aeronautical, Chemical & Petroleum, Food, Heating & Air Conditioning, Medical & Biological, Metal & Ceramics, Power, Transportation, Administrative Automation, Machinery-Instruments-Equipment. Mfg. & Rubber, Paper, Scientific Laboratories, and Textiles.

2. Each of the 14 Industry Divisions may establish those technical committees most appropriate to their respective industries.

3. Dashed lines indicate the representation of the technical committees within the Industries Division on the appropriate committees of the Technical Division.

85561 O - 57 (Face p. 4) No. 2

GROWTH OF INSTRUMENTS AND RELATED PRODUCTS INDUSTRY

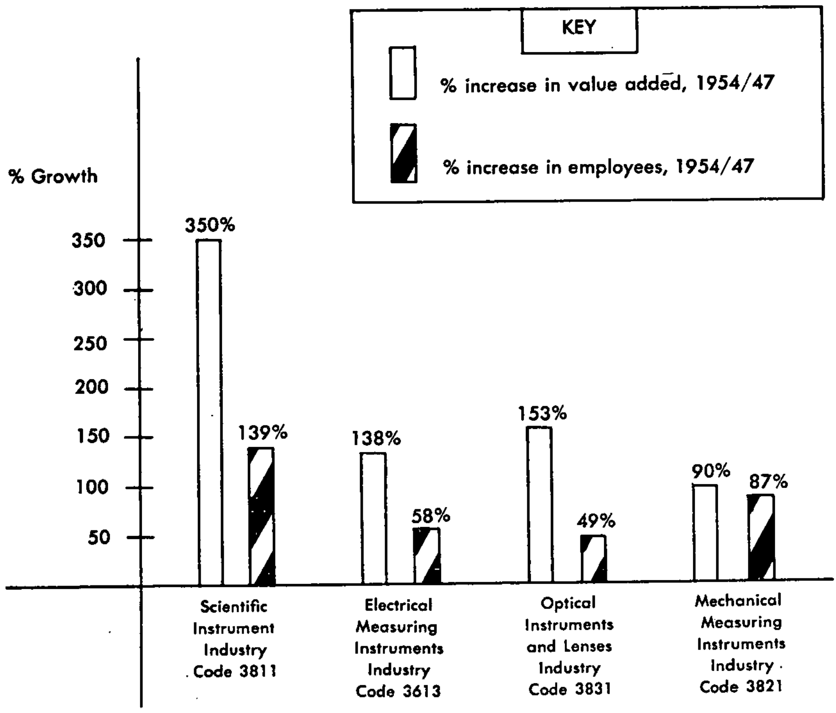


Table 2.

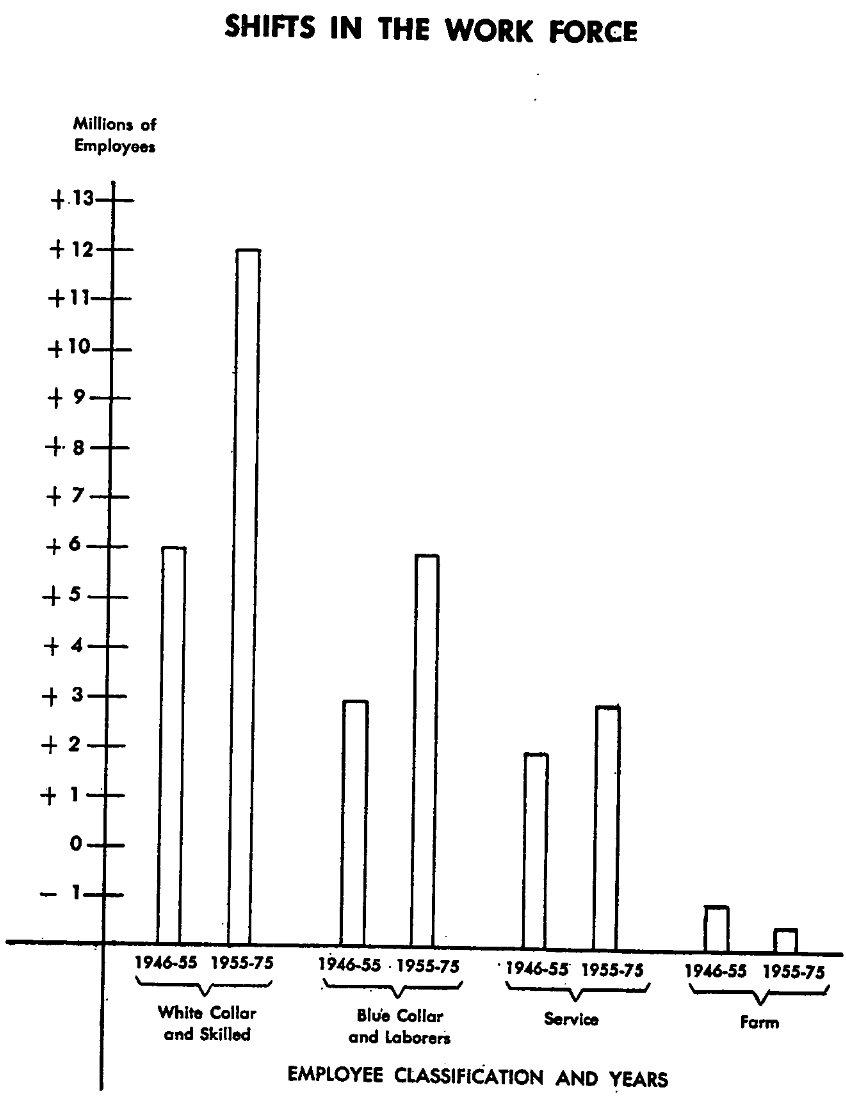

SHIFTS IN THE WORK FORCE
Millions of Employees
+13
+12
+11
+10
+9
+8
+7
+6
+5
+4
+3
+2
+1
0
-1
1946-55 1955-75
White Collar and Skilled
1946-55 1955-75
Blue Collar and Laborers
1946-55 1955-75
Service
1946-55 1955-75
Farm
EMPLOYEE CLASSIFICATION AND YEARS

Table 3.

ENGINEERING MANPOWER—U.S. and U.S.S.R

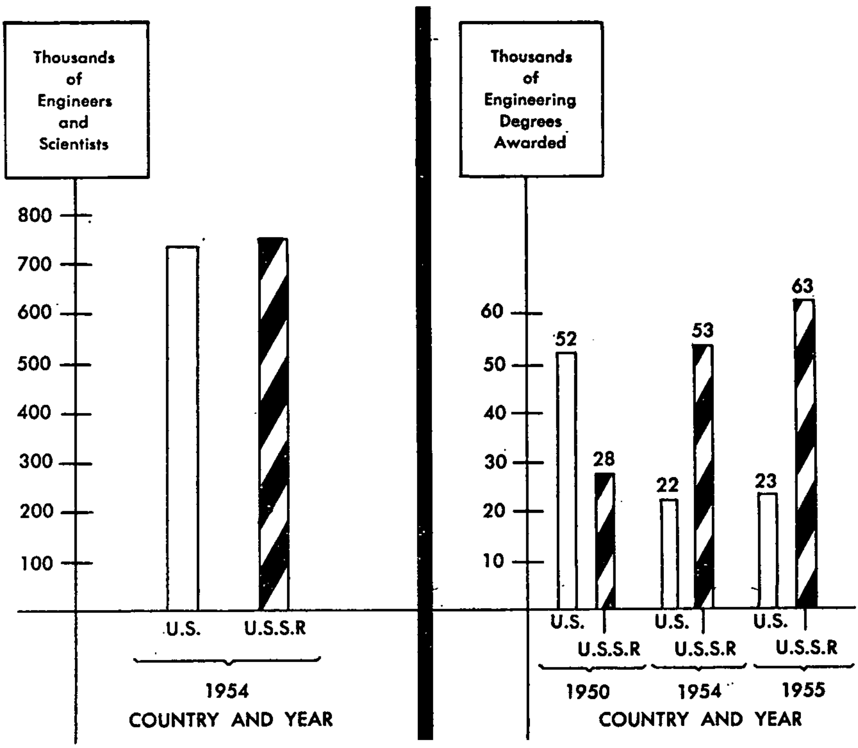


Table 4.

Acknowledge ESSENTIALITY of INSTRUMENTATION and AUTOMATION to

1—ECONOMY

2—NATIONAL DEFENSE

Acknowledge INADEQUACIES IN PRESENT SITUATION

FOUR MAJOR NEEDS

1—EDUCATE CURRENT FORCE

2—MANPOWER DEVELOPMENT

3—EFFICIENCY

4—COMMUNICATION

MEDIA FOR SOLUTION

1—HIGH SCHOOLS

2—TECHNICAL INSTITUTES

3—ENGINEERING EXTENSION SERVICES

4—MILITARY

5—FOUNDATIONS

6—NATIONAL BUREAU OF STANDARDS

7—INFORMATION CENTERS

8—MILITARY-INDUSTRIAL CROSS-FERTILIZATION

Table 5.

Mr. Sheen. There are obviously many special types of instruments and controls peculiarly designed and adapted to the needs of each of these specific industry interests.

At the same time, there is a common language of instrumentation and many instruments used in one field can be applied in others.

The society therefore serves both as a sounding board for problems and needs of the specific interest—and even more important to a cross fertilization of ideas between the several interests through the media of the technical committees.

Take for example, computers and the field of data reduction. This is instrumentation that has a broad field of application from office automation through the aircraft industry to petroleum refining.

This organization chart illustrates graphically the role of the Instrument Society of America serving as a catalyst in the dissemination of information to enhance the cross fertilization of ideas, and know-how.

The Instrument Society of America holds an annual conference and exhibit. At the meeting this year in New York City, over 30,000 attended the exhibits in the new Coliseum Building of over 450 manufacturers of instruments.

Approximately 3,000 attended conference sessions on analysis instrumentation, instrumentation for production processes, testing instrumentation, computers and data handling, aeronautical, transportation, operating and maintenance, biological and medical, nuclear radiation and physical properties and measurements.

Four sessions were devoted to instrumentation in the International Geophysical Year and instrumentation required for the world-circling satellites. This is a very interesting aspect of instrumentation. These satellites are being sent into outer space for one reason only and, that is, to carry instruments around the earth, sending back signals to the earth, received by instruments on the face of the earth, to tell us about conditions that exist in outer space.

Referring again to our exhibit in New York clinics were held including data handling workshop, maintenance clinic and analytical clinic to give information and educational training not obtainable from any other source.

In addition to this organization, which includes the national industry divisions and committee structure, we are a society with local roots throughout the 86 local sections spread throughout the United States and Canada.

There is just beginning, with our encouragement and cooperation, similiar activities in foreign lands. For example, a Mexican Society for Instrumentation and Automatic Control was formed this year and used as the basis of their constitution, the constitution of ISA.

Each of the local ISA sections have local officers and local porgrams and a series of 8 to 12 local meetings a year. Many of the local programs are geared to the needs of the instrument users and manufacturers in the specific areas; for example, sections were quickly formed at Oak Ridge; Hanford, Wash.; and Savannah River, comprised of men specifically interested in nuclear instrumentation.

I am happy to report that there are many examples where the initiatory efforts of the local ISA sections have resulted in the establishment of permanent regularly scheduled courses for instrumentation in local institutions—colleges, technical schools, and high schools.

To sum up, the Instrument Society of America is the only technical society in America devoted exclusively and completely to the interests and problems of instrumentation and automation.

Therefore, it is keenly aware of the growth problems and the necessity to insure its orderly progress and acceptance.

During the 10 years of ISA's existence, we have witnessed a tremendous growth in the broad instruments industry. Chart 2 summarizes the growth data, in terms of increases in value added in 1947–54.

And again you will find this chart included in the material before you.

McGraw-Hill's economics department estimates that the production of control field products will grow 70 percent by 1960, 200 percent by 1970—the fastest growth rate of any industry.

They point out that factory sales of data processing equipment alone have soared from rock bottom in 1940 to $25 million in 1953. Sales in this field are expected to reach $500 million in the next 4 years.

This rapid growth attests to accelerating industrywide needs, in the sciences, in engineering, and in production.

A spokesman (assistant to the chief engineer, September 20, 1956) for E. I. du Pont de Nemours just this past September states:

> A large and constantly growing percentage of the money spent on new Du Pont plants goes for advanced instrumentation. This year we'll spend about $5½ million on instruments of all types, including the highest percentage ever for automatic control components.
>
> You might gage the importance of instruments to today's plant from this example: A project we completed last year, a moderate-sized manufacturing plant, cost $8½ million. Of this sum, $1¼ million went for instrumentation.
>
> Highly advanced instrumentation is a basic economic necessity as far as we are concerned. Many of the processes which are typical of today's chemical manufacturing, would be completely impossible without extensive instrumentation. There is just too much to do and too little time in which to act for any operator to handle the many demands of complex multipurpose operations.
>
> In one Du Pont plant, for example, 520 variables affect product quality and output. Keeping track of these variables and making necessary process adjustment in time and with safety is a job which can be handled only by automatic controls.

I anticipate that Dr. John Grebe, of Dow Chemical Co., will probably amplify this subject in greater detail this afternoon.

Other factors in the rapid growth of the instruments using and manufacturing industry are the increasing defense needs of our country.

We submit that technological advances made possible by the advent of instruments and automation have enabled us to remain strong in the face of the Red menace.

For example, the Aircraft Industries Association of America, Inc., states:

> Along with the larger flight test program is the necessity for advanced methods of data recording. The complexity of instrumentation has increased in order to record the data for a complete evaluation.
>
> New systems have been developed which are capable of continuously and automatically measuring as many as 600 different channels of data by telemetering the information to the ground to be immediately analyzed by highly trained personnel.
>
> To accomplish this task of testing aircraft, the industry has been forced to expend substantial amounts of time and money on the development of instrumentation systems and to maintain a higher level of professional and technical knowledge among its personnel.

Statements of this type, emphasizing the indispensability of automatic equipment to the advancement of our technology, as well as to our defense effort, are also carrying an increasing emphasis on the manpower shortage problem that has developed.

In the past, we have heard fears expressed that automation may take place more quickly than people can be trained to fill other jobs.

In August of this year, however, the United States Department of Commerce reported that employment had hit the peak of a peak year—67 million people at work.

New jobs have been created at the rate of approximately 1 million per year, for the past 10 years, while the labor force's natural growth is estimated at only 600,000 a year. The people most in demand are trained, skilled workers, as indicated by chart 3.

Statements such as these indicate that what should concern us is not an erroneous assumption that automation may take place too quickly, but that we are not able to move ahead in instrumentation and automation as quickly as we should.

Quoting again from the Aircraft Industries Association of America, Inc.:

> The optical bombing system of the heavy piston engine bomber required 3 "black boxes" of electronic equipment, the medium jet required 43 "black boxes," all of great complexity. Current planning must include provisions for the scientists and engineers qualified to design and develop the mechanical and nuclear aircraft of the next era of flight, and the facilities to manufacture them. The aircraft manufacturer faces the unique threat of being run over by the future.

The Instrument Society of America believes that the primary problems lie within the field of education and training. My predecessor as president of ISA, Mr. Warren H. Brand, appointed a special ISA president's commission comprised of men qualified in this field to study what ISA could do to accelerate educational programs.

This commission reported back to me and recommended the formation of a foundation for instrumentation education and research. This foundation was formed this year and ISA has budgeted approximately $50,000 to start work of the foundation for the coming year.

The work of this foundation will be largely conceptional and catalytic to stimulate, organize, and promote educational programs at all levels. There is much that this foundation can do as a contribution toward the solution of this problem. The needs are urgent and great.

It is no secret that our country's greatest rival in the struggle for the minds of men, Communist Russia, has a crash program to spawn engineers and technicians of all kinds. These forced programs have been underway in Russia for years and heavy emphasis has been laid on automation by Russia as most necessary to achieve her objectives.

Chart 4 shows the comparison on the technical trained manpower between Russia and the United States.

For a further excellent discussion of this subject, I commend to the committee a recent article by Dr. Arnold O. Beckman, president of Beckman Instruments, Inc., and a past president of the Instrument Society of America—given before the Los Angeles Chamber of Commerce—that appeared in the November 30, 1956, issue of the U. S. News & World Report, appended to this report.

This report clearly indicates that we are now behind in this race with Russia in educating scientific manpower. We don't have to wait for an H-bomb to strike us to lose the cold war. We will lose it soon in the scientific manpower war if we do not bend every possible effort to solve the shortage of skilled labor and technical experts on the industrial front.

What does the ISA specifically suggest for the consideration of this committee? In the interest of clarity these recommendations are summarized on chart 5.

First, we believe that Congress should acknowledge that instrumentation-automation is essential to both our domestic economy and the national defense and that preparation for instrumentation-automation should be a common goal not only for management and labor but also for educators and for our Government.

Secondly, we hope that following this hearing that Congress will acknowledge that there are inadequacies in the present situation due largely to insufficiently trained and inadequately educated manpower.

The third point is that there are four specific needs that must be filled to correct the inadequacies of the present situation. These four needs in summary are:

1. Education of the current work force.
2. The steady influx of more engineering and science student graduates into our technological environment.
3. Increase the efficiency of each worker through the availability of instrumentation services.
4. An enhancement of the effectiveness of each person in activity through a broader base of communications as to instrumentation techniques and equipment.

Perhaps the greatest and most urgent need is for an education of our current work force. Note that we stress the educational programs for the workers now in industry just as heavily as the education of our youth to assume positions of responsibility in this new age of instrumentation-automation.

For our present workers, this means education of potential users of instrumentation-automation equipment, so that the equipment can be introduced and utilized more effectively in their own industrial areas to take advantage of our technological prowess to date.

There are specific problems in this area which should be recognized. Technical institutes and vocational high schools either are not aware, or do not have the facilities or staff to train the great host of subprofessional instrumentation personnel required to assist in research and to man the highly instrumented plants of today and tomorrow.

Educators in our colleges and universities do not have the equipment nor the experience, in most cases, to incorporate modern instrumentation techniques and courses into their curricular and student experiences.

We find that process designers, plant and machinery designers, instrument component and systems designers, all need to understand the fundamental principles of measurement, computation data handling, automatic control, and the status and dynamics of the situation to which instrumentation is to be applied.

They need desperately to keep up with the advances of fundamental and applied knowledge in these fields. They need to continuously appraise or evaluate the potential and application of new equipment and techniques of instrumentation.

There is, concurrently, an increasing demand on the abilities of the technicians who operate and maintain the complex devices and systems of instrumentation. These technicians need the opportunity to improve their talents.

In many instances, their whole backgrounds in physics, mathematics and quantitative concepts of measurement and control need up-dating. All too often, their technical background is nonexistent.

This need is a national need—every paper mill in the South, and every chemical plant in Florida, has a need for an education of its current work force at all levels, from a mechanic who must maintain the instruments, to the president who must pass on their purchase.

The educational activities directed to meet this need must be offered locally—they must be offered at a time and via a medium which is economically and physically feasible.

The teaching force taken at large for such an activity does not now exist. The very first job would be the development of such a teaching force. People in the working world must be upgraded so that they can become teachers of others in the working world. This is a postcollegiate, post-high-school educational project.

The second and obvious need inherent to this situation is for the regular influx of new blood into these areas of technological development.

This means, of course, that we must have more graduates of science and engineering from our colleges. This is a problem which is already recognized by many and to which we can only add our emphasis.

We are very pleased to acknowledge the efforts of the several groups who are studying and striving toward this objective and we wish merely to recite at this point that it is one of our major needs.

Anything which is done to enhance the development of future scientists and engineers in this country and our capacity for training them; anything done to enhance the attractiveness of the professions to procure and maintain such people in such activities is a step toward the solution of some of our problems.

Thirdly, we need access to know-how on what has been done—access to advice on how something might be done—what equipment is available, how it can be operated and, perhaps, equally important—access to such equipment that might be needed on a very infrequent schedule, but where purchase could not be justified on a continuing basis.

Some means for providing instrumentation reference, and calibration services for various scientists in all the fields is essential if we are to use these men most effectively. This could conceivably take the form of a series of regional instrumentation service centers.

This problem of communication also implies that there should be more effective exchange of information between the programs of the Government and those of industry. Each has much to learn from the other.

Therefore, I would cite as one of the most urgent needs, the cross-fertilization of military and industrial ideas and techniques.

The fourth need in this broad field of instrumentation-automation has to do with the efficiency of the people working in it and has basically to do with communications.

I am speaking broadly here of the need of a central clearinghouse for the rapidly accumulating information and knowledge. This would avoid, at least in some degree, the duplication of valuable time by a number of workers on a similar subject, all of whom are achieving a common result but without knowledge of the work of the other, thus wasting valuable time which otherwise would have been saved.

Under this area of admitting major needs, I have named essentially four problems if we are to use instrumentation-automation in as most effective a way as possible in enhancing our economy and our national defense.

Now having stated the four needs, I will now suggest seven possible media through which our major needs might be met. These are—

1. Improvement of curricula and training of teachers in high schools;
2. The development of technical institutes for vocational training;
3. The establishment of engineering extension services in the land-grant colleges;
4. Effective utilization of the military training period;
5. Enhancement of the programs in the National Science Foundation and in the Foundation for Instrumentation Education and Research;
6. A more active role by the National Bureau of Standards in communication of information, the development of a national information instrumentation-automation center; and
7. A series of systematic military industrial cooperative studies and liaison activities.

First, our high schools must develop better preparatory courses to encourage and attract and prepare students for collegiate work in the sciences and in engineering. We also must have at the high school level, vocational courses developed to produce technicians and mechanics to serve those industries.

In the same way when in past years we recognized the necessity for vocational training for carpenters, plumbers, electricians, and printers, we must now develop vocational training for instrument mechanics and instrument technicians to take at least a part of the load from the more highly educated engineer.

In line with this, there is a great need now for the development of a new type of educational institution—new in the sense that it is not now existent in numbers nearly significant with respect to the magnitude of the problem.

We need the development of technical institutes. These would be post-high school, they would be specifically oriented in the programs toward the development of technicians to serve these newly spawned areas of need.

Basically, what I am saying is that we should revive a series of technical institutes at the community level throughout our Nation. But in each community the curriculum objectives of these technical institutes could be in large part directed specifically toward the industrial needs of that area.

For further education of the current work force on a national scale at the professional level, engineering extension work by our universities may be desired. We have witnessed the excellent work done by agricultural extension services as part of our State universities.

It is strongly recommended that a comparable program be developed of engineering extension services administered through the engineering stations in land-grant colleges.

Such programs might provide for trained representatives comparable to the county agents who would be available as a service to industry to work with them on the definition of their instrumentation problems, communicating to them the developments and latest techniques in equipments and applications.

Such a service might embrace a program of basic research in instrumentation technique and equipment appropriate to the area being served. It might also conduct courses and conferences for the industries of that area.

It is within our concept that instrumentation-automation education for the existing work force must be locally based but perhaps nationally coordinated and supported, at least in part.

Another area where much can be done to contribute toward meeting the needs is in the area of military training. The military has a great need for many of the skills which are also required by industry with respect to the subject matter in content of instrumentation-automation. It seems entirely feasible to us that with planning and some little additional effort, the training programs of the military could be guided and articulated so as to provide a continuing flow of technicians into industry who will already be trained and be competent to maintain and utilize the most advanced instrumentation techniques and equipment.

The objectives and the work of the National Science Foundation are most commendable and a later witness will speak to you in greater detail on its programs.

We would encourage greater recognition of the importance of measurement and control in instrumentation-automation as part of basic sciences; and hence, a legitimate concern of the National Science Foundation.

The Foundation for Instrumentation Education and Research, born of the Instrument Society of America this year, and, as previously described, can and we expect will, play an increasing role in meeting the needs. This foundation invites to its support those interested in furthering these objectives.

Another agency that has been and will continue to contribute greatly toward meeting the needs of instrumentation-automation is our National Bureau of Standards. As guardian of our national standards of measurement, it will continue to play an active part in instrumentation education and communications.

The initial efforts toward the establishment of an instrumentation information service within the National Bureau of Standards, and the program of the Armed Services Technical Information Agency, are to be commended, but they are just the beginning of filling the need for an effective information service.

Certainly the potential users of such service should play an important role in the determination of its machinery and mechanics of operation.

One last medium which seems entirely feasible as the means toward resolving some of the needs which I have recited, is for a series of military and industrial conferences. Perhaps the answer to this may be the formation of a military-industrial liaison committee on instrumentation and automatic controls.

Such committees and such conferences serve the purpose of communication, cross-fertilization, and definition of problems and ideas.

Into such meetings would come industry knowledge of militarily developed techniques and equipment. Out of such meetings would come the military appreciation of the requirements of industrial environment.

Together, it is quite conceivable that there could be formulated a private series of evaluation projects which would tend to establish or deny the applicability of military developments toward industrial areas.

Such studies and projects might be undertaken by Government agencies, by universities, or under the direction of appropriate nonprofit foundations.

In order to put action into these several recommendations, I propose to you, on behalf of the Instrument Society of America, that Congress, or some other proper administrative body of the Government, establish a task force—perhaps it might be called an Instrumentation-Automation Commission for Effective Productivity and Research.

This commission should have as its objectives the study of these 4 basic needs, and the applicability of these 7 and possibly other mediums as solutions to the stated problems.

We further respectfully suggest that the representatives on such a commission be invited from the Department of Defense, the Foundation for Instrumentation Education and Research, Land-Grant Colleges Association, the Department of Commerce, the American Society of Engineering Education, the Instrument Society of America, Engineers Joint Council, and from the National Science Foundation.

On behalf of the Instrument Society of America, I assure you that we will be most happy to cooperate by furnishing individual representation on such a group, by assisting with statistical information, and to contribute in any way possible through our membership and the agencies of our national office in the studies of these urgent problems.

While preparing this material, I had several communications with the Engineers Joint Council, and Dr. Thomas H. Clinton, president, submitted to me, just this week, a statement to be included along with my material. With your permission, I would like to include this now.

Chairman PATMAN. They will be inserted along with the charts and other material that you referred to in your presentation. And do you know of anything else that should go in the record in connection with your testimony?

Mr. SHEEN. Yes, sir; there is also an article from the December issue of Control Engineering, which was devoted very largely to this specific subject. We are suggesting this also be included in the testimony of this hearing.

Chairman PATMAN. They may be inserted.

Mr. SHEEN. Thank you, sir. I will be very happy to answer any questions that you may have.

(The statements by Dr. Thomas H. Chilton, Dr. Arnold O. Beckman, and the article from Control Engineering are as follows:)

STATEMENT OF DR. THOMAS H. CHILTON, PRESIDENT, ENGINEERS JOINT COUNCIL

Transmitted to Robert T. Sheen, president, 1955–56, Instrument Society of America, for incorporation in testimony presented to Congress of the United States, hearings before the Subcommittee on Economic Stabilization

ENGINEERS JOINT COUNCIL,
New York, N. Y., December 7, 1956.

Mr. R. T. SHEEN,
Milton Roy Co., Philadelphia, Pa.

DEAR MR. SHEEN: In response to your suggestion, I am sending you under separate cover a brief statement that I would be pleased to have you present on my behalf before the Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report. I hope it reaches you in time to serve the intended purpose.

Sincerely yours,

T. H. CHILTON, *President.*

The term "automation" is relatively new; the concept is not. Actually, automation is merely the further application of instrumentation and automatic controls in manufacturing and industrial processing. These applications of instrumentation and automatic control have permitted a basic expansion in the overall economy of the country through increased productivity at lower production cost. This has been accompanied by important achievements in making the labor requirements less onerous. Not the least of these achievements has been in industrial safety.

It is believed by those who have watched these developments in genesis and application for at least two decades that technological developments incident to the further application of instrumentation and automatic controls will produce an enlarged need for technically educated people. These requirements are both quantitative and qualitative. They indicate the need for increased emphasis in the whole hierarchy of technical education.

For engineering education these requirements include more complete orientation and curricula emphasis on the mathematical and scientific basis of engineering and for further development in engineering graduate education or its industrial equivalent. It involves also a further understanding and development of technian-level training which has as its unique characteristic and goal bridging the gap between the highly skilled and the highly educated in technical activity.

There is in industry, engineering education, and the engineering societies, growing awareness of these needs if not full agreement on the method of their achievement. The problems are greatly sharpened by the current requirements of national security. These requirements have helped considerably in achievement of the realization that the recruitment, training, and utilization of technical personnel should be seen as an integrated sequence of responsibilities with which the professional societies, education, industry, Government, and the public are all vitally concerned.

The engineer has proved himself essential in fields other than engineering, such as administration and management. The application of engineering know-how in such functions will become increasingly important as integration of individual unit operation becomes essential in order to effect balanced stability between the productive and consuming cycles.

The work of the engineer, in applying instrumentation and automatic control to what have heretofore been standardized manual or semiautomatic operations, will have important effects on the utilization of the country's labor force. We have already alluded to some of these. Devices can perform many functions faster, more efficiently, and with greater safety than can individual persons. We have every assurance, however, from our experience with these applications, that, while they have the short-range effect of job change, their somewhat longer range effect is employment increase. Of course, this involves retraining and reassignment. It is therefore clear that the skill level of the labor force must rise. The widespread use of training programs initiated by industry, by workmen's association, and other institutions have enabled these transitions to be made with a minimum of undesirable social or economic effect.

Outstanding examples of these phenomena have already been accomplished in certain industries such as the chemical industry and communications industry. Indeed the growth which has taken place here would not have been possible without the application of instrumentation and automatic control of productive processes.

Thus, present-day advances in technology require instrumentation and automatic control of processes. Requirements of speed of operation and quality control have far exceeded human sensory capacity. Hybridization of these devices would involve sacrifice of safety standards and the abandonment of technical achievements.

Instrumentation and automatic control can be the answer to two heretofore apparently opposing forces: rising monetary costs and rising production. Thus is promised an answer to the need for the expansion of our productivity to meet the needs of our population, to achieve an ever-rising standard of living. As such, it is quite possibly the key—technologically speaking—to freedom from want.

THOMAS H. CHILTON,
President, Engineers Joint Council.

Public Education—A Menace to Science?

An Address by Dr. Arnold O. Beckman, founder-president, Beckman Instruments, Inc., president, Los Angeles Chamber of Commerce

The purpose of my remarks today is to call attention to a situation which, in my opinion, is one of the major problems confronting our Nation, a situation which may be a decisive factor in our national security. It unquestionably will be a limiting factor in the rate at which new scientific and medical discoveries will be made. It will determine to a great extent how rapidly we can reap the benefits of the new industrial revolution known as automation. It is a serious situation which affects all of us, whether we are parents, educators, employers in search of talent, or simply citizens and taxpayers. I refer to the shortage of competent technical manpower, especially in the fields of electronics, physics, and mathematics.

Why is the situation so serious, one may ask? Aren't we habitually short of really good men in almost every field? Hasn't it always been, as Sophie Tucker used to sing, "A Good Man Is Hard To Find"? Is there anything new or alarming in the fact that we don't have all the able scientists and engineers we could use at the moment? Why worry that we could move ahead a little faster if we had a few more. Look at all the amazing discoveries and technological developments of our country during the past few years. The United States leads the world in science and industry. We are doing all right. Why worry?

In March of this year the Congressional Joint Committee on Atomic Energy published an authoritative and disturbing report on Engineering and Scientific Manpower in the United States, Western Europe, and Soviet Russia. Statistics cited in this report showing the number of engineers and scientists in our country and in the Soviet Union should destroy any feeling of complacency we might have concerning the superiority of the United States in science and technology. They point up the need for immediate and effective action if we are to provide adequately for our national security and maintain a leading position in the future in scientific discovery and technological development.

In 1954 Russia had more than 540,000 engineers, plus about 160,000 scientists in educational and research institutions, a total of 700,000. In the United States there are between 700,000 and 750,000 actively employed engineers and scientists. At the moment, therefore, we are about on a par with Russia.

This fact may come as a shock to many of us who are accustomed to think of Russia as a backward country. Even more shocking is a study of the trends in technical education in this country and in Russia. From 1900 to 1950 engineering and scientific professional graduates in the United States increased almost twice as fast as did the population. Since 1950 there has been a sharp decline: 52,732 first professional or bachelor's engineering degrees were granted in 1950; in 1954 there were only 22,236 such degrees. Sixty-one thousand and one similar degrees were granted in natural sciences in 1950; in 1954 only 31,168. Despite the increase in total population during this period and the increased demand for engineers and scientists by new technologies and greatly increased emphasis upon research, the annual crop of technical graduates decreased by more than 50 percent.

Contrast this situation with what has taken place in Russia. In 1950 there were 28,000 engineering degrees awarded in Russia. In 1954 the number had nearly doubled, being 53,000. For 1955 the number is estimated at 63,000, a figure to be compared with only 23,000 similar degrees for the United States.

Over the last 5 years we have turned out only 142,000 engineers, compared to an estimated 216,000 in Russia.

Allen W. Dulles, Director of the Central Intelligence Agency, has summed up the situation with a prophecy for the decade 1950–60. The Soviets will graduate 1,200,000 in the sciences, while the United States will graduate 900,000. He said: "Unless we quickly take new measures, increase our facilities for scientific education, Soviet scientific manpower in key areas may well outnumber ours in the next decade."

The latest available engineering enrollments show that the United States has 1 engineering student for every 974,000 of its total population. Russia has 1 to every 725,000. The population of Russia is one third greater than that of the United States.

There is no comfort to be gained from the hope that the quality of Soviet training is inferior to ours. Russian university students start out with more intensive mathematical and scientific preparation at the high-school level. They study harder and longer in college. The Joint Committee report states that because of the emphasis on science and the vigorous scholastic competition in the Soviet educational system, Soviet graduates are professionally as competent as scientific graduates in the United States.

Science predominates in Russian higher education. More than half of all Russian university graduates are in the fields of science and mathematics; only a fifth of the United States graduates are in these fields. Russian doctors of philosophy, or the equivalent, are 3:1 in favor of science and engineering, in comparison with 1:3 for the United States.

Why has our country failed to provide the number of technical graduates it needs? With a current need of 35,000 to 50,000 new engineers per year, why have our schools provided only a little over 22,000 each year for the past 2 years? In my opinion, the blame rests squarely on our public education system, especially at the high-school and elementary levells.

In what ways has our education system failed? First, it has failed to anticipate and prepare for the steadily increasing need for more scientists and engineers. An essential function in any big business is to forecast future needs for its products and to anticipate and be prepared for changes in its output to meet the changing needs of the times. We should not forget that education is big business. Of the $1.8-million 1955–56 California State budget, 38 percent, or $784 million, is for education. This is big business, and we, as taxpayers, have a right to expect that our public-education business will be operated as efficiently as other businesses.

Public utilities and large manufacturing companies are constantly engaged in market surveys, studies of trends, et cetera. They accept without question the responsibility for seeing that telephones, electricity, and manufactured products of all kinds are provided when and where needed. Our public education system has an equal responsibility to anticipate the needs for its product, trained students, in the quantities required and with skills necessary to meet the needs. This is an essential part of the business of education. The job has not been well done.

Our educational system appears to have failed in another serious way, namely, by permitting progressive deterioration in the rigor of its mental training and disciplines. Our elementary and high schools appear to suffer from what might be described as pernicious softening of the curriculum. Over the past two or three decades there has been a marked decline in the number of students required to take subjects such as mathematics, physics, and chemistry, which demand and develop clear thinking and analytical reasoning. At the beginning of the century 1 in every 5 high-school students studied physics; today only 1 out of about 25 throughout the Nation. In place of basic courses in mathematics and science, students have been permitted to choose elective courses which fail to provide an adequate foundation for college work in any field of engineering or scincee. The result is that our high schools have been turning out thousands of students woefully unqualified to undertake college-level studies in technical fields.

One explanation which has been advanced for the shortage of technical graduates from our universities is the inadequate number of university professors. It is said that our universities are losing professors to industry, because of higher salaries paid by industry. Whether or not this is true to a significant extent appears to have little bearing on the technical manpower problem. There is no evidence that university students are denied training in science and engineering because of an insufficient number of university professors or inadequate laboratory or classroom facilities. The technical manpower problem arises from the fact that too few students enter colleges and universities who are interested in and are prepared to follow careers in science and engineering.

The failure of our elementary and high schools to inspire students to enter technical fields and to train them properly for technical careers is reflected in the statistics of university graduates. In 1950, graduates in engineering and science in the United States represented 25 percent of the entire graduating class. In 1954 they represented 18 percent, and the forecast is that the class of 1960 will have not more than 15 percent of its graduates in engineering and science. This situation does not represent a crisis which developed suddenly. It is the inevitable result of a long history of declining interest at the high-school level in subjects such as mathematics, chemistry, and physics, which are basic to engineering and science. It is amazing that this decline should have occurred at a time when the interest of young students in new scientific developments has been at an all-time high. Even some of the most popular comic strips for children are based on pseudoscientific subjects, involving Space Travel, Death Rays, et cetera. How have our teachers managed to kill off this interest?

There are several explanations. One is that many science teachers are not interested in science nor are they competent to teach science. A personal experience drove home this fact to me a number of years ago when a competitive examination, with university scholarships as prizes, was sponsored by a local section of the American Chemical Society. I was amazed by the number of high-school teachers who asked for sets of the correct answers so that they could discuss the examination later with their students! An investigation showed that 30 percent of the high-school chemistry teachers had taken no university courses in chemistry. There is little reason to believe that the situation is much different today.

Last November, Lewis L. Strauss, chairman of the United States Atomic Energy Commission, in commenting upon an analogous situation stated, "A survey of 30 States showed that about 1,800 new mathematics teachers were urgently needed, but 700 of the positions had to be filled with unqualified persons, including instructors in such unrelated subjects as music, home economics, and physical culture."

Last week's issue of Time magazine reports a year-long survey of instruction in high-school mathematics which was financed by the Carnegie Corporation of New York and conducted by the well-known Educational Testing Service of Princeton, N. J. The survey showed that the teaching of mathematics is in a deplorable state. A large number of elementary mathematics teachers not only did not know how to teach the subject effectively but were barely able to keep ahead of their pupils. In a survey of 211 prospective elementary teachers, 150 reported "a long standing hatred of arithmetic." High-school teaching is so bad that 62 percent of colleges surveyed reported a necessity to repeat high-school mathematics in college. The math situation is so bad in secondary schools that 5 years ago Annapolis abolished trigonometry as an entrance requirement, began to teach it itself.

"Elementary teachers, for the most part," according to one observer who has taught them, "are ignorant of the mathematical basis of arithmetic; high-school teachers * * * fall in this category also. This ignorance is scarcely surprising, for little knowledge of mathematics is expected, even officially, of prospective schoolteachers. In the majority of cases, an individual with ambition to teach in an elementary school can matriculate at a teachers' college without showing any high-school mathematics on his record. He can be graduated without studying any college mathematics. And in this condition, he can meet the requirements of most States for a certificate to teach arithmetic. * * * Nearly one-third of the States will license (high-school math) teachers even though they have had no college mathematics at all, and the average requirement for all States is only 10 semester hours."

The whole situation, says Educational Testing Service, finally boils down to this: "Future teachers pass through the elementary schools learning to detest mathematics. They drop it in high school as early as possible. They avoid it in teachers college because it is not required. They return to the elementary school to teach a new generation to detest it."

The alarming spread of teacher incompetence throughout our public-school system reflects the powerful influence of teachers colleges and certain teacher organizations which have succeeded over the years in establishing regulations and practices which may be to their interests but are not necessarily beneficial to education. Rigid restrictions governing teaching credentials, which purportedly guarantee a measure of competence, actually do nothing of the kind, as surveys have shown. These restrictions, based largely on exposure to certain courses in methods of teaching, have little to do with a person's effectiveness as an inspiring and effective teacher.

To the extent that teaching credential restrictions are arbitrary and unrealistic, they injure rather than aid the teaching profession. The Committee for the 1955 White House Conference on Education, in its report to President Eisenhower, stated, "Teacher preparation programs have the reputation of requiring needless and repetitious courses. This reputation has the effect of deterring brilliant young people from becoming teachers."

Not only are brilliant young people deterred from becoming teachers, and thus aid in relieving the shortage of competent teachers, the arbitrary restrictions prohibit many able persons from teaching in our public schools. Does it not strike you as strange that leading professors in science at famous universities, such as the University of California and Stanford University, are not qualified to teach their subjects in our high schools, yet a high-school drama or music teacher with no training in science may do so.

If unreasonable restrictions on teacher qualifications were eliminated hundreds of competent teachers in mathematics, science, and engineering would be available from industry on a part-time basis—teachers of the kind needed now, teachers who can inspire students to enter technical fields because they can speak from firsthand experience of the challenge and opportunities of their profession. George Bernard Shaw is reputed to have said: "Those who can—do. Those who can't—teach." This cynical comment is unfair to the thousands of capable teachers who are dedicated to their profession, but it does suggest that those who are doing might, indeed, add something to teaching, that something which might inspire young Johnnie to become a future Einstein.

Many able educators have cried out against onerous policies and practices in public education which have been established largely through the influence of teachers colleges. This is an involved matter. I will merely point out here that a major criticism has been the overemphasis on methods of teaching versus the underemphasis on knowledge of the subject being taught. The late Dr. Robert A. Millikan fought this battle at the University of Chicago many years ago. He insisted that teachers of physics know something about physics and not merely have taken courses in the methods of teaching. Within the last few months, Dr. Wallace A. Sterling, president of Stanford University, also decried the fact that many of our teachers today are more concerned with the methods of teaching than with teaching.

I have been interested in education most of my life: as a student, a university teacher, a parent, an employer, and a taxpayer. During the 14 years I was engaged in teaching at the California Institute of Technology I had the opportunity to become well acquainted with the product of our high schools and to learn something about our public-school system. Many things have been happening to public education which bother me greatly. While obviously there are many factors which have contributed to our present educational problems, I believe that there are certain trends which are most important. Some of these are the trends of the times. The broad socialistic movement which has engulfed our country as well as other countries, which tends to destroy competition, eliminate free enterprise and destroy individual initiative, shows up in our school system in several ways. One is the attempt to do away with a competitive grading system in our public schools. In certain schools, grades which showed comparative performances of pupils or measured their skills were eliminated. Some schools even went so far as to attempt to grade pupils not on their performance in an absolute sense but upon their performance in relation to their estimated ability, as measured by an I. Q. test or some other means. On the basis of this standard, a moron who handed in all of his homework, even though it was worthless, would receive a higher grade than a brilliant student who was somewhat careless in turning in his papers. In some school districts where indignant parents have demanded that grades be reestablished, the attempt is made to minimize the significance of grades denoting proficinecy, by having several other grades for each course. In arithmetic, for example, there are grades which purportedly measure such things as responsibility and self-direction and relationships with others. Much of this educational tomfoolery can be credited to the unfortunate influence of certain groups in our educational system, such as so-called progressive educators, who, unfortunately, before aroused parents found what was going on and demanded a change, injured untold thousands of our youth through the imposition of educational procedures based upon immature theories of a few educational cultists.

The swing away from progressive education is an encouraging sign that improvements are underway. We should not be misled, however, for, to a large extent, the same group of educators which permitted progressive education to infiltrate our public schools is still in charge. The same people are tinkering with our educational machinery, often apparently without any clear understanding of what their objectives are or should be.

Several years ago the national American Chemical Society took the lead in fighting a move to emasculate rigorous scientific instruction by eliminating specific courses in physics, chemistry, and biology, and substituting a course in general science. Educators stated that nature embraces all science; that the division into separate fields, such as chemistry and physics, is entirely arbitrary and therefore should be eliminated. While this may be an interesting subject for an argument, the fact was that the courses in general science which were offered failed to provide fundamental training in any field of science.

There is a heavy student loss between high school and college graduation. The Joint AEC Committee report states: "Of all high school graduates whose qualifications are such as to warrant their striving to become engineers and scientists, about one-half cease further schooling to go into the business of earning a livelihood. Of the one-half who go on to college only about 40 percent graduate. Thus, of every 10 high school pupils with capacities for potential careers in engineering or science, only 2 graduate from college. From there on, the attrition is even greater, for of all college graduates less than 3 percent continue their studies to earn a doctor of philosophy degree."

Recently there has been a rush on the part of certain large industries to provide scholarship funds. This action is based presumably upon the belief that lack of finances is a chief cause for the loss of technical students after high school. The providing of scholarship funds is a splendid thing, and should be encouraged. I do not believe, however, that the availability of new funds will solve the problem, at least with respect to top students. Any able student can finance himself through college today.

What can be done to improve the situation? It is obvious that more of our youth must become interested in science and engineering and must be provided with educational opportunities for proper rigorous training in these fields. The first step is to interest the student. Inspiration can come only from enthusiastic, competent teachers. Teachers untrained in a subject should not be permitted to teach that subject, regardless of the number of courses he or she may have taken in so-called pedagogy. Incompetent teachers must be weeded out.

The teachers' tenure system should be investigated. The tenure plan was instituted, I understand, as a method of taking politics out of teaching. A teacher with 3-year's full-time teaching acquires tenure status. This means that thereafter it is virtually impossible to discharge a teacher, except for very grave charges of misconduct or something of equally serious nature. Any obligation on the teachers' part to be an effective teacher during the long period of guaranteed employment is vague and usually amounts, at most, to attendance at a few lectures or an occasional summer-school course. There is no yardstick by which a person's effectiveness as a teacher is measured. To the best of my knowledge, the routine rating of teachers on the basis of their actual effectiveness in the classroom is something which is not attempted. Why not? I can see no reason a teacher should be permitted to remain on a job when he fails to perform satisfactorily. The working of the tenure principle should be carefully studied to make sure that it gives reasonable security to teachers, on the one hand, but, on the other hand, that it gives corresponding assurance to parents that their children will not be subjected to education by incompetent teachers.

Merit rating for teachers is receiving attention from some school boards and other agencies interested in the quality of teaching. In the May 1956, issue of the Tax Digest, E. Maxwell Benton, educational counselor for the California Taxpayer's Association, states: "Considerable criticism is developing of teacher salary schedules which use only the two yardsticks, college training and teaching experience, for determining salaries. There is a growing conviction that teacher salaries should also be related to the quality of instruction." He points out that the prevalent automatic advancement plan by which the mediocre teacher advances at the same rate as the outstanding teacher lowers the prestige of the teaching profession and discourages able teachers. He quotes the American School Board Journal, May 1954: "Union protection, automatic increments, indefinite tenure—these safeguards attract a certain type of person into the teaching profession. True leaders, people who 'have it on the ball,' do not search for positions offering such safeguards."

Proponents of merit rating contend that the practice of paying teachers what they are worth, rather than rewarding them merely for becoming older teachers, would bring about a great improvement in teaching. Merit programs would tend to draw and hold superior teachers. Acting upon the recommendation of a Citizens Advisory Committee, the Pasadena, Calif., School Board is now working on a procedure for formal evaluation of current job performance which will be a part of its teachers' salary schedule code. As the idea spreads, we may hope for improvement in the quality of teaching in elementary and secondary schools.

The curriculum of secondary and elementary schools should be under constant study, and should be revised when necessary to reflect current needs. The tremendous advances in science in recent years have created, and will continue to create in the future, vast amounts of new knowledge which must be taught. How can this new information be worked into a curriculum which is considered to be overcrowded today[Several things can be done. Much subject matter of today's elementary and high school curricula could be eliminated advantageously. There is a great deal of educational rubbish and scholastic trivia in our present curricula.

Many subjects could be taught at an earlier age. Why should foreign languages, for example, be retained for the later years. These can be taught just as well, and possibly more readily, in the early years.

Our curricula today are largely the result of tradition. They are the carryover of past generations in which classical education predominated. I think it is time that a fresh look be taken by unprejudiced, imaginative and able educators, persons who can throw off the shackles of blind adherence to tradition. Let these persons look at the world as it is today and ask themselves: "What knowledge, what training, what skills does the youth of today need to prepare him best for the problems he will encounter in his lifetime?" The answer will be a sensible, realistic course of study which, by comparison with our present curricula, would show that we are now wasting tremendous amounts of time on subjects of little value. We are dulling the interests of many potential scientific leaders by failing to provide courses, as well as teachers, which would inspire them to enter professions in which their abilities can be used most beneficially.

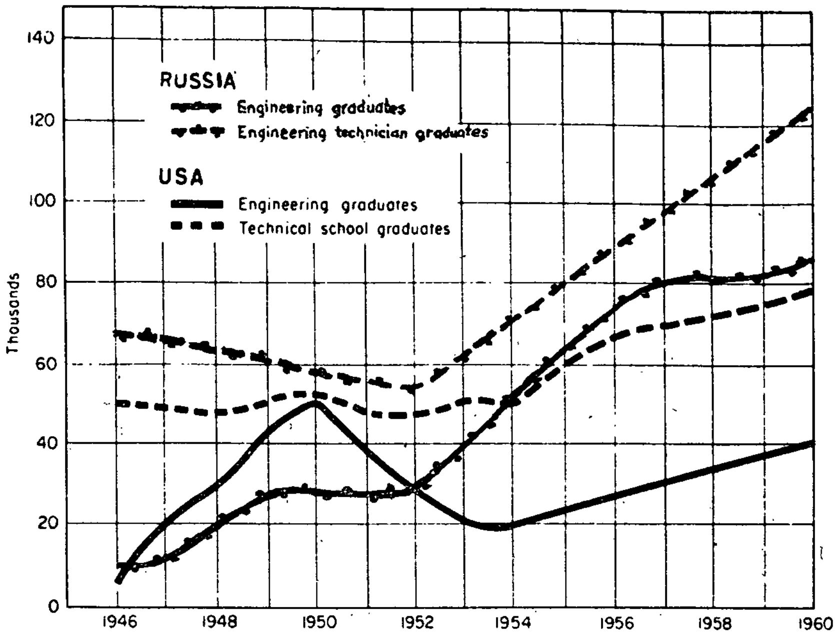
One weakness of our public-school system is the attempt to confine students of all kinds in the same classroom. Observant educators have noted that it is "impossible for a small corps of teachers to serve both terminal and college preparatory students with vital, relevant, inspiring work in the range of subjects needed by both groups." There is evidence that some of our junior colleges stress terminal courses, to the detriment of the student aspiring to enter college.

In a commencement address a few weeks ago, Dr. Frank Baxter, noted Shakespearian professor at the University of Southern California, suggested that it was high time that our public schools stop putting all students through the same mill; that we may be wasting one of our most valuable national resources when we fail to develop to their fullest extent the talents of students having superior ability; and that these talents cannot be developed favorably in an educational system geared to mediocrity. There was an immediate reaction to the suggestion that superior ability be recognized and cultivated in our public schools. "It's Un-American," said one. "It violates the principle of equal rights for all." Such shallow thinking overlooks the fact that there is no greater inequality than the equal treatment of unequals.

In these remarks I have stressed certain weaknesses and shortcomings of our public education system. I have deliberately refrained from discussing the good features, and there are many, for my primary purpose was to indicate areas in which improvement is needed and to suggest some ways in which improvements can be made. I hope that no one will construe the critical nature of my remarks, as an indication of lack of faith in our system of public education, nor lack of confidence in our public-school teachers.

Public education is a magnificent institution—I wish to make it still better. We are fortunate in having in our public schools many able, inspiring teachers who are dedicated to their profession. I have the greatest respect for them. My wish is to see their ability recognized and their burden lightened by providing them with able associates.

It is my hope that civic organizations throughout the Nation will take a more active interest in public education and will do their utmost to end the current wastage of potential technical manpower before it is too late.



How two nations are training for control.

[From Control Engineering, December 1956]

UNITED STATES STEPS UP ITS TECHNICIAN-ENGINEER RATIO THROUGH SOCIETY ACTIVITIES BY EMPHASIS IN SCHOOLS WITH MORE MANUFACTURER TRAINING

The graph above[1] dramatizes an aspect of engineering manpower that is often overlooked in today's frenzied search for qualified engineers: the importance of the qualified technician in backing up the engineer—and thus contributing to the solution of the current shortage.

Study the graph and see what is happening to the technician gap in the United States' most important engineering competitor. Since 1952 the Soviet Union, observing a decline in its technicians due to emphasis on professional education, has put steam into a program for getting more graduates from its technicians turned out by these schools. The dshed black line for the United increase in technicians over the 1950 level—was exceeded, and it is now estimated that Russia's 3,500 technicums are turning out close to 1 million vocationally trained people each year. The dashed red line in the graph indicates roughly 100,000 technicum graduates in 1956, but it covers only the engineering technicians turned out by these schools. The dashed black line for the United States, however, represents the enrollments in 69 technical institutes and includes all types of vocational training.

THE OPTIMUM RATIO

An important key to its attitude toward technician training lies in what Russia calls its optimum ratio between semiprofessionals and professionals. In prewar days the ratio was less than a desired 2:1, and declined by 1950 to only 1.3 technicians to back up each engineer. Today the aim in Russia's automatic control field is four technicians for each professional engineer—and all signs point to fulfillment of this aim.

Many American industrial firms are also aware of this need for an optimum ratio between technicians and engineers. E. Allan Williford, president of Link

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[1] Sources: On engineering and Soviet technicum graduates—estimates from Nicholas De Witt. Soviet Professional Manpower; on United States technical school graduates—Annual Surveys of Technical Institutes, Rochester Institute of Technology.

Aviation, says, "We have approximately 120 graduate engineers at Link. We also have about 160 trained technicians, not nearly enough. We probably should have a ratio of at least three technicians to every engineer. Any lower ratio simply means that we're not getting maximum value for our engineers * * *." Some other ratios:

Westinghouse Electric, Air Arm Division, 2 technicians to 1 engineer.

Standard Oil of Indiana, 1.9 technicians for each engineer.

United States Steel Co., American Bridge Division, 800 technicians, 700 engineers.

Not all companies, however, match the ratios above. A survey by the Engineering Manpower Commission of 18 oil and chemical companies, for example, showed an average 0.9 technicians per chemical engineer.

WHY STRESS THE RATIO?

As Bob Jeffries implies in his guest editorial on page 61, a lack of emphasis in training technicians for automatic control can result in two things:

(1) Our dedicated efforts to put automatic control in American industry can come to a grinding halt—technicians are needed to keep operating what is placed in the field—it is as simple as that.

(2) Our so-called engineering manpower shortages will never be solved—without technicians, creative engineers will bog down in a mass of routine, time-consuming operational and design details.

It is the second point that is starting to preoccupy today's engineering manager and may be the real prime mover for getting technician training in the United States well off the ground. Bidding next June for an estimated 23,000 engineering graduates will be over 5,000 companies—which means that less than 5 new recruits will be available per firm. Yet most expanding industrial firms today claim they need new engineers by the scores, even hundreds. An answer, they are finding, is to use the trained technician for some staff engineering jobs and to upgrade him, if necessary, to full engineer status. This is causing industrial recruiters to include technical institutes in their itineraries and is causing companies like Carbide & Carbon (see p. 65) to emphasize the engineering apprentice approach in its on-the-job training program.

ORGANIZED RATIO BOOSTERS

Though it lags notoriously right now, the United States has high hopes for matching and besting the Soviet Union's remarwable technician training program. For while both bank heavily on formal schooling plus some on-job training, the United States has, in addition to these sources, two other prime movers: (1) The engineering societies, with their focus on lower-echelon education; (2) the product manufacturers, with their free schools for training customer technicians.

The next five pages of What's New offer a current glimpse of some of these forces at work in the training of American technicians for control.

ISA WORKS FOR TECHNICIANS

Progress in product and technique may have been the theme at the recent 11th annual Instrument Society of America conclave (see November issue, pp. 25–40), but there was one problem in the minds of the membership that threatened to overshadow it: the problem of producing the properly qualified technicians needed to service and run the new installations.

The problem did not simply fester in the minds of ISA members, however. They did something about it. Besides conducting training clinics (Control Engineering, November, pp. 38–39), the ISA announced an education foundation with funds to attack the technician shortage problem (see p. 61); conducted a symposium on ways and means to increase the training of manpower in instrumentation; held an education committee meeting on the day following the symposium to mull over possible action based on what was learned; cooperated with Control Engineering in a display of work being done in the control field by eight education institutions.

The ISA's new Foundation for Education and Research will function as a separate corporation under the direction of a board of trustees drawn from industry, Government, and education. While its initial grant of $40,000 is from the society itself, it hopes to be financed through funds supplied by individuals, other technical associations, and industrial contributors. It will be housed at first in the ISA headquarters in Pittsburgh. Bill Kushnick will serve as executive director (a post he now holds, and will continue to hold in ISA).

AT THE SYMPOSIUM

Four of the five papers offered during the special education symposium on Tuesday, September 18, concentrated on the problem of developing instrument and control technicians. Foxboro's W. H. Furry complained that instrument technicians are too often categorized with bricklayers and carpenters—almost invariably by unions and frequently by management. He called for abolishment of the term "instrument mechanic" and said that the status of technicians could be raised by placing them on salary and thereby removing them from union jurisdiction. The body of his talk was about technician training, which he wants formalized. His three-part method: learning the why of instrument operation; showing the man what to do and how to do it; making him practice until management is sure he can do it.

Paul Huss of the University of Akron gave an impassioned plea for more emphasis on the role of the secondary school in expanding technical manpower. He felt that the humanities were being stressed too much and that more interest on a broader science-and-mathematics base could be stimulated by such things as good science films at the junior high level. He advocated "pushing the people who could become good engineers or technicians" but was "opposed to regimentation." Mr. Huss didn't quite tell the audience how to do the necessary pushing.

CHAPTER ACTIVITIES

The final paper in the education symposium, by A. T. Sherman, of Du Pont, dealt with instrument courses sponsored by ISA chapters and instrument manufacturers. Sherman briefly discussed the results of a survey that went to 57 instrumentmakers and the 76 ISA chapters. Of 20 chapters replying, 8 had a program of some sort—either organized and run by the chapter, or taught at a local university.

The good work that ISA chapters are performing in training technicians has been reported before. In 1954 R. J. McCausey, of Detroit Edison, found that 10 chapters conducted 37 training courses in 1952 and 1953, and that these were attended by 596 individuals. One of the best organized of these courses was run by the Boston section. It was advertised as an "instrument technician refresher course," ran for 5 weeks (2½ hours per week), and cost $3. A total of 82 attended, and as a result of enthusiastic answers to its questionnaire, similar courses became standard activity for the Boston section.

UNIVERSITY ACTIVITIES

Educational activities at the college level were brought out during the ISA show in a special exhibit (see pictures below) of instrument and control development projects in eight eastern universities cosponsored by Control Engineering and ISA. Manning the exhibits were graduate students and faculty members associated with the conception and design of the photo-type systems on display. (See Control Engineering, September 1956, pp. 185–192, for details on some of the projects.)

Eight of the faculty members connected with the exhibit met in a formal session Tuesday morning, September 18, to discuss their respective projects and educational programs in control. Managing Editor Lloyd Slater, who served as recorder at this session, reports, "The interchange of ideas in this group was extremely interesting. Three of the men were medical-instrument oriented, three were outright theoretical control engineers, and the other two dealt in physics and mechanical engineering. Yet all were able to develop provocative comments about each others' project. For example, Dr. Slocumbe of Tufts became very intrigued with Jim Reswick's nonupset technique for systems analysis and planned to team up with Jim in a study of the 'dynamics' of a rat under automatic anesthesia. McClintock of RPI, on the other hand, enthusiastically saw his time-modulated six-count tape recorder as a tool in the servo analysis projects at three of the schools."

EDUCATORS FOCUS ON THE TECHNICIAN SHORTAGE

New York's roving team of education administrators, described in a visit to Sperry Gyroscope Co. on page 19, furnishes vivid proof that action is accompanying the intense soul-searching going on in American public school education today.

In attempting to meet industry's plea for more technically trained youngsters, the educators find themselves compelled to seek answers to the kind of questions posed by Dorothy Thompson in a recent column. Why do, she asked—

Only 4 percent of American high school students study elementary physics?

Only 7 percent study chemistry, 27 percent algebra. and 13 percent geometry?

Only half our schools offer courses in chemistry and physics?

Nathan Clark, supervisor of technical subjects, New York City Board of Education, and a member of the team of visiting educators, feels the need for a concerted effort by both industry and State and local education authorities. "There are countless American children entering high school," points out Clark, "with IQ's of 105 or over who could make very capable technicians or engineers. In our vocational program we have found we can give these students a full 4 years of math and 4 years of science. Further, our laboratory work gets the student's hands busy with electronic and industrial devices, as well as his mind into the basic theory behind such equipment. Then when the boys and girls graduate they are literally conditioned for industry—and are happy and interested in the jobs they get." Mr. Clark goes on to point out that this "industrial conditioning" is often lacking in most technical schooling—even colleges. "Why do 50 percent of graduating engineers drop this field in their first 5 years out in industry?" he asks.

Supervisor Clark is very enthusiastic about the New York board's program of meetings with industry to determine what the latter needs in the way of special training in vocational school graduates. In the get-together with Sperry, for example, observation of Sperry technicians at work suggested some mild adjustments in the courses offered in five New York technical high schools. After it reviews the suggested adjustments, the group will confer with Sperry again.

STEPPING UP TRAINING

New York City, advises Clark, is now embarked on a stepped-up plan for technical education. "We are working out better ways to select students and are determining what schools can best be set up for technical education." But city programs are relatively easy, he comments. "Other, smaller communities have a great problem in getting the necessary funds to train or hire the proper type of teacher for technical education. Engineers are needed—hence the community must compete with local industry. It seems to me that industry, in order to satisfy its larger, broader need for technicians and engineers, must get behind a local movement for higher starting salaries to entice teacher-engineers into nearby schools. From these schools will come the technicians they need so badly."

Industrial leaders, increasingly aware of the technician shortage and the potential for technician relief of the more difficult professional engineer problem, are starting to echo Nathan Clark's sentiments. The Thomas A. Edison Foundation meeting at West Orange, N. J., November 19–20, and the joint program for technical education of the Columbia School of Engineering, which held a session at Arden House, Harriman, N. Y., October 30–November 2, brought together educators and industrialists to discuss what draws young people to technology and how our colleges can help the hard-pressed science departments of high schools. These are but two of the many meetings throughout the land that are approaching the so-called engineering shortage problem in this new direction: through renewed, rebuilt emphasis on technology in secondary education.

Editor's note: The report above on increased activity by educators in technician training does not include the important area covered by the post-high-school technical institute. Many schools in this category have added, in the past few years, special courses in instrumentation and control. We hope to survey these courses and perhaps come up with an Industry's Pulse (similar to the one this month) that will tabulate the information.

BOB JEFFRIES, A CATALYST FOR TRAINING

Robert Joseph Jeffries is never completely happy unless he's doing at least six things at once. In his 15 years as an educator and consultant he has tackled control field projects ranging from motor control through aeronautics to navigation and human engineering—often keeping to a schedule that would shame an election-year campaigner. A typical Jeffries week: teaching at Michigan State,

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editing the ISA Journal in Pittsburgh, serving on a national committee in Washington, and spending a day each with clients in Chicago and Detroit.

Today, as assistant to the president of Daystrom, Inc., Jeffries still maintains his wonderfully varied, back-breaking pace. Catch him for a few minutes between flights and he'll enthusiastically tell you why. "I'm a flying catalyst. People are the most important ingredient in the future of our company—and our technology. I'm making it my business to activate this ingredient—to launch and catalyze programs for training and developing the potentials of people. A catalyst has to be where the reactions are—not on a nice quiet shelf." (Editor's note: Jeff then stayed on the ground long enough to give us his views on educational needs—see editorial, following.)

START OF THE REACTION

Bob Jeffries' career as a control catalyst began with EE and MS degrees from the University of Connecticut, which he sought with funds earned as a surveyor of the "fine terrain" of his native Connecticut, as a teacher of motor control and electronics, and as a summer employee of Pratt & Whitney. During the era of the VI's and V2's Jeff was at Langley Field with the NACA working on the development of its prototype missile tracking system and teaching extension engineering courses at nearby University of Virginia. In 1948 Jeffries was awarded his doctorate in engineering by Johns Hopkins, where he taught electrical engineering and participated in a pioneer study of human dynamics in control—a subject which later became known as "human-engineering." In the fall of 1948 he went down to North Carolina State College, where he directed a pilot research installation of a long-range navigational system and taught automatic control (using the new Brown and Campbell text).

In 1953, during his fourth year as an associate professor of electrical engineering at Michigan State, specializing in automatic control, Jeffries, then chairman of the ISA Education Committee, roganized the first national industry-government-university meeting devoted to educational problems posed by the new technology. Meanwhile he was editing the newly founded ISA Journal and squeezing out hours for consulting to industry on problems of control, system design, and education. Soon he and two associates formalized their consulting practice in Educational & Technical Consultants, Inc.—a service which draws on the talents of specialists in 73 colleges. One of his clients, Schlumberger Well Surveying Corp., took a cue from his report and formed Schlumberger Instrument Co., bringing in Jeff as technical planning adviser to President Henri-Georges Doll (Control Engineering December 1955, p. 15). Upon completing his phase of the work last spring he went to Daystrom as assistant to President Thomas Roy Jones.

At 33, Bob Jeffries is only at the start of a remarkable career, but he sees no reason to pace himself. "Education is a long-term, continuing proposition," he reminds us, "but it never gets off the ground without dedicated effort." Jeff's attractive wife Anna and his two children have grown to accept his time away from home that such dedication requires. "But," says Anna philosophically, "I'm looking forward to the day when Jeff becomes president of ISA (now president-elect secretary, he'll be president in 1957–58) because I will then at least be able to keep up with his activities through the ISA Journal."

PROGRAM FOR TRAINING

(Our control personality this month, Dr. Robert J. Jeffries, offers this guest editorial on the elements of a program for training people in our field)

In today's ideological conflict between East and West, the survival of our concepts of individual dignity and opportunity depends chiefly on our continuing prosperity and on the example we set. This requires, among other things, more and better-trained engineers to conceive and design more machines incorporating the latest products of control technology, and a supply of highly skilled technicians to operate and maintain this equipment. It requires, also, that we continually upgrade existing personnel to enable them to keep pace with the growth of the field.

Several things can be done to meet the challenge. Drawing on our knowledge and associations, we might address ourselves to the following:

Bolster science education in secondary schools — this requires better teachers.

Enhance the scope and effectiveness of collegiate programs—this requires industrial and community support.

Attract people to careers in the control field—this requires broader public appreciation of its content and potential.

Cultivate a better understanding of our technology at all levels of management and employment—this requires an effective and varied industry educational program.

Translate the sophisticated theories of academic and military programs into economically justified equipment and techniques for industry—this requires an effective two-way communication in needs, interests, practices, and experiences.

Develop a practical way to tap the great reservoir of experience already in the literature—this requires an effective technique for storing and retrieving that makes the information available to all.

How can we implement such a program? A good start has been made by the Instrument Society of America with its recently established Foundation for Instrumentation, Education and Research. The foundation's functions will be largely conceptional and catalytic. In general, it will assist in developing education and research projects in instrumentation not only for other societies, but for governmental, industrial, and educational groups at all levels. These projects will be nurtured by the ISA; by individual industries and industrial trade associations; by civic, labor, and fraternal organizations; and by educational institutions and Government agencies.

The success of the foundation's program—of any program for training, for that matter—depends on how much support it gets from that group certain to benefit the most from it—the men in the field.

ROBERT J. JEFFRIES.

INDUSTRY'S PULSE—HOW CONTROL MAKERS WILL TRAIN YOUR TECHNICIANS

A recent study by McGraw-Hill's department of economics indicates that the users of control will purchase over $4 billion worth of equipment in 1957. The incoming devices and systems will bolster an already incredible array of complex, highly specialized measurement and control equipment now being used throughout business, the military, and industry. But to the users they will create this pressing question: Where will the trained technicians come from to install, maintain, and operate the new systems?

One powerful answer to this question resides in the training schools, formal and informal, offered to control users by the makers themselves. Most of the two-thousand-odd companies that manufacture specialized products for the control field are prepared to back up their equipment either with informal in-plant or use-site instruction, or through organized training facilities. It is the growing emphasis on this latter category—the formal, organized customer training school—that prompted Control Engineering recently to survey 100 control manufacturers. By October 15, 33 companies returned complete answers on their organized facilities. The answers are crammed into the next pages.

To help the user with specific requirements, the table groups control-maker schools into four categories: aircraft and ordnance, analysis and test instruments, computers and data processing, industrial control. Thus, 1 group of the 3 companies trains technicians to service and run the highly specialized systems it makes for controlling aircraft, ships, and military vehicles. One distinguishing feature of this group is its stress on field training. All three companies take their students out or even up in the air to work on operating systems.

The five makers of analysis and test equipment that answered the survey use their brief courses (mainly 1 week) to focus on theory and function rather than field application. This approach, they believe, will enable the user to broaden his own ability to put the new tools of product measurement and system test to work in the many unplumbed applications in his plant.

Operational techniques are emphasized in the courses offered by the five digital manufacturers responding to the survey. All recognize the need to equip technicians to program and code (and simply operate) the rather complex digital systems they now have on the market. Because of the complexity of these systems, background is especially important; most firms require a knowledge of electronics and/or computer experience. One even suggests that the trainee be a graduate engineer with pulse experience if he is to take the maintenance course.

A much broader approach to the service and operation of automatic-control system is offered by the 17 industrial control firms in the survey, whose courses run from 2 days to 14 weeks. Many in this group have been conducting user schools for as long as 20 years, and several have developed special courses to suit the industrial background of the trainee.

Over all, the most impressive thing about the survey is the astounding number of people that these few manufacturers train. Excluding IBM (with its fantastic "mobile" program which handles 70,000), roughly 8,000 technicians pass through the portals of 33 control-maker training schools each year. What would the grand total be if all programs and all firms were included in the survey?

The tabulation reveals some interesting uniformity in the scope of user training by control makers:

All courses (with the exception of Kollsman's, some of Consolidated Electrodynamics', and the Westinghouse "CYPAK" class) are tuition free.

Most firms are staffing their schools with graduate engineers, many of whom are trained to teach.

Most of the companies require that their "students" be customers (at least 12, however do not).

One more thing is quite apparent from the table: more than half of all these control-maker schools seems to be enrolled to capacity long before classes start. So if you plan to send a man—get in your request right now.

Chairman PATMAN. The other members of the committee, who are in the city, are engaged with other committees. Senator Flanders is especially interested in this type of work and activity, and he wanted to be here, but he is engaged in another committee and he cannot leave. So is Senator O'Mahoney. Senator Watkins is not in town. And our House Members are engaged.

However, these hearings are printed, of course, and made available to all of the Members of the House and the Senate; and also the libraries throughout the country, and to other people.

I think you have presented a wonderful statement. I know it will be helpful to all of the Members of the Congress.

You made a statement about your proposal to have a task force set up. I do not object to any task force, and I am sure it would be helpful and constructive in its efforts and activities, but I think that the best way to get consideration of a legislative body—and, obviously, some of their recommendations would require legislation; I assume you agree to that?

Mr. SHEEN. Yes, sir.

Chairman PATMAN. Is to go directly to the Congress, and through the legislative setup to the committees having to do with these problems. Then the same people who receive the testimony will also be charged with getting something done, and take a personal interest in trying to push it through Congress.

When you go about it with a task force, you not only have to convince the task-force members, but after you have gotten up your recommendations, after months, and sometimes years of study, and have gotten up unanswerable, convincing proof of your recommendations that you need as to why they should be enacted into law, you must then go to the legislative committee. Do you not agree with me that there is something to that point that should receive consideration?

Mr. SHEEN. Possibly so. What we are trying to do is to point out that we have an immediate need.

Chairman PATMAN. That is right.

Mr. SHEEN. We have some specific problems. We are also trying to suggest possible ways to solve those problems.

Chairman PATMAN. But that makes it more important that you approach the people who have the power to act.

Mr. SHEEN. We are happy to do so.

CTURERS

N ...E	THE STUDENTS			ENROLLMENT	
	NO. PER YEAR	WHERE FROM	PREREQUISITES	METHOD	ANY WAIT?
I. LE Sa	250	from military & distributor service facilities	none	written application from his employer	no
KO Ele	200	military, airframe mfrs., airlines, systems mfrs.	determined by the customer who sends him	contractual or other agreement	2 months
SP Gn	to 1,000	aircraft, govt., shipping, executive aircraft, cargo	depends on course basic knowledge essential	customers request training on specific products	3 months at most
II. BA Ca 0	100	metals industry, industrial & research labs	users only are invited to attend course	write well in advance of Oct. 22 deadline	only one course a year
BA Ro	50	labs, surgical schools, instrument dealers	selected by management of respective companies	invitation from B&L Optical Co.	only 6 courses a year
BR Cle	60	manufacturing, research, and development	fundamentals of electr. and mech. measurement	direct application to Brush or factory rep	5 weeks
CO Pa	200	from customer plants aircraft to refining	good electronics background very helpful	through field sales offices after purchase	up to 3 months
NO Mo	500	all types of industry	none	merely write that you wish to attend	no
III. EL Pa	750	industry, services, research, etc.	an EE degree with pulse expr. for maint. course	write field office or direct to Pasadena	1-3 wks
EL Lo	150	research & development groups, industry, govt.	analog computer experience	invitation	no
IBI Ne	70,000	all types of locations, classes go to them	aptitude tests and prerequisite machine exams	through local office & local sales reps	1 month
LO Re	250	mfg., process, govt., business, transport	grad. eng. or mathematics, or aptitude	write or call and make arrangements	2 weeks
J. Sa	200	engineering, aircraft, chemical, etc.	none	through correspondence with J. B. Rea Co.	variable
RE Ne	120	across all business & industry, institutions	basic knoweldge or electronics	by customer or government request	few wks
RE Ne	1,500	from industry, business, government	none except for advanced programming	through local RR branch or RR training director	2 months
UN Lo	100	industrial, casualty firms, govt., etc.	none	contact training director of the divis on	no
IV. AS Ch	100	steel mills, process plants in industry	must be customers	send in name of man who will attend	usually
BA Cl 0	250	mainly power co.'s, but some process plants	none	request by letter, wire, or 'phone	5-6 mos
TH Wa 0	70	mainly process, but all areas of industry	recommendation by student's company	write giving man's name & primary interest	not often
FIS Ha 12	40	all types—no restriction	none	request on company letterhead	no
TH Fo 0	250	process industries all over world	at least 6 mo exper. plus h.s. physics, math	application from customer mgmt	3 months
GE We 5	150	chemical & metal-working industries	no but technical background recommended	write to Mr. Shattuck, Product Service, GE	no
TH Mi 30	25-30	wherever combustion control is located	must be responsible for Hays eqpt.	direct request	no
INI Co 2	100	nationwide industrial firms	should be associated with an installation	letter to Sales Training Dept.	yes
LE Phi 0	700	process, utilities, labs, govt., & education	nomination by L&N customer or real interest	Apply to Philadelphia L&N office	maybe
MA Str 0	60	usually from process all welcome	users or contractors of MM&M equipment	indicate desire to attend course	only 3 a year
MI Phi 0	350	all inclusive	none	written request	3-5 mos
PO Sk 4	40	various customers	none	request through local sales office	no
RE Cle 2	300	process, ferrous & non-ferrous, machine tool	Reliance customer with electrical background	request through district office	6 months
TH Cl 5	100	primarily refining & chemical - many others	none	reserve through local sales office	sometimes
TA Br 7	30	bridge & road authorities, airfields	must be sent by company	automatic if a customer	no
TA Ro 2	275	process industries	try to fit course to background	contact local sales representative	3 months
WE Pit 3	100	industrial cross-section	none	through local salesman	yes

Chairman PATMAN. A lot of task forces have worked hard and have accomplished a lot in alerting the people as to the needs of certain things, but they are not the people who can act. They are only people who can present it to the people who can act.

Mr. SHEEN. We would be delighted to see this committee or any other committee act directly on these recommendations.

Chairman PATMAN. Well, this committee is set up more in the line of a task force committee, in that we do not have legislative power. Under the Employment Act of 1946, we are more than, I guess you would call, a watchdog committee. We are a committee to pass upon these questions and make recommendations to the legislative committees.

Mr. SHEEN. We will be very happy to carry the story in any committees that you might suggest.

Chairman PATMAN. That is very fine. I am not objecting to the task force; it could serve a very good purpose, but those same people will have later to be called before the legislative committee. And anything that is urgent, that is needed real soon, I suggest and urge that you consider getting hearings before the legislative committees for it. And you will have the cooperation of this committee in getting it done.

Mr. SHEEN. Thank you.

Chairman PATMAN. I started out turning down a page of your statement that I wanted to ask you about and I find I have turned down all of the pages when we got through. I won't obviously ask you about all of them. But I want to mention some of them.

You mentioned accelerating the educational programs. Of course, that is very fine. I want to commend your organization for establishing this foundation and putting up the first $50,000 to start it off in its work. The needs are urgent and great. I agree with you on that.

You know, our committee over a year ago, November 1955, I believe it was, for the first time brought to the attention of the country that there is a great shortage of engineers and scientists. We disclosed through such witnesses as Dr. Vannevar Bush and others that Russia was 'way ahead of us and that Russia would graduate in 1956 twice as many engineers for instance, as we were going to.

The most alarming and shocking thing of all that was brought to our attention was the fact that Russia during the year 1956 would graduate 32 times as many technicians than the United States of America. That is what is so shocking to me. I went into it a little further. And I discovered that Russia is doing what you have suggested here on one of the pages that I turned down, that we do here in this country, that is, the young men in military service that we should pay some attention to them and give them training.

Mr. SHEEN. That is right.

Chairman PATMAN. That is what Russia is doing. That is the reason that they can graduate 32 times as many technicians. They are training their military personnel in that way. So that there is no reason why we could not do it here. I think it would be not only helping the country but be helping the young men, too. I think one of the major problems, just like you pointed out, is the problem of insufficiently trained and inadequately educated manpower.

Mr. SHEEN. That is correct.

Chairman PATMAN. Your idea about a central clearinghouse for the rapidly accumulating information of knowledge, I think is a wonderful suggestion.

And so is your suggestion about the improvement of curricular and training of teachers in high schools. I asked Dr. Bush what he considered to be the weakest point in our educational system. He said the lack of trained teachers in the high schools. He put his finger right on it.

And you have, too, here. I noticed that you brought out some other points, effective utilization of military training period. That is the point that I brought out a while ago, that Russia is getting ahead of us on technicians in that same way.

Mr. SHEEN. I had a young man in my office, a graduate mechanical engineer, Monday of this week, just out of the service, and he told me that three-quarters of his time before he was actually transferred to any technical activity at all was spent on more or less menial work and the average training of the men in his particular company (military) was actually 14½ years of school, which meant that more than half of them were college graduates.

He had a Ph. D. and M. S. working along with him on menial tasks.

I submit to you that is a radical waste of manpower.

Chairman PATMAN. Like cleaning up the barracks or KP. They do not seem to make any difference on that. We all had to go through it, you know, in military service.

Mr. SHEEN. That is true.

Chairman PATMAN. But we can utilize our manpower in a much better way than that. I think this hearing will have a tendency to bring it to the attention of the public and of the Congress.

The more active role by the National Bureau of Standards and communication of their information and so forth—I am strong for the Bureau of Standards. I believe the Congress is sold on the need to support and cooperate with the National Bureau of Standards.

I won't comment on your testimony except to say it is very helpful. I certainly appreciate it and I know Members of Congress will be greatly helped by it.

We will hear from you this afternoon on this small-business aspect of the question.

Mr. MOORE. One criticism we have of the committee's report last year on automation is that the committee did not undertake to define "automation." Those who were at the hearings discovered that automation was a pretty broad conceptual thing, rather than one that could be precisely defined and narrowed.

Since we are going to be using this word "instrumentation" so much in the next day or two, I wonder if you could point out the boundaries or how far instrumentation goes. I know it is a difficult question just as we found automation was impossible. But I think it would be helpful if we knew what you mean by that.

Mr. SHEEN. I think our next witness has one of the finest definitions in his testimony that I have as yet seen. That is by Mr. Jones.

Chairman PATMAN. That will be by Mr. Jones?

Mr. SHEEN. Although I would not hesitate to approach it, at the same time I would not want to duplicate his material.

Chairman PATMAN. One other suggestion about the task force: If you set up a task force that you expect the Congress to accept and not go through a committee, you are thereby placing elected representatives of the people in competition with those who are appointed by someone. And you get into trouble with our system of government.

Mr. SHEEN. I understand.

Chairman PATMAN. That is what I am trying to urge upon you for consideration, that you present your proposals directly to the legislative committee on all urgent matters.

Mr. SHEEN. I greatly appreciate that suggestion.

Chairman PATMAN. Thank you very much, Mr. Sheen.

Mr. SHEEN. Thank you.

Chairman PATMAN. We will look forward to hearing you again this afternoon.

Mr. SHEEN. Thank you again.

Chairman PATMAN. Now, Mr. Jones. You may sit there at the table with him if you desire, Mr. Sheen.

Mr. JONES. I am very sorry that I did not speak first for the reason that there is a good deal of duplication in recommendations between the first speaker and my paper.

Chairman PATMAN. That is all right. We can stand it, because we need it. You cannot repeat it too much.

STATEMENT OF THOMAS ROY JONES, PRESIDENT, DAYSTROM, INC., ELIZABETH, N. J.

Mr. JONES. My name is Thomas Roy Jones. I am president of Daystrom, Inc.

To provide understanding of the basis for my observations and conclusions, it would be appropriate and valuable if I should describe to you the type of activities and the organization with which I am daily associated.

Daystrom, Inc., is a management holding company which has several operating divisions and subsidiaries whose principal activities lie in the broad fields of electronics, avionics, nucleonics, electrical indicating, recording, and controlling instruments and systems, laboratory standards, and military and industrial intelligence and computing systems.

Our products also embrace several electronic devices used in the home, for example: high fidelity sound-reproduction equipments, and hobby equipments.

One of our subsidiaries, the Weston Electrical Instrument Corp., is the world's largest manufacturer of electrical indicating instruments. One of our other subsidiaries, the Daystrom Pacific Corp., pioneered the development and manufacture of miniaturized devices for aircraft and guided missiles.

Our nuclear division is building the world's first medical research reactor for the Brookhaven Laboratories of the AEC.

The purpose in reciting these varied activities of our company is to try to explain the breadth of concern and association which my particular position as president of Daystrom, Inc., represents with respect to instrumentation and automatic controls.

My premise is that the electrical instruments, laboratory standards, and electronic test equipment of the types manufactured by Daystrom constitute the foundations of automation.

Some of our other products, in particular the devices for sensing physical quantities, the indicating, recording, and controlling instruments and systems, are the actual instrumentation of automation.

We are, therefore, vitally interested in automation and feel that we are in a good position to appraise its potential and its needs, and also to contribute to its enhanced applications in industrial and military environments.

With this introduction I should like now to try to develop a pattern which is inherent to automation—a pattern in the technological sense. Automation may be defined as anything having to do with an extension of human senses and capabilities via machines.

The senses are those of sight, touch, hearing, smell, and taste. The capabilities include motion, force, work, and the mental operations of arithmetic and algebraic manipulation, selection, and rejection.

Those are terminologies of the electronic brain.

The extension of these senses and capabilities are accomplished within the concept of automation by machine sensors, such as thermocouples and resistive elements for the sensing of temperature; orifice plates, rotating armatures, and so forth, for the sensing of flow; diaphrams for the sensing of pressure; photocells for the sensing of light; microphones for the sensing of sound; and analytical type instruments, such as, infrared and ultraviolet spectrometers, mass spectrometers, and vapor phase chromatographs, which determine the chemical composition of materials, through the analysis of light reflected by those materials.

The capabilities of motion, force, and work are realized within the concept of automation by pneumatic, hydraulic and electromagnetic actuators. Equivalent mental operations are performed by analog and digital computers—popularly known as electronic brains—in the most elementary machine equivalents of mental arithmetic, selection, and rejection.

Electrical instruments, laboratory standards and electronic test equipment are the foundation of automation because these equipments are used in the development of automation equipments and systems. (Electrical instruments, laboratory standards, and electronic instruments are essential to the development of sensing, indicating, recording, controlling, actuating, and computing automation equipments.)

Therefore, the instrument development and the instrument manufacturing activities in which Daystrom and other similar companies engage constitute the source of knowledge, the components, and the application know-how which make automation possible.

These devices, such as my company makes, must precede and are essential to automation applications. Therefore, the instrument industry is necessary if automation is to exist. Automation as an industrial evaluation will be no more healthy nor dynamic than is the instrument industry.

Should automation be encouraged? The answer is, categorically, "yes." The principal arguments have been previously stated in hearings before this committe some time ago by representatives from several industrial areas.

I add my endorsement to their arguments as to why automation is beneficial to our national welfare.

In addition, I submit the following points as a summary of my personal beliefs as to why automation is good and should be accelerated in its application.

First, automation is essential to the economy. If this Nation is to increase its productivity at a rate which will provide a standard of living to which we all aspire, with our available manpower, we must have a greater unit productivity on the part of the individual worker.

The only way the American worker can increase his real wages is through an increased individual productivity. He can do this by working more hours or management can do it for him by increasing his productivity per hour.

Increased productivity per hour can be achieved only through a greater application of automation. In our research activities it is not possible to conduct the studies that must be conducted in order to advance the frontiers of knowledge—it is not possible to perform the mathematical computations which must be performed if we are to understand the world and its workings about us—unless there are developed more sophisticated types of automation equipments.

Therefore, in these senses automation is essential to our economy. Automation is essential to the creation of new jobs—new jobs which are better jobs, which require higher skills and will therefore elevate the worker and consequently pay him more money.

Second, the advent and the acceleration of automation is essential to our moral fiber. So long as man is endowed with an ingenious and an inventive brain, one capable of creative thought, and a body capable of creative effort, he must find an application for these capacities.

It would be spiritually and morally decadent for man to ignore the possible improvement of his own position and method of operation when such improvement is obvious to him.

Therefore, I submit that it is a psychological necessity that man continually seek to extend himself to the limit of his inherent capabilities.

Great progress has already been made in this direction. When I started my career as an engineer back in 1913, I started as a laborer on a railroad-signal gang out in Oregon. My engineering training certainly was not essential to the work and there was little opportunity for me to be technically creative.

This was because our technology was temporarily stagnant. The profession of engineering had little stature, the engineer himself was not considered a particularly important individual.

Times changed gradually, but it was true not very long ago that it was considered standard practice for an engineer to serve a 2 or 3-year apprenticeship as a draftsman before he was assigned any design responsibility.

Today we cannot afford this waste of technical talent. Today we recognize and try to provide opportunities for expression of personal creativity—we try to cultivate the abilities and capacities of our engineers systematically.

Third, automation is essential to national defense. Technologically speaking, we need new weapons; we need new defenses. Missile and aircraft fly too high and too fast to be detected and counted by means employing human senses and capabilities only. We need sophisticated weapons systems embracing refined measurements, rapid calculations, and precinsion control to insure our security.

When we were forced into the Second World War, we had a surplus of labor on which we could call to provide the additional production required. Currently we are at nearly full employment. If another war should come, the war production would have to come at the expense of the civilian economy—perhaps to an extent that it would endanger the ability of the civilian economy to support the military production.

Certainly, the sacrifices and deficiencies which would be forced on the civilian economy would be far greater than anything we have ever known. The only answer to an increased demand whether it be for military or civilian goods is greater productivity through increased automation.

Now, some of the foregoing statements, which are in a sense generalities, should be supported by statistics. I propose, therefore, with the permission of this committee, to enter into the record certain statistical and factual information in support of some statements I have made. These evidences are much too lengthy to repeat here in detail. It would be helpful, therefore, if the full content of these evidences could be included within the record.

Basically, these evidences consist of statistics establishing the nature of the field of automation in terms of its products, its services, and the companies engaged in it; included is information concerning the market potential and the growth potential of the automation industry as implied and thus required by the growth and development of the industries which embrace automation. These are appendixes A 1, 2, and 3.

Chairman PATMAN. They may be inserted at the end of your remarks.

Mr. JONES. Thank you.

It would be helpful to enter into the record an article which appeared in the journal of the Instrument Society of America in April 1956, which outlines in quite a comprehensive fashion the problems faced by America in effective utilization of automation. That is appendix B.

Chairman PATMAN. It may be inserted.

Mr. JONES. Thank you.

It would also be helpful to enter into the record excerpts from the text of a descriptive brochure prepared to justify and explain the nature of a Foundation for Instrumentation Education and Research which has recently been established in recognition of the several needs of automation—needs recognized by a group of eminent leaders of the Instrumentation-Automation-Science Fraternity, a voluntary association of freemen, representing free industries, bound together by a dedication to the welfare of our country and its economy through enhanced automation. That is appendix C.

Chairman PATMAN. It may be inserted.

Mr. JONES. Thank you.

Based on these evidences, it is clear that automation is imperative; that electronics and instrumentation are essential to automation; and, in order for automation to progress, the instrumentation-electronics industries must be healthy.

Now, what is the present situation? As a matter of fact, the electronics-instrumentation industries are being held back from realizing their ultimate potential, technologically and economically, by several factors. The electronics-instrumentation industry is a dynamic growth industry, with its markets expanding, its technology developing. Economically—traditionally—you would term it "an immature industry." There are many small, marginal operators. New companies are being formed every day. Mergers and consolidations are taking place. We are just on the threshold of recognizing this aggregate of activity as an automation industry. Already, however, this industry is beginning to be pinched by some fundamental weaknesses in our national picture.

At this point, a digression is indicated. The administration and Congress are greatly exercised over the large number of mergers which have been and are taking place. We hear much talk about little business and big business, but nowhere is anyone worried about the welfare, and the encouraging of formation, of the business backbone of the economy and the great resource of the Nation in time of sudden war—the middle-sized business.

It is not maintained that all mergers are good. A few have been economically unsound and a few have been shamefully conceived in a spirit of selfish greed—but let's not throw out the baby with the bath water.

Small business cannot match the technological research of big business. Medium-sized business, confining itself to its specialized area, can. In the case of national emergency, small business generally has not the management, the flexibility, the size or the resources to do other than be subcontractors taking the scraps perforce let out to them from the prime contractor. The big businesses have these things and, having them, tend to grow bigger. A strong layer of medium-sized business—the middle class of the economic society—is the mainstay of the normal economy and the safety of the Nation in time of war.

This subject cannot be treated in three paragraphs but suffice it to say that Congress should give serious thought, particularly in this field of instrumentation and automation, to encouraging those small businesses which, in order to achieve strength and corporate security, wish to combine. Congress should not build up roadblocks of bureaucratic redtape and delays and the huge expense of reports and legal fees.

Now to pick up the thread dropped at the digression and enumerate the fundamental weaknesses before mentioned. First, the pricing in the industry is at such a level that many small businesses in the industry itself cannot support their own growth. This is a fault, in part, of the industry itself and, in part, of the tax structure.

Second, the industry is being hampered severely by an inadequate appreciation and understanding of the capabilities, limitations, and potentialities of its products and services on the part of those whom it would serve, both in industry and in Government.

This is to say that, if industry as a whole and many Government activities are to take advantage of the potentialities inherent in existing automation techniques and equipments, there is a mass education job to be done to explain, to investigate, and to create a basic understanding of principles and practices of the potential users of automation and its techniques and its equipments. We need a vast automation-market educational program.

Third, there is a corresponding need within the ranks of the automation manufacturers themselves—those industries who manufacture electronic-measuring equipment and engage in instrumentation, components, and systems development and manufacture—for an education of their personnel as to the very latest technological, scientific developments—the ivory-tower developments—which have application to their industry.

We need to shorten the time span between the concept and understanding of a scientific principle to the time when it is embodied in a piece of practical equipment that will be economically and technologically justified in a user plant or production environment.

The history of the application of automation equipments is essentially a pattern of timing. Some research scientist somewhere in a laboratory identifies a fundamental physical principle. At some later date—maybe months, maybe years—an instrument is devised which measures or displays or characterizes this principle.

From a laboratory bench model, over a period of years usually, there will evolve a laboratory instrument made available through the instrument industry to laboratory scientists. With years of laboratory application, gradually this instrument may get out into a plant laboratory and ultimatley, several years later, out into the plant as a plant-worthy instrument. The infrared spectrometer—that is the instrument which analyzes light rays below those of human vision—is a good example of this historical evolution where generations went by from the first concepts of the infrared spectrometer to our present state of plant application of these kinds of equipments. Now this time span is being shortened. There is a greater acceptance of the new today, not only by industry but by the public. With every new instrument that is conceived, with every new instrument that finds its way into a plant, we recognize and we appreciate the shortening of this time span. But much more must be done to shorten this time span.

Fourth, both the potential user of automation equipments and the developer and manufacturer of such equipments is hamstrung; is being held back at the moment by an inadequate supply of technically trained personnel at all levels—Doctors of Philosophy, bachelor's degrees, technicians.

This country's educational system simply is not geared at present to producing the number of people required with technological training to absorb and apply and develop the automation equipments which are possible; which are desirable, and which, in many instances, are basically necessary to our modern economy. The situation is frightening.

This is now the point at which can be brought out an opportunity which has lain in the hands of the United States Government ever since the Korean war—an opportunity so great and so apparent that I am amazed that, in the face of the great national necessity, nothing has been done to take advantage of it.

I have had two sons in the Army. I have been shocked at the amount of time spent in unnecessary manual labor—or even in doing nothing at all—by men of superior technical possibilities.

I am convinced that essential military instruction and training can be condensed into half the time now taken. The remainder of the time can be utilized in study in scientific courses given by men already in the service either as officers or as enlisted men. Servicemen not interested in advancement, or incapable of carrying the work, could do the manual labor. Interest in scientific learning and scientific pursuits could be aroused to the end that technical education could be completed under the G. I. bill of rights after release from the Army.

In the automation field there is a great need for effective communications so that the work done by one group and the experiences of all groups can be made available to everyone who has a need for the information.

With the shortage of manpower, with the needs for instrumentation-automation research and development and application; and with the urgency of needs in many of these areas, it is criminal for people to spend time rediscovering the truths already known—to go through all the growing and application pains which have previously been experienced by others.

We need fundamentally a basic system of communication in this country by which the accumulated knowledge and experience of all can be made available to all. We need an effective instrumentation-automation information, storage and retrieval system. This would embrace statistics of the industry and of the markets, technological developments and operational experience.

One major facet of the communications problem is a need—an urgent need—for a much more effective cross-fertilization between those working on military developments and those concerned with civilian application.

In order to get the maximum mileage out of our research and development dollar, both within the military and within industry, we need to have a much greater liasion activity so that the developments designed for one field of application can properly be appraised and related and correlated with the needs of other industry areas.

Specifically, the military programs of research and development have made great strides in a technological sense and have pushed back the capability frontiers of equipments far beyond those presently utilized in industry. There is a need for closing that gap, for bringing together the people from industry with their appreciation of their problems and the people with the knowledge of the military progress.

Perhaps some neutral unbiased group jointly supported by military and civilian interests could evaluate the military developments and their application and adaptation to civilian production. This can be justified in terms of its effect on a national economy. It can be justified in terms of greater return for every military dollar spent on research and development. It can be justified on the basis that the increased productivity and lower costs of the resulting civilian industry will in fact result in lower acquisition costs of material by the military in its other purchasing programs.

Now there have been and there are activities which are directed toward meeting some of these needs. The Office of Basic Instrumentation of the National Bureau of Standards is an exemplary organization in its concept and limited functioning. It, too, is plagued, as I understand it, by manpower problems.

The various technical societies through the medium of the various technical meetings and symposia they hold are contributing substantially to the communications problem. The National Science Foundation through its support of basic scholarship is contributing somewhat to the manpower problem, but they are only scratching the surface with respect to the magnitude of the problem before them.

The establishment of the Foundation for Instrumentation Education and Research to which I previously referred is, as far as I know, the first specific directed activity of the instrument-automation industry as represented through the membership of the board of trustees.

To approach some of these problems that foundation, to be completely effective, will need the active support and cooperation of the users of automation equipments and techniques, civilian and military. They will need the active participation of several Government agencies. To my mind, it is the best device available on the horizon for accomplishing several of the objectives which are implicit in the problems I have described.

In summary, I should like to leave you the basic recommendations which are inherent in my previous remarks. In all of these recommendations I wish to emphasize that the Government need not undertake the actual operating details. It is rather that we need the unified approach and direction which the Government is in the best position to offer.

First, the Government should consider the establishment of a centralized, information-coordination storage and retrieval system, cooperatively planned, operated and utilized by government and industry.

Second, the Government should encourage activities designed to enhance the cross-fertilization of military development and industrial adaptation.

Third, the Government should attempt within the bounds of practicality to contribute to the support of research and development activities in small business in the field of automation techniques and equipment by letting military contracts to such organizations. The plea here is for a broader base of participation in Government research and development programs relating to instrumentation.

My fourth recommendation is with respect to the educational needs of industry and the military from the standpoint of the enhanced utilization of existing automation techniques and equipments and the concept and development of new techniques and equipments.

The Government should consider programs by which it can enhance the application of these equipments and techniques in these areas through the establishment of a series of locally based educational activities. This might take a form similar to the engineering, science and management war-training programs instituted during the early stages of the last war, or support for some of the current cooperative industry-technical society programs now in the experimental stage.

My fifth recommendation has to do with manpower development. The Federal Government should undertake immediately programs designed to strengthen our science education in our secondary school systems. First it is necessary to impress on those responsible for educational curriculums the need for instituting basic science courses in physics, chemistry, and mathematics. Every effort should be made to improve the quality and the quantity of our science teachers, particularly at the high-school level.

There must be a coordinated, integrated program of orientation and indoctrination of appropriate potential teachers and existing teachers with respect to the needs of our economy. An appalling lack of scientific instruction of any kind exists in most of our high schools.

My sixth recommendation is that the United States Government should, through the military, institute basic scientific courses of training for the men under draft in the service.

My seventh point of recommendation is that—when agencies designed to meet some of these needs are brought into existence, such as the Office of Basic Instrumentation within the Government and the Foundation for Instrumentation Education and Research outside the

Government, when these machineries are established and it is determined that they provide a mechanism by which some of these objectives can be realized, then the various Government agencies should cooperatively join and participate in the programs of those groups so that those programs may be advanced.

There are my seven recommendations to this committee. I don't think they are sufficiently detailed so that they can be formulated in terms of possible legislation at this time. But I think as principles of problems to be resolved they do point the way for the establishment of a series of advisory committees to the Congress and to various Government agencies, such committees to include representatives of the Government and of industry, both the instrument-manufacturing and the instrument-using groups. These committees should be able to sit down and give birth to specific proposals leading hopefully toward legislation.

I add only one thing in closing. One of the major characteristics of these problems is their urgency. These problems are not problems which are to be studied and treated at some distant time. They are problems which exist now and they are needs which exist now. And I state flatly that, as of this moment, automation is being held back and our national security is being jeopardized by the existence and the lack of solution to these problems. The rate at which automation can be introduced in industry will be lessened by every day that these problems go unresolved.

I appreciate the opportunity of being able to present this information to you.

(Appendixes A–1, A–2, A–3, B and C, referred to above, are as follows:)

APPENDIX A–1

[From the Advance Report, 1954 Census of Manufacturers, April 1956, Series MC–38–1.1]

SCIENTIFIC INSTRUMENTS INDUSTRY

(S. I. C. Code 3811)

During 1954, manufacturers in the scientific instruments industry shipped products valued at $562 million, an increase of 379 percent over 1947, according to preliminary results obtained from the 1954 census of manufactures conducted by the Bureau of the Census, Department of Commerce. Average employment in this industry has increased 139 percent since 1947 (when the last census of manufactures was taken) to a total of 43,900 employees in 1954. Value added by manufacture in the industry amounted to $342 million in 1954, an increase of 350 percent over 1947. "Value added" is derived by subtracting the cost of materials, etc., from the value of shipments. It avoids, therefore, the duplication in the value of shipments which result from the use of products of some establishments as materials by others and is the best measure available for comparing the relative economic importance of manufacturing among industries and geographic areas. Changes between the two census years for other key measures of activity for the industry are shown in table 1. No adjustments have been made for changes in price levels between the 2 years. All figures in this report are preliminary and, therefore, subject to revision in the final industry bulletin.

The scientific instruments industry represents manufacturing establishments engaged primarily in the manufacture of laboratory, scientific, and engineering instruments such as nautical, navigational, aeronautical, surveying, drafting, mathematical instruments, and instruments for laboratory work and scientific research (except microscopes and telescopes, which are in "Industry 3831, optical instruments and lenses). Establishments primarily manufacturing surgical, medical, and dental instruments are classified in group 384, "Medical equipment and supplies; mechanical measuring and controlling instruments in

"Industry 3821, mechanical measuring instruments"; machinists' precision measuring tools in "Industry 3545, metalworking machinery attachments; and instruments for recording electrical quantities and characteristics in "Industry 3613, electrical measuring instruments." The industry classification for scientific instruments used in the 1954 census of manufactures is based on the Standard Industrial Classification Manual, volume I, Manufacturing Industries, 1945 edition.

The value of shipments, as reported by establishments classified in the scientific instruments industry, consisted not only of products described above as primary to the industry, but also included the value of secondary products (which are primary to other industries). In tables 1 and 2, the $562 million total value of shipments reported by establishments classified in "Industry 3811, scientific instruments," consisted of $520 million manufactured products and $42 million miscellaneous receipts for contract work, repair work, sales of scrap, etc. The $520 million product shipments were accounted for by $394 million of scientific instruments, and $126 million of products primary to other industries (e. g., electrical and mechanical measuring instruments, electric motors, aircraft parts). Thus, the industry's shipments of scientific instruments represented 76 percent of its total manufactured product shipments (primary and secondary). This figure describes the "primary product specialization ratio," that is, the extent to which plants classified in an industry "specialize" in making products regarded as primary to the industry. The 1947 primary product specialization ratio for the industry was 81.

The industry's total value of shipments should be clearly distinguished from the total value of primary products of the industry shipped by all producers. The latter figure, appearing in table 3, indicates that $620 million value of scientific instruments were shipped by all producers. Of this total, 64 percent was shipped by plants classified in industry 3811, while the remainder was shipped as secondary products by plants classified in other industries. The figure 64 percent is known as the coverage ratio, that is, it measures the extent to which all shipments of primary products of an industry are covered by plants classified in that industry, as distinguished from secondary producers elsewhere. In 1947, the coverage ratio for this industry was 84. This significant decrease in coverage ratios between the 2 years is due to the increasing production of aircraft flight instruments by establishments primarily producing ordnance equipment. Such establishments in 1954 accounted for about one-sixth of all of the scientific instruments shipped.

Relatively low coverage and specialization ratios are characteristic of the several instruments industries. There tends to be considerable overlap among scientific instruments, mechanical measuring instruments, electrical measuring instruments and fire control equipment as well as a characteristic of establishments in this group of industries to produce secondary products such as motors, optical instruments, fire control equipment and other products which require similar production facilities, materials, etc. Since the classification of an establishment is determined by its principal products in a given year, a relatively small shift in the emphasis on a given line of production (e. g., scientific instruments to electrical measuring instruments, or vice versa), may change the classification of the establishment and result in sizable variations in the general statistics such as employment, cost of materials, etc. for both industries affected. Such developments are not wholly valid measures of changes in activity of the industries but reflect important differences in the industry classification of the same establishment from one census year to the next. A somewhat more accurate picture of the changes in activity in the instruments industry is obtained by aggregating the three instruments industries. The product data on instruments are, of course, not affected by these shifts in industry classification of individual establishments.

The general statistics (employment, payrolls, cost of materials, value of shipments, etc.) are reported for each establishment as a whole. Aggregates of such data for an industry reflect not only the primary activities of the establishments in that industry, but also their activities in the manufacture of secondary products and receipts for their other activities (contract work on materials owned by others, repair work, etc.). This fact should be taken into account in comparing industry statistics (tables 1 and 2) with product statistics (table 3) which show the shipments by all producers of the primary products of the industry.

More detailed figures for this industry will appear later in the Census Bulletin, MC-38A, Instruments; Surgical, Dental, and Ophthalmic Goods, which will be published and offered for sale at a later date by the Superintendent of Documents, United States Government Printing Office. Also, in this bulletin, there will be a comprehensive discussion of such concepts as industry, establishment, secondary production, as well as the various statistical items such as employment, value added, etc. Similar advance reports and final bulletins will be issued for other industries during the coming months. A summary of preliminary United States totals for each manufacturing industry and totals for each State will also be issued in the next few months. Advance reports for individual States will appear in May and June of 1956, to be followed later in the year by the detailed State bulletins. (Order blanks which list these reports and bulletins and their prices may be obtained from local United States Department of Commerce field offices or by writing to: Bureau of the Census, Washington 25, D. C.)

The 1954 Census of Manufactures is the 26th such census of the United States since 1809. For 1954, it was conducted jointly with the Censuses of Business (Wholesale, Retail, and Services) and Mineral Industries, covering continental United States, Alaska, and Hawaii. Present legislation provides for a Census of Manufactures every 5 years, with the next one scheduled to cover 1958. In addition, the law authorizes annual sample surveys to be conducted in interim years.

TABLE 1.—*General statistics for the scientific instruments industry, in the United States, 1954 and 1947 (Standard Industrial Classification Code 3811)*

Item	Unit of measure	1954	1947 [1]	Percent change 1947–54
Establishments	Number	367	215	+71
All employees:				
Number	Thousands	43.9	18.4	+139
Payroll	Million dollars	210.5	56.0	+276
Production workers:				
Number	Thousands	29.7	13.5	+120
Man-hours	Millions	61.5	27.2	+126
Wages	Million dollars	129.4	37.7	+243
Value added by manufacture [2]	do	341.6	75.9	+350
Cost of materials, fuel, electricity, and contract work [3]	do	220.5	41.4	+433
Value of shipments [4]	do	562.1	117.3	+379
Capital expenditures, new	do	8.6	4.5	+91

[1] Revised.
[2] Value of shipments less cost of materials, supplies, fuel, electric energy, and contract work.
[3] Excludes cost of products bought and resold in the same condition.
[4] Includes, for all establishments classified in this industry, not only (*a*) their value of products "primary" to the industry, but also (*b*) their value of "secondary" products, which are primary to other industries, and (*c*) their "miscellaneous receipts" for repair work, sales of scrap, installation of own products, etc. Excludes sales of products bought and resold in the same condition.

TABLE 2.—*General statistics for the scientific instruments industry (S. I. C. Code 3811), by region and selected States: 1954 and 1947*

Region and State	1954										1947 [5]	
	Establishments (number)	All employees		Production workers			Value added by manufacture [2]	Cost of materials, etc. [3]	Value of shipments [4]	Capital expenditures, new	All employees (number)	Value added by manufacture [2]
		Number	Payroll	Number	Man-hours	Wages						
			Thousands		*Thousands*	*Thousands*	*Thousands*	*Thousands*	*Thousands*	*Thousands*		*Thousands*
United States, total [6]	367	43,938	$210,530	29,707	$61,472	$129,360	$341,559	$220,532	$562,119	$8,599	18,419	$75,922
New England	36	3,559	14,941	2,423	4,965	8,677	26,785	11,233	38,048	1,119	585	2,766
Massachusetts	23	2,387	10,294	1,693	3,367	6,168	16,514	6,705	23,219	807	549	2,652
Middle Atlantic	113	19,019	96,412	12,856	26,343	59,770	138,156	100,508	238,664	3,981	12,056	49,076
New York	54	5,403	28,515	3,637	7,470	17,279	36,524	17,206	53,731	903	5,294	22,611
New Jersey	33	11,133	57,544	7,379	14,898	34,943	80,548	69,034	149,583	2,758	5,959	24,035
Pennsylvania	26	2,481	10,351	1,840	3,974	7,547	21,082	14,266	35,349	319	803	2,430
East North Central	68	8,402	40,436	5,809	12,759	26,417	71,671	61,168	132,840	1,216	2,823	11,972
Illinois	30	2,118	9,522	1,421	3,121	5,821	14,104	8,568	22,672	624	2,256	9,483
West North Central	15	6,947	31,306	4,269	8,751	17,233	57,961	24,319	82,281	812	177	801
South	51	2,563	11,172	1,755	3,580	6,698	17,769	9,361	27,131	598	1,327	5,224
Maryland	12	1,079	4,511	715	1,406	2,664	6,774	4,431	11,206	71	846	3,138
Mountain	9	72	336	62	122	270	508	482	991	16	------	------
Pacific	75	3,374	15,924	2,529	4,949	10,292	28,705	13,457	42,163	853	1,451	6,083
California	70	3,154	15,157	2,344	4,645	9,720	27,261	12,901	40,162	818	(7)	(7)

[1] Each producing State not shown separately has been withheld either (*a*) to avoid disclosing figures for individual companies; or (*b*) because the State had less than 1,000 employees in the industry. (Additional publishable detail will appear in the final census bulletin for this industry.)

[2] Value of shipments less cost of materials, supplies, fuel, electric energy, and contract work.

[3] Includes cost of materials, fuel, electricity, and contract work; excludes cost of products bought and resold in the same condition.

[4] Includes, for all establishments classified in this industry, not only (*a*) their value of products primary to the industry, but also (*b*) their value of secondary products, which are primary to other industries, and (*c*) their miscellaneous receipts for repair work, sales of scrap, installation of own products, etc. Excludes sales of products bought and resold in the same condition.

[5] Revised.

[6] Sum of regional figures may not equal United States total, due to independent rounding.

[7] Withheld to avoid disclosing figures for individual companies.

TABLE 3.—*Value of scientific instruments shipped by all producers in the United States, 1954 and 1947 (includes value of those products reported both by establishments classified in the scientific instruments industry and by those establishments making these items as secondary products in other industries)*

Product code	Product	Total value of shipments including interplant transfers	
		1954	1947
		Thousands	*Thousands*
3811	Scientific instruments, total	[1] $620,427	[2] $107,445
38111	Aircraft and nautical instruments, except aircraft engine instruments.	515,834	(3)
3811111	Aircraft flight instruments and automatic pilots	378,897	20,478
3811198	Other aircraft, nautical, and navigational instruments	136,935	(4)
3811211	Surveying and drafting instruments and apparatus	17,998	[2] 19,658
3811311	Other scientific instruments and laboratory apparatus (excluding electrical quantity measuring instruments, and industrial process instruments).	86,594	[4] 67,309

[1] Of this total 64 percent was shipped by plants classified in the scientific instruments industry; the remainder was shipped as secondary products by plants classified in other industries.
[2] Revised.
[3] Not available.
[4] Data for other aircraft, nautical and navigational instruments for 1947 are included with "Other Scientific Instruments and Laboratory Apparatus" (code 3811311).

[From the Advance Report 1954 Census of Manufactures, April 1956, Series MC-38-1.2]

OPTICAL INSTRUMENTS AND LENSES INDUSTRY

(S. I. C. Code 3831)

During 1954, manufacturers in the optical instruments and lenses industry shipped products valued at $118 million, an increase of 160 percent over 1947, according to preliminary results obtained from the 1954 census of manufactures conducted by the Bureau of the Census, Department of Commerce. Average employment in this industry has increased 49 percent since 1947 (when the last census of manufactures was taken) to a total of 12,700 employees in 1954. Value added by manufacture in the industry amounted to $86 million in 1954, an increase of 153 percent over 1947. "Value added" is derived by subtracting the cost of materials, etc., from the value of shipments. It avoids, therefore, the duplication in the value of shipments which results from the use of products of some establishments as materials by others, and is the best measure available for comparing the relative economic importance of manufacturing among industries and geographic areas. Changes between the 2 census years for other key measures of activity for the industry are shown in table 1. No adjustments have been made for changes in price levels between the 2 years. All figures in this report are preliminary and, therefore, subject to revision in the final industry bulletin.

The optical instruments and lenses industry represents manufacturing establishments engaged primarily in grinding optical lenses and prisms and in manufacturing microscopes, telescopes, field and opera glasses, and related optical equipment, such as refractometers, spectrometers, spectroscopes, colorimeters, polariscopes, and optical measuring instruments. (Establishments primarily manufacturing optical glass blanks are classified in Industry 3211, Flat glass; the grinding of eyeglass lenses and the manufacture of other ophthalmic goods, such as frames or fittings, are classified in Industry 3851. Ophthalmic goods; and those engaged in manufacturing sighting and fire-control instruments but not engaged in manufacturing optical components are in industry 1941, sighting and fire-control equipment.) The industry classification for optical instruments and lenses used in the 1954 census of manufactures is based on the Standard Industrial Classification Manual, volume I, Manufacturing Industries, 1945 edition.

The value of shipments, as reported by establishments classified in the optical instruments and lenses industry, consisted not only of products described above as primary to the industry, but also included the value of secondary products (which are primary to other industries). In tables 1 and 2, the $118 million total value of shipments reported by establishments classified in Industry 3831, Optical instruments and lenses, consisted of $113 million manufactured products and $5 million miscellaneous receipts for contract work, repair work, sales of scrap, etc. The $113 million product shipments were accounted for by $93 million of optical instruments and lenses and $20 million of products primary to other industries (e. g., photographic equipment and scientific instruments). Thus, the industry's shipments of optical instruments and lenses represented 82 percent of its total manufactured product shipments (primary and secondary). This figure describes the "primary products specialization ratio," that is, the extent to which plants classified in an industry "specialize" in making products regarded as primary to the industry. The 1947 primary product specialization ratio for the industry was 93. This change of 11 percent reflects the increased production of photographic equipment and parts by establishments in Industry 3831.

The industry's total value of shipments should be clearly distinguished from the total value of primary products of the industry shipped by all producers. The latter figure, appearing in table 3, indicates that $122 million value of optical instruments and lenses were shipped by all producers. Of this total 76 percent was shipped by plants classified in Industry 3831, while the remainder was shipped as secondary products by plants classified in other industries. The figure 76 percent is known as the coverage ratio, that is, it measures the extent to which all shipments of primary products of an industry are covered by plants classified in that industry, as distinguished from secondary producers elsewhere.

The general statistics (employment, payrolls, cost of materials, value of shipments, etc.) are reported for each establishment as a whole. Aggregates of such data for an industry reflect not only the primary activities of the establishments in that industry, but also their activities in the manufacture of secondary products and receipts for their other activities (contract work on materials owned by others, repair work, etc.). This fact should be taken into account in comparing industry statistics (tables 1 and 2) with product statistics (table 3) which show the shipments by all producers of the primary products of the industry.

More detailed figures for this industry will appear later in the Census Bulletin, MC–38A, Instruments; Surgical, Dental, and Ophthalmic Goods, which will be published and offered for sale at a later date by the Superintendent of Documents, United States Government Printing Office. Also, in this bulletin, there will be a comprehensive discussion of such concepts as industry, establishment, secondary production, as well as the various statistical items such a employment, value added, etc. Similar advance reports and final bulletins will be issued for other industries during the coming months. A summary of preliminary United States totals for each manufacturing industry and totals for each State will also be issued in the next few months. Advance reports for individual States will appear in May and June of 1956, to be followed later in the year by the detailed State bulletins. (Order blanks which list these reports and bulletins and their prices may be obtained from local U. S. Department of Commerce field offices or by writing to: Bureau of the Census, Washington 25, D. C.)

The 1954 census of manufactures is the 26th such census of the United States since 1809. For 1954, it was conducted jointly with the censuses of business (wholesale, retail, and services) and mineral industries, covering continental United States, Alaska, and Hawaii. Present legislation provides for a census of manufactures every 5 years, with the next one scheduled to cover 1958. In addition, the law authorizes annual sample surveys to be conducted in interim years.

TABLE 1.—*General statistics for the optical instruments and lenses industry in the United States, 1954 and 1947 (Standard Industrial Classification Code 3831)*

Item	Unit of measure	1954	1947 [1]	Percent change 1947–54
Establishments	Number	205	115	+78
All employees:				
Number	Thousands	12.7	8.5	+49
Payroll	Million dollars	58.2	24.7	+136
Production workers:				
Number	Thousands	9.4	6.7	+40
Man-hours	Millions	18.6	13.6	+37
Wages	Million dollars	38.2	18.0	+112
Value added by manufacture [1]	do	86.4	34.1	+153
Cost of materials, fuel, electricity, and contract work [2]	do	31.3	11.3	+176
Value of shipments [3]	do	117.6	45.3	+160
Capital expenditures, new	do	4.6	1.5	+207

[1] Value of shipments less cost of materials, supplies, fuel, electric energy, and contract work.

[2] Excludes cost of products bought and resold in the same condition.

[3] Includes, for all establishments classified in this industry, not only (*a*) their value of products "primary" to the industry, but also (*b*) their value of "secondary" products, which are primary to other industries, and (*c*) their "miscellaneous receipts" for repair work, sales of scrap, installation of own products, etc. Excludes sales of products bought and resold in the same condition.

TABLE 2.—*General statistics for the optical instruments and lenses industry (Standard Industrial Classification Code 3831), by regions and States: 1954 and 1947*

Region and State[1]	1954										1947	
	Establishments (number)	All employees		Production workers			Value added by manufacture[2]	Cost of materials, etc.[3]	Value of shipments[4]	Capital expenditures, new	All employees (number)	Value added by manufacture[2]
		Number	Payroll	Number	Man-hours	Wages						
			Thousands		*Thousands*	*Thousands*	*Thousands*	*Thousands*	*Thousands*	*Thousands*		*Thousands*
United States, total[5]	205	12, 658	$58, 175	9, 447	18, 555	$38, 256	$86, 379	$31, 268	$117, 648	$4, 554	8, 478	$34, 090
New England	26	1, 501	7, 013	1, 016	2, 221	4, 170	11, 871	5, 182	17, 054	339	596	2, 344
Middle Atlantic	93	7, 972	37, 588	5, 903	11, 146	24, 584	53, 044	15, 756	68, 800	2, 301	6, 605	26, 261
New York	68	7, 611	36, 245	5, 601	10, 535	23, 603	51, 283	14, 859	66, 144	2, 243	6, 342	25, 261
North Central	40	1, 247	5, 044	1, 015	2, 107	3, 684	7, 271	2, 983	10, 254	261	[6]	[6]
South	10	521	1, 833	444	888	1, 298	4, 116	1, 012	5, 129	44	[6] v	[6]
Pacific	36	1, 414	6, 697	1, 066	2, 190	4, 510	10, 075	6, 334	16, 410	1, 605	185	[6]
California	33	1, 372	6, 517	1, 035	2, 128	4, 380	9, 728	6, 173	15, 901	1, 578	185	[6]

[1] Each producing State not shown separately has been withheld either (*a*) to avoid disclosing figures for individual companies; or (*b*) because the State had less than 1,000 employees in the industry. (Additional publishable detail will appear in the final census bulletin for this industry.)

[2] Value of shipments less cost of materials, supplies, fuel, electric energy, and contract work.

[3] Includes cost of materials, fuel, electricity, and contract work; excludes cost of products bought and resold in the same condition.

[4] Includes, for all establishments classified in this industry, not only (*a*) their value of products primary to the industry, but also (*b*) their value of secondary products, which are primary to other industries, and (*c*) their miscellaneous receipts for repair work, sales of scrap, installation of own products, etc. Excludes sales of products bought and resold in the same condition.

[5] Sum of regional figures may not equal United States total, due to independent rounding.

[6] Withheld to avoid disclosing figures for individual companies.

TABLE 3.—*Value of optical instruments and lenses shipped by all producers in the United States, 1954 and 1947 (includes value of those products reported both by establishments classified in the optical instruments and lenses industry and by those establishments in other industries making these items as "secondary" products)*

Product code	Product	Value of shipments including interplant transfers 1954	1947
		Thousands	*Thousands*
3831	Optical instruments and lenses, total	[1] $121,814	$55,134
3831011	Photographic and projection lenses and prisms, for sale separately.	31,178	21,087
3831031	Field glasses, prismatic and nonprismatic; terrestrial and celestial telescope.	9,741	4,293
3831051	Microprojectors, and photomicrographic equipment	977	[2] 29,754
3831053	Microscopes	6,854	
3831071	Optical measuring instruments (refractometers, colorimeters, spectrometers, spectrographs, spectrophotometers, polariscopes, contour projectors, metallographic equipment, etc.).	20,719	
3831098	Other and not specified optical instrument, lenses, parts and accessories.	52,345	

[1] Of this total, 76 percent was shipped by plants classified in the optical instruments and lenses industry.
[2] Revised.

[From the Advance Report, 1954 Census of Manufactures, April 1956, Series MC–38–1.4]

MECHANICAL MEASURING INSTRUMENTS INDUSTRY

(S. I. C. Code 3821)

During 1954, manufacturers in the mechanical measuring instruments industry shipped products valued at $792 million, an increase of 87 percent over 1947, according to preliminary results obtained from the 1954 Census of Manufactures conducted by the Bureau of the Census, Department of Commerce. Average employment in this industry has increased 13 percent since 1947 (when the last Census of Manfactures was taken) to a total of 68.5 thousand employees in 1954. Value added by manufacture in the industry amounted to $534 million in 1954, an increase of 90 percent over 1947. "Value added" is derived by subtracting the cost of materials, etc., from the value of shipments. It avoids, therefore, the duplication in the value of shipments which results from the use of products of some establishments as materials by others and is the best measure available for comparing the relative economic importance of manufacturing among industries and geographic areas. Changes between the two census years for other key measures of activity for the industry are shown in table 1. No adjustments have been made for changes in price levels between the 2 years. All figures in this report are preliminary and, therefore, subject to revision in the final industry bulletin.

The mechanical measuring instruments industry represents manufacturing establishments engaged primarily in the manufacturing of mechanical instruments for indicating, recording, measuring, and controlling temperature, pressure, mechanical motion, rotation, flow, liquid level, humidity, density, acidity, alkalinity, and combustion; dial pressure gages; physical-property testing apparatus such as hardness, tension, compression, torsion, ductility, and elasticity testing apparatus; and instruments for household and office use such as thermometers, barometers, and grain gages. Establishments primarily manufacturing instruments for indicating, measuring, and recording electrical quantities and characteristics are classified in industry 3613, electrical measuring instruments; watches and clocks in industry 3871, watches and clocks; and measuring and dispensing pumps in industry 3586, measuring and dispensing pumps. The industry classification for mechanical measuring instruments used in the 1954 Census of Manufactures is based on the Standard Industrial Classification Manual, volume I, Manufacturing Industries, 1945 edition.

The value of shipments, as reported by establishments classified in the mechanical measuring instruments industry, consisted not only of products described above as primary to the industry, but also included the value of secondary products (which are primary to other industries). In tables 1 and 2, the $792 million total value of shipments reported by establishments classified in Industry 3821, Mechanical Measuring Instruments, consisted of $764 million manufactured products and $28 million miscellaneous receipts for contract work, repair work, sales of scrap, etc. The $764 million product shipments were accounted for by $667 million of mechanical measuring instruments and $97 million of products primary to other industries (e. g., ordnance, valves, and fittings, scientific instruments). Thus, the industry's shipments of mechanical measuring instruments represented 87 percent of its total manufactured product shipments (primary and secondary). This figure describes the "primary product specialization ratio," that is, the extent to which plants classified in an industry "specialize" in making products reparded as primary to the industry. The 1947 primary product specialization ratio for the industry was 83.

The industry's total value of shipments should be clearly distinguished from the total value of primary products of the industry shipped by all producers. The latter figure, appearing in table 3, indicates that $845 million value of mechanical measuring instruments and other products primary to industry 3821 were shipped by all producers. Of this total, 79 percent was shipped by plants classified in industry 3821, while the remainder was shipped as secondary products by plants classified in other industries. The figure 79 percent is known as the "coverage ratio," that is, it measures the extent to which all shipments of primary products of an industry are "covered" by plants classified in that industry, as distinguished from secondary producers elsewhere.

The general statistics (employment, payrolls, cost of materials, value of shipments, etc.) are reported for each establishment as a whole. Aggregates of such data for an industry reflect not only the primary activities of the establishments in that industry, but also their activities in the manufacture of secondary products and receipts for their other activities (contract work on materials owned by others, repair work, etc.). This fact should be taken into account in comparing industry statistics (tables 1 and 2) with product statistics (table 3) which show the shipments by all producers of the primary products of the industry.

More detailed figures for this industry will appear later in the Census Bulletin, MC–38A, Instruments; Surgical, Dental, and Ophthalmic Goods, which will be published and offered for sale at a later date by the Superintendent of Documents, United States Government Printing Office. Also, in this bulletin, there will be a comprehensive discussion of such concepts as "industry," "establishment," "secondary production," as well as the various statistical items such as "employment," "value added," etc. Similar advance reports and final bulletins will be issued for other industries during the coming months. A summary of preliminary United States totals for each manufacturing industry and totals for each State will also be issued in the next few months. Advance reports for individual States will appear in May and June of 1956, to be followed later in the year by the detailed State bulletins. (Order blanks which list these reports and bulletins and their prices may be obtained from local United States Department of Commerce field offices or by writing to: Bureau of the Census, Washington 25, D. C.)

The 1954 Census of Manufactures is the 20th such census of the United States since 1809. For 1954, it was conducted jointly with the Censuses of Business (Wholesale, Retail, and Services) and Mineral Industries, covering continental United States, Alaska, and Hawaii. Present legislation provides for a Census of Manufactures every 5 years, with the next one scheduled to cover 1958. In addition, the law authorizes annual sample surveys to be conducted in interim years.

TABLE 1.—*General statistics for the mechanical measuring instruments industry, in the United States, 1954 and 1947 (Standard Industrial Classification Code 3821)*

Item	Unit of measure	1954	1947	Percent change 1947–54
Establishments	Number	609	466	+31
All employees:				
Number	Thousands	68.5	60.5	+13
Payroll	Million dollars	298.1	173.9	+71
Production workers:				
Number	Thousands	47.7	46.7	+2
Man-hours	Millions	96.6	93.1	+4
Wages	Million dollars	187.7	122.4	+53
Value added by manufacture [1]	do	534.2	281.5	+90
Cost of materials, fuel, electricity, and contract work [2]	do	256.4	141.9	+81
Value of shipments [3]	do	792.2	423.4	+87
Capital expenditures, new	do	21.4	8.8	+143

[1] Value of shipments less cost of materials, supplies, fuel, electric energy, and contract work.
[2] Excludes cost of products bought and resold in the same condition.
[3] Includes, for all establishments classified in this industry, not only (*a*) their value of products "primary" to the industry, but also (*b*) their value of "secondary" products, which are primary to other industries, and (*c*) their "miscellaneous receipts" for repair work, sales of scrap, installation of own products, etc. Excludes sales of products bought and resold in the same condition.

TABLE 2.—*General statistics for the mechanical measuring instruments industry (Standard Industrial Classification Code 3821), by region and selected States: 1954 and 1947*

Region and State [1]	1954 Establishments (number)	1954 All employees: Number	1954 All employees: Payroll	1954 Production workers: Number	1954 Production workers: Man-hours	1954 Production workers: Wages	1954 Value added by manufacture [2]	1954 Cost of materials, etc.[3]	1954 Value of shipments [4]	1954 Capital expenditures, new	1947 All employees (number)	1947 Value added by manufacture [2]
			Thousands		*Thousands*	*Thousands*	*Thousands*	*Thousands*	*Thousands*	*Thousands*		*Thousands*
United States, total [5]	609	68, 458	$298, 144	47, 679	96, 633	$187, 676	$534, 240	$256, 384	$792, 198	$21, 424	60, 481	$281, 482
New England	74	9, 723	41, 614	6, 698	13, 745	25, 290	77, 419	32, 547	111, 539	3, 347	8, 481	42, 172
Massachusetts	37	5, 319	21, 956	3, 672	7, 582	13, 189	39, 516	17, 833	57, 350	1, 306	2, 963	(6)
Connecticut	32	4, 326	19, 340	2, 976	6, 071	11, 945	37, 393	14, 486	53, 453	2, 032	5, 319	26, 722
Middle Atlantic	213	22, 114	96, 965	15, 575	30, 431	62, 260	165, 043	80, 693	245, 737	4, 587	21, 362	99, 328
New York	127	6, 852	28, 380	5, 473	10, 537	20, 754	54, 273	22, 429	76, 703	981	10, 310	46, 557
New Jersey	39	1, 863	7, 835	1, 442	2, 803	5, 248	14, 069	7, 989	22, 060	723	1, 596	6, 412
Pennsylvania	47	13, 397	60, 749	8, 659	17, 090	36, 255	96, 698	50, 272	146, 972	2, 882	9, 456	46, 359
East North Central	153	19, 653	85, 530	13, 490	28, 365	53, 241	150, 305	85, 729	236, 034	5, 017	17, 323	(6)
Ohio	53	5, 681	24, 127	3, 423	8, 270	14, 527	37, 384	19, 225	56, 610	1, 772	3, 897	18, 154
Indiana	8	1, 642	6, 303	1, 321	2, 569	4, 532	14, 865	6, 246	21, 111	636	1, 558	(6)
Illinois	55	6, 820	30, 597	4, 608	9, 302	17, 912	57, 964	26, 695	84, 659	1, 395	6, 694	30, 529
Michigan	25	3, 275	14, 895	2, 489	4, 862	9, 724	23, 336	24, 013	47, 349	448	2, 174	7, 971
Wisconsin	12	2, 235	9, 607	1, 647	3, 361	6, 544	16, 755	9, 549	26, 304	766	3, 000	(6)
West North Central	26	7, 867	33, 675	5, 349	10, 974	19, 688	68, 977	21, 294	90, 271	2, 565	(6)	(6)
Missouri	10	1, 598	7, 576	959	1, 938	3, 935	15, 168	6, 238	21, 407	261	1, 431	(6)
South	63	2, 900	11, 610	2, 278	4, 489	8, 358	20, 514	9, 995	30, 509	1, 151	2, 198	10, 636
Mountain	8	61	214	43	82	128	263	381	645	38	(6)	(6)
Pacific	72	6, 135	28, 533	4, 242	8, 543	18, 708	51, 717	25, 742	77, 460	4, 714	(6)	(6)
California	66	6, 021	28, 027	4, 160	8, 381	18, 407	50, 777	25, 275	76, 053	4, 653	3, 173	13, 167

[1] Each producing State not shown separately has been withheld either (*a*) to avoid disclosing figures for individual companies; or (*b*) because the State had less than 1,000 employees in the industry. (Additional publishable detail will appear in the final census bulletin for this industry.)

[2] Value of shipments less cost of materials, supplies, fuel, electric energy, and contract work.

[3] Includes cost of materials, fuel, electricity, and contract work; excludes cost of products bought and resold in the same condition.

[4] Includes, for all establishments classified in this industry, not only (*a*) their value of products primary to the industry, but also (*b*) their value of secondary products, which are primary to other industries, and (*c*) their miscellaneous receipts for repair work, sales of scrap, installation of own products, etc. Excludes sales of products bought and resold in the same condition.

[5] Sum of regional figures may not equal United States total, due to independent rounding.

[6] Withheld to avoid disclosing figures for individual companies.

TABLE 3.—*Quantity and value of mechanical measuring instruments shipped by all producers in the United States, 1954 and 1947 (includes quantity and value of those products reported both by establishments classified in the mechanical measuring instruments industry and by those establishments making these items as secondary products in other industries)*

Product code	Product	Total shipments including interplant transfers			
		1954		1947	
		Quantity (1,000 units)	Value	Quantity (1,000 units)	Value
			Thousands		*Thousands*
3821	Mechanical measuring instruments, total	(1)	[2] $845,342	(1)	$425,277
3821111	Aircraft engine instruments	(1)	80,257	(1)	4,992
38212	Integrating meters, nonelectrical type	(1)	106,174	(1)	63,262
3821211	Gasmeters	1,609	37,840	1,335	22,459
3821231	Watermeters	1,352	37,298	1,338	23,246
3821298	Other liquid meters (except electric), including gasoline dispensing [3]	(1)	31,036	(1)	17,557
38213	Industrial process instruments, including indicating, recording, and controlling instruments (excluding aircraft, nautical, navigational, electrical quantity measuring and automotive types)	(1)	271,518	(1)	[4] 168,369
	Temperature thermometers (glass stem and bimetal):				
3821311	Industrial and laboratory	(1)	11,347	(1)	12,549
3821313	Clinical	10,789	6,320	9,296	5,360
3821315	Household	13,642	6,808	13,494	4,051
3821321	Temperature instruments, other than thermometers	(1)	55,268	(1)	[4] 44,120
3821331	Pressure and vacuum	(1)	44,901	(1)	27,535
3821341	Fluid flow and liquid level	(1)	39,927	(1)	19,211
3821351	Physical properties testing and inspection equipment, including hardness, strength of materials, wear, abrasion, and similar testers	(1)	19,472	(1)	[4] 13,402
3821398	Other industrial process instruments	(1)	87,475	(1)	[4] 42,141
38214	Motor-vehicle instruments	(1)	76,401	(1)	39,495
3821411	Speedometer for motor vehicles [5]	8,585	28,774	(6)	11,433
3821498	Other motor vehicle indicating instruments, except electric (fuel level, oil pressure, etc.)	(1)	47,627	(1)	28,062
3821511	Automatic temperature controls, activated by pressure, temperature, level, flow, time, or humidity (including pneumatic controls) of the type principally used as components of air-conditioning, refrigeration, and comfort heating or as components of major household appliances	(1)	259,970	(1)	[4] 100,640
3821611	Other and not specified mechanical measuring instruments	(1)	51,022	(1)	48,519

[1] Not applicable.
[2] Of this total, 79 percent was shipped by plants classified in the mechanical measuring instruments industry; the remainder was shipped as secondary products by plants classified in other industries.
[3] Includes some gas and water meters shipped unassembled from the factory.
[4] Revised.
[5] Excludes some speedometers produced by plants of motor vehicle companies for incorporation into automobiles and trucks of their own assembly.
[6] Not available.

[From the Advance Report, 1954 Census of Manufacturers, June 1956, Series MC-36-1.3]

ELECTRICAL MEASURING INSTRUMENTS INDUSTRY

(S. I. C. Code 3613)

During 1954, manufacturers in the electrical measuring instruments industry shipped products valued at $358 million, an increase of 134 percent over 1947, according to preliminary results obtained from the 1954 Census of Manufactures conducted by the Bureau of the Census, Department of Commerce. Average employment in this industry has increased 58 percent since 1947 (when the last Census of Manufactures was taken) to a total of 33,000 employees in 1954. Value added by manufacture in the industry amounted to $248 million in 1954, an increase of 138 percent over 1947. Valued added is derived by subtracting the cost of materials, etc., from the value of shipments. It avoids, therefore, the duplication in the value of shipments which results from the use of products of some establishments as materials by others and is the best value measure available for comparing the relative economic importance of manufacturing among industries and geographic areas. Changes between the 2 census years for other key measures of activity for the industry are shown in table 1. No adjustments have been made for changes in price levels between the 2 years. All figures in this report are preliminary and, therefore, subject to revision in the final industry bulletin.

The electrical measuring instruments industry represents manufacturing establishments engaged primarily in the manufacture of pocket, portable, panelboard, and graphic recording instruments for measuring electricity, such as voltmeters, ammeters, watt meters, watthouse meters, demand meters, and other meters and indicating instruments. Also included are establishments primarily manufacturing meter transformers and analyzers for testing the electrical characteristics of internal-combustion engines, radio apparatus, etc., and instruments for indicating, measuring, and recording electrical quantities and characteristics. Establishments primarily manufacturing mechanical instruments for indicating, recording, measuring, and controlling temperature, pressure, mechanical motion, rotation, flow, liquid level, humidity, etc., are included in industry 3821, mechanical measuring instruments. The industry classification for the electrical measuring instruments industry used in the 1954 Census of Manufactures is based on the standard industrial classification.

The value of shipments, as reported by establishments classified in the electrical measuring instruments industry, consisted not only of products described above as primary to the industry, but also included the value of secondary products (which are primary to other industries). In tables 1 and 2, the $358 million total value of shipments reported by establishments classified in industry 3613, electrical measuring instruments, consisted of 349 million manufactured products and $9 million miscellaneous receipts for contract work, repair work, sales of scrap, etc. The $349 million product shipments were accounted for by $263 million of electrical measuring instruments and other products primary to the industry, and $86 million of products primary to other industries (e. g., aircraft engine and other mechanical measuring instruments, aircraft flight instruments, and electrical distribution and control apparatus). Thus, the industry's shipments of electrical measuring instruments represented 75 percent of its total manufactured product shipments (primary and secondary). This figure describes the "primary product specialization ratio," that is, the extent to which plants classified in an industry "specialize" in making products regarded as primary to the industry. The 1947 primary product specialization ratio for the industry was 84. This change of 9 percent reflects the increased production, since 1947, of aircraft engine and flight instruments by establishments in this industry.

The industry's total value of shipments should be clearly distinguished from the total value of primary products of the industry shipped by all producers. The latter figure, appearing in table 3, indicates that $345 million value of electrical measuring instruments and other products primary to industry 3613 was shipped by all producers. Of this total, 76 percent was shipped by plants classified in industry 3613, while the remainder was shipped as secondary products by plants classified in other industries. The figure 76 percent is known as the coverage ratio, that is, it measures the extent to which all shipments of primary products of an industry are covered by plants classified in that industry, as distinguished from secondary producers elsewhere.

The general statistics (employment, payrolls, cost of materials, value of shipments, etc.) are reported for each establishment as a whole. Aggregates of such data for an industry reflect not only the primary activities of the establishments in that industry, but also their acivities in the manufacture of secondary products and receipts for their other activities (contract work on materials owned by others, repair work, etc.). This fact should be taken into account in comparing industry statistics (tables 1 and 2) with product statistics (table 3) which show the shipments by all producers of the primary products of the industry.

More detailed figures for this industry will appear in the Census Bulletin, MC-36A, Electrical Industrial Apparatus, which will be published and offered for sale at a later date by the Superintendent of Documents, United States Government Printing Office. Also, in this bulletin, there will be a comprehensive discussion of such concepts as industry, establishment, secondary production, as well as the various statistical items such as employment, value added, etc. Similar advance reports and final bulletins will be issued for other industries during the coming months. A summary of preliminary United States totals for general statistics with separate figures for most individual manufacturing industries is now available. Advance reports for individual States are now being published, to be followed later in the year by the detailed State bulletins. (Order blanks which list these reports and bulletins and their prices may be obtained from local United States Department of Commerce field offices or by writing to: Bureau of the Census, Washington 25, D. C.)

The 1954 Census of Manufactures is the 26th such census of the United States since 1809. For 1954, it was conducted jointly with the Censuses of Business (wholesale, retail, and services) and mineral industries, covering continental United States, Alaska, and Hawaii. Present legislation provides for a Census of Manufactures every 5 years, with the next one scheduled to cover 1958. In addition, the law authorizes annual sample surveys to be conducted in interim years.

TABLE 1.—*General statistics for the electrical measuring instruments industry, in the United States, 1954 and 1947 (Standard Industrial Classification Code 3613)*

Item	Unit of measure	1954	1947	Percent change 1947–54
Establishments	Number	302	154	+96
All employees:				
Number	Thousands	33.0	20.9	+58
Payroll	Million dollars	144.9	60.7	+139
Production workers:				
Number	Thousands	24.2	16.1	+50
Man-hours	Millions	47.6	32.6	+46
Wages	Million dollars	90.7	42.3	+114
Value added by manufacture [1]	do	247.7	103.9	+138
Cost of materials, fuel, electricity, and contract work [2]	do	110.7	49.4	+124
Value of shipments [3]	do	358.4	153.4	+134
Capital expenditures, new	do	16.1	4.3	+274

[1] Value of shipments less cost of materials; supplies, fuel, electric energy, and contract work.
[2] Excludes cost of products bought and resold in the same condition.
[3] Includes, for all establishments classified in this industry, not only (a) their value of products "primary" to the industry, but also (b) their value of "secondary" products, which are primary to other industries, and (c) their "miscellaneous receipts" for repair work, sales of scrap, installation of own products, etc. Excludes sales of products bought and resold in the same condition.

TABLE 2.—*General statistics for the electrical measuring instruments industry (S. I. C. Code 3613), by regions and selected States: 1954 and 1947*

Region and State[1]	1954										1947	
	Establishments (number)	All employees		Production workers			Value added by manufacture[2]	Cost of materials, etc.[3]	Value of shipments[4]	Capital expenditures, new	All employees (number)	Value added by manufacture[2]
		Number	Payroll	Number	Man-hours	Wages						
			Thousands		*Thousands*	*Thousands*	*Thousands*	*Thousands*	*Thousands*	*Thousands*		*Thousands*
United States, total[5]	302	32, 991	$144, 926	24, 175	47, 588	$90, 694	247, 670	$110, 714	$358, 386	$16, 132	20, 926	$103, 946
New England	36	8, 725	37, 636	5, 932	11, 762	21, 464	72, 703	25, 563	98, 267	1, 925	6, 068	(6)
New Hampshire	5	2, 274	8, 403	1, 796	3, 574	5, 919	21, 727	8, 479	30, 206	(6)	319	(6)
Massachusetts	19	5, 938	27, 378	3, 783	7, 506	14, 502	47, 845	15, 284	63, 131	1, 140	5, 490	(6)
Middle Atlantic	128	11, 973	53, 928	9, 036	17, 896	35, 220	86, 071	41, 217	127, 290	2, 114	7, 480	(6)
New York	61	2, 888	13, 383	2, 032	3, 916	7, 850	21, 798	17, 272	39, 072	551	480	(6)
New Jersey	43	7, 795	35, 596	6, 031	12, 159	24, 428	57, 785	20, 269	78, 055	1, 342	6, 100	32, 649
Pennsylvania	24	1, 289	4, 948	972	1, 820	2, 941	6, 487	3, 675	10, 163	221	900	3, 065
East North Central	56	7, 705	32, 282	5, 776	11, 178	20, 275	55, 614	24, 418	80, 033	1, 918	6, 646	29, 740
Ohio	16	1, 600	5, 639	1, 272	2. 369	3, 744	9, 195	6, 421	15, 617	110	1, 429	4, 345
Illinois	22	4, 711	19, 994	3, 467	6, 713	12, 666	33, 194	12, 924	46, 118	1, 537	4. 039	18, 452
West North Central	12	331	1, 081	269	555	745	1, 613	917	2, 531	(6)	202	564
South	13	712	2, 474	525	1, 050	1, 520	2, 500	3, 190	5, 691	(6)	(6)	(6)
West	57	3, 542	17, 522	2, 634	5, 143	11, 467	29, 165	15, 405	44, 571	(6)	(6)	(6)
California	52	3, 010	14, 817	2, 269	4, 420	9, 776	22, 619	13, 677	36, 297	1, 481	267	1, 748

1 Each producing State not shown separately has been withheld either (*a*) to avoid disclosing figures for individual companies; or (*b*) because the State had less than 1,000 employees in the industry. (Additional publishable detail will appear in the final census bulletin for this industry.)

2 Value of shipments less cost of materials, supplies, fuel, electric energy, and contract work.

3 Includes cost of materials, fuel, electricity, and contract work; excludes cost of products bought and resold in the same condition.

4 Includes, for all establishments classified in this industry, not only (*a*) their value of products primary to the industry, but also (*b*) their value of secondary products, which are primary to other industries, and (*c*) their miscellaneous receipts for repair work, sales of scrap, installation of own products, etc. Excludes sales of products bought and resold in the same condition.

5 Sum of regional figures may not equal United States total, due to independent rounding.

6 Withheld to avoid disclosing figures for individual companies.

TABLE 3.—*Quantity and value of electrical measuring instruments shipped by all producers in the United States, 1954 and 1947 (includes quantity and value of these products reported both by establishments classified in the electrical measuring instruments industry, and those establishments making these items as secondary products in other industries)*

Product code	Product	Total shipments including interplant transfers			
		1954		1947	
		Quantity (1,000 units)	Value	Quantity (1,000 units)	Value
			Thousands		*Thousands*
613	Electrical measuring instruments, total	(1)	[2]$345,389	(1)	$157,453
36131	Integrating instruments, electrical	(1)	73,090	(1)	63,650
	A. c. watt-hour meters:				
3613111	Single phase	2,880	36,938	3,277	44,967
3613115	Polyphase	167	6,491	211	5,096
3613121	Combined watt-hour and time-switch meters.	126	3,807	(1)	(3)
	Combined watt-hour and demand meters:				
3613131	Single phase	26	1,141		
3613135	Polyphase				
3613141	Demand meters (including kilowatt and kilovolt-ampere).	126	8,900	(4)	6,862
3613151	Other electrical integrating meters including d. c. watt-hour meters, ampere-hour meters, and other miscellaneous integrating instruments not included in the above classifications.	(1)	2,930	(1)	[3] 2,121
3613161	Parts for integrating meters, electrical type (including meter mounting and test equipment), sold separately.	(1)	12,883	(1)	4,604
36132	Test equipment for testing electrical, radio, and communication circuits and motors.	(1)	188,115	(1)	54,805
3613211	Oscilloscopes, high-frequency types, designed primarily for radio testing.	(1)	7,051	(1)	766
3613215	Other types of oscilloscopes and oscillographs.	(1)	16,475	(1)	4,048
3613221	Volt-ohm-milliammeters	(1)	4,460	(1)	2,535
3613227	Electronic volt-ohm-milliammeters	(1)	3,624	(1)	723
3613233	Resistor, capacitor, and inductor measuring equipment.	(1)	3,209	(1)	1,653
3613239	Analyzers for testing characteristics of internal combustion engines and auxiliary uipment.	(1)	23,189	(1)	15,193
3613245	Tube characteristic measuring instruments for receiving tubes.	(1)	5,805	(1)	2,058
3613251	Microwave test equipment	(1)	8,488	(1)	2,512
3613257	Signal generators	(1)	15,155	(1)	3,774
3613263	Broadcast transmitter test equipment	(1)	1,622	(1)	(5)
3613269	Radio frequency measuring equipment	(1)	13,790	(1)	1,812
3613281	Parts for test equipment sold separately	(1)	11,389	(1)	481
3613298	Other test equipment	(1)	68,179	(1)	[5] 9,992
3613200	Test equipment for testing electrical, radio, and communication circuits and motors, not specified by kind.	(1)	5,679	(1)	9,257
36133	Other electrical measuring instruments	(1)	84,184	(1)	38,998
	Electrical instruments which are designed fundamentally to indicate, measure, or record electrical quantities, but whose scales may be marked in other than electrical quantities:				
	Indicating and recording instruments:				
	Indicating instruments:				
3613311	Panel-type instruments, nominal size 4½ inches and smaller. Initial accuracy within ±2 percent of full-scale deflection for all types except rectifier types which shall be within ±13 percent. Excluding instruments for use on motor vehicles and aircraft.	2,037	19,011	1,039	8,369

See footnotes at end of table.

TABLE 3.—*Quantity and value of electrical measuring instruments shipped by all producers in the United States, 1954 and 1957 (includes quantity and value of these products reported both by establishments classified in the electrical measuring instruments industry, and those establishments making these items as secondary products in other industries)*—Continued

Product code	Product	Total shipments including interplant transfers			
		1954		1947	
		Quantity (1,000 units)	Value	Quantity (1,000 units)	Value
	Electrical measuring instruments—Con.				
	Other electrical measuring instruments—Con.				
	Indicating and recording—Con.		*Thousands*		*Thousands*
	Indicating instruments—Con.				
3613313	Panel-type instruments, nominal size larger than 4½ inches including all exploded types. Initial accuracy within ±2 percent of full-scale deflection for all except rectifier types which shall be within ±5 percent. Excluding instruments for use on motor vehicles and aircraft.	40	$2,217	108	$2,155
3613315	Panel types for use on aircraft only (for measurement of electrical quantities only including ammeters, voltmeters, volt-ammeters, watt-varmeters, frequency meters, phase sequence indicators, etc.	55	2,848	43	408
3613321	Switchboard-type instruments 4½ inches nominal size and larger with accuracy within ±1 percent of full scale.	130	71,57	115	3,111
3613331	Industrial portable ammeters, voltmeters, watt-varmeters, etc., including hook-on and split care current measuring types.	108	4,223	68	1,659
3613335	Laboratory portable instruments—with accuracies within ±1 percent, up to 1/10 percent of full scale and better, all case sizes.	33	3,461	44	2,317
3613345	Other indicating instruments, except motor vehicle and test equipment.	(1)	3,332	(1)	(6)
3613351	Instrument relays—all types	45	2,098	40	899
3613361	Recording instruments, not including control types.	(1)	10,191	(1)	1,911
3613371	Parts for indicating and recording instruments.	(1)	5,985	(1)	3,468
3613381	Instrument, meter, and tripping transformers (current and potential).	298	17,649	278	10,628
3613385	Ammeters and voltmeters for motor vehicles.	2,503	1,590	(4)	[6] 2,502
3613300	Other electrical measuring equipment, not specified by kind.	(1)	4,422	(1)	1,571

[1] Not applicable.
[2] Of this total, 76 percent was shipped by plants classified in the electrical measuring instruments industry; the remainder was shipped as secondary products by plants classified in other industries.
[3] In 1947, shipments of combined watt-hour and time switch meters (code 3613121) included with other integrating meters (code 3613151).
[4] Not available.
[5] In 1947, shipments of broadcast transmitter test equipment (code 3613263) included with other test equipment (code 3613298).
[6] In 1947, shipments of ammeters and voltmeters for motor vehicles (code 3613385) included with other indicating instruments (code 3613345).

APPENDIX A–2

[From Control Engineering Around the Loop, May 1955, New York, N. Y.]

REPORTS POINT UP DYNAMIC CONTROL EXPANSION

Anyone doubting that the control market has entered an era of dynamic expansion can stand a brush-up on two authoritative reports issued by McGraw-Hill's department of economics.

One report is a long, hard look at what the American economy will be like in 1960, a summary of the Twentieth Century Fund's study of America's Needs and Resources.

"The economy is being remolded by titanic forces of a technological nature, with almost bewildering prospects of rapid change," the summary says. If our society can absorb a rapid rate of technological change, the prospects are "absolutely glowing." The technology must grow progressively more efficient, the report adds, to provide for a population which has been increasing at a much more rapid rate than anyone could foresee from past experience.

How is industry reacting to the "titanic forces" of change? Its plans for capital spending give valuable insight into the control market's potential as industry meets the new industrial revolution.

A second McGraw-Hill report describes those capital spending plans. It's titled "Business' Plans for New Plants and Equipment 1955–58."

"United States business as a whole," the report says, "plans to spend more for new plants and equipment in 1955 than in any previous year." And, on the basis of present planning, there is every indication that the uptrend in capital spending will continue well into the future. In 1955, manufacturing industries plan to spend $9.2 billion for new plants and equipment, about 3 percent more than in 1954.

EXPANDING MARKETS FOR CONTROL

Standouts among major control users are chemical processing and textiles. Chemical processing companies plan a 7 percent increase in capital spending this year over last. Textile companies expect a 5 percent rise. Over the period 1955–58, the chemical industry foresees a 22 percent increase in manufacturing capacity.

Since last fall, practically every manufacturing industry has raised its sights on capital spending. Papermakers, figuring last year on a drop of 6 percent, now expect an increase of 10 percent in 1955.

SALES TIE IN WITH SPENDING PLANS

Manufacturers' capital investment plans, of course, tie in closely with their sales expectations. In 1955, manufacturers as a group look for an average 7 percent sales increase over last year. By 1958 they expect a sales gain of 21 percent.

How manufacturers are expanding capacity

	Percent 1954–55	Increase 1955–58
Primary metals	3	8
Iron and steel	2	7
Nonferrous	4	12
Metalworking	6	12
Machinery	6	13
Electrical machinery	7	15
Autos	4	10
Transportation equipment (including aircraft)	8	11
Other metalworking	6	12
Chemical processing	6	16
Chemicals	7	22
Paper	7	16
Rubber	5	10
Stone, clay, and glass	5	14
Petroleum refining	1	4
Food and beverages	5	9
All manufacturing	5	11

The part control can be expected to play in the development of specific industries can be inferred from the table above. McGraw-Hill research points out that experience with previous surveys shows that plans for years ahead are always lower than plans for current periods. Thus, actual expansion in the 1955–58 period may well exceed the estimates shown.

Automatic control is the bond of common interest linking two huge fall engineering meetings separated widely by geography.

The production engineering show, Chicago, September 6 to 16, is aimed at the men who direct, design, and apply the methods and mechanisms of industrial production. It is planned to help them achieve the goals of automatic production and processing in their plants.

The ISA Instrument-Automation Conference and exhibit, Los Angeles, September 12–16, will offer business and industry the newest components, instruments, computers, devices, and systems needed in control development.

Marking these vital control events, the September issue of Control Engineering will present close to 80 pages of new, practical ideas for the control of automatic processes and production machinery. Editorial material will cover the mutual control interests of production engineering men and process instrumentation men.

80 PAGES OF NEW IDEAS

Because September will be Control Engineering's first anniversary issue, its editors have gone all-out to make it a truly outstanding issue for both subscribers and advertisers.

The production engineering show is new this year, so no figures are available for breakdown of previous years' attendance. ISA, however, has supplied an audit of the first International Instrument Exposition held last year in Philadelphia. From it (in the box at right) we have derived figures on attendance which should be of interest and value to anyone planning to attend or exhibit in Chicago or Los Angeles this year.

In September, 150,000 production men will attend production engineering show in Chicago, 25,000 process instrumentation men will gather for ISA show in Los Angeles, and, control will dominate both shows.

BREAKDOWN OF 1954 INSTRUMENT SHOW ATTENDANCE

A total of 21,363 people attended the First International Instrument Show last year; 31 industrial and business groups were represented by men in 47 general job classifications.

A total of 568 sales and advertising managers were at the show, along with 1,317 sales engineers and 1,076 salesmen. These groups made up 14 percent of attendance.

Industrial and business groups with more than 1,000 attending included: Instrument manufacturers, 6,871; electrical manufacturers, 2,269; chemical and allied products, 2,087; National, State, city government, 1,899; service industry and supply houses, 1,307.

Men with "engineer" in their titles—39 percent or 8,278 of total–included: Engineers, miscellaneous consulting, 3,235; chief engineers, 806; research engineers and associates, 731; development engineers, 710; instrument engineers, 527; design engineers, 508; electrical engineers, 469; mechanical engineers, 319; chemical engineers, 285; test engineers, 128; product superintendent and engineers, 125; maintenance superintendent and engineers, 115; production managers and engineers, 107; plant engineers, 100; material engineers, 64; gas superintendent, combustion, power, heat and fuel engineers, 49.

Groups having 500 to 1,000 attendance included: Iron and steel industries, 886; educational institutions, 814; research and analytical laboratories, 721; petroleum products, 606; machinery manufacturers, 573; consulting engineers, 514.

Management and allied titles comprised 22 percent or 4,641 of attendance. Research, laboratory, testing, chemist and medical made up 8 percent or 1,667.

Geology, geophysicists, scientists, mathematicians, metallurgists made up 3 percent, or, 688.

Inspectors, electricians, mechanics, instrument men, draftsmen, architects, 7 percent or 1,435.

Four hundred professors attended—about 2 percent; 251 students, about 1 percent.

The instrument manufacturing people comprised the largest group with 32 percent of attendance; 1,583 or 23 percent of their total were sales and advertising managers, sales engineers, and salesmen.

Smaller groups with high percentages of sales personnel included: Iron and steel industries, 18 percent; forest and paper products, 17 percent; machinery manufacturers, 20 percent; nonferrous metals industries, 30 percent.

[From Control Engineering Around the Loop, September 1955, New York, N. Y.]

Control Engineers in Industrial or Military Work Are Same Kind of People

Engineers have hairy ears, the ballad tells us, distinguishing them from lesser citizens.

Beyond that, what's the difference between a control engineer in an industrial setup, and a control engineer doing military or defense work?

There is none. Knowing quite a few of both binds, we've been reasonably sure of it for some time.

We thought it might be well, though, to give the notion some scientific verification, by testing it across our subscription list. A reasonable number of subscriber cards were pulled out at random and this sampling was polled.

We can announce, with a hint of smugness, that the inquiry bore out our own observations.

Among the respondents, 46 percent were involved in industrial control engineering; 34 percent in military control engineering; 20 percent were doing both.

We found that a ratio of 4-to-1 respondents in military control engineering foresaw important industrial applications for their present military work. The sampling disclosed also that the areas in which military control work would have industrial applications was almost evenly divided between process control, machine control and production control.

Engineers Welcome Change of Pace

Inherent noisiness impelled us to inquire in our questionnaire, what engineering media these subscribers worked in. Inherent politeness impelled them to answer, permitting us to observe that 66 percent work in electrical; 67 percent in mechanical, pneumatic, and electronic; 13 percent optical.

These percentages do not add up to a neat 100 because all respondents indicated they work with more than one engineering medium. Few will quarrel with our conclusion that these control engineers welcome a varied editorial cuisine covering varied interests and occupations. Since its first issue, Control Engineering has been written on that basis.

Based on the number of years these subscribers said they had been working for their present companies, we concluded that their median age is roughly 32 to 39, youthful enough to bang away hard at building careers, sharpening skills, acquiring knowledge. For the most part they have solid academic backgrounds and don't wince at math—differential equations, transforms and such like.

Complete Report Will Give Details

Sometime soon, when summer has simmered away, we'll have the information from the questionnaires processed into presentable form, with a more generous helping of specific than offered here. We will supply a breakdown on job titles for those who are fascinated by such information. If you'd like to see a complete report on this study call one of our district managers. But give us a month or so, m-m-m?

In the realm of product research, we are (with the collaboration of McG-Hill's erudite research department) developing some specific information from the control field on the application of pneumatic and hydraulic components and relays. We hope to have this material available to you in about 2 months. Orders taken now for the complete report. Flag a district manager or write us here in New York. If this report is as incisive and illuminating as our recent vacuum study, your postage will be well rewarded.

The September issue marks Control Engineering's first birthday, and we feel entitled to cover the occasion with a brief, dignified statement, quote: We're happy about the way subscribers have responded to this new editorial service, glad of the evidence the magazine is slotted to their needs. We're gratified too, at the reaction of advertisers with the perspicacity to use Control Engineering as a means of marketing their products. The record shows: September 1954 issue circulation, 15,235 net paid; September 1955 issue circulation, 24,412 net paid; September 1954 advertising pages, 71; September 1955 advertising pages, 115.

MANUFACTURERS REPS AND SALES PERSONNEL NEEDED

"Where can we hire, hypnotize or abduct a good manufacturers' rep?" More and more of these plaintive inquiries are drifting our way, for reps, sales engineers, and advertising managers. At this point we can't give a straight-out answer—a condition we're in the process of correcting.

We take the enlightened attitude that for advertising in Control Engineering to have greatest effectiveness, our advertisers must have adequate sales representation. We've begun compiling a manufacturers' rep file.

We are requesting from manufacturers' representatives confidential information concerning the companies whose lines they handle, products they sell, territories they cover, their abilities to provide engineering services.

FILE WILL BE CONFIDENTIAL

Because this information is necessarily of a confidential nature, we will retain this file in our office in New York. We will, however, be glad to provide manufacturers with names of competent representatives in various parts of the country, after we get the file set up and rolling.

We would appreciate some help from manufacturers, too. If you have a list of representatives, send us their names and addresses. We will, in turn, send them questionnaires to be returned for our file.

If you need representation, let us know where it's needed, and general characteristics you're looking for in your man. We will send the information along just as soon as the file builds up to a point of usefulness.

Let us emphasize that we will use scrupulous care to insure that the passing along of information will serve only to supplement lines handled, not duplicate them.

Representatives to sell delay lines, magnetic storage elements, and pulse transformers. Well established highly technical reps who will be looking for orders above $50,000. All territories open.

Sales reps: Not just catalog sellers, but reps who can give technical service. Must have thorough experience in sale of complete systems for automation, remote control, or telemetering. Can bird-dog leads, get facts for action into reports. Salary and territory open.

Sales engineer, for sales and engineering application, to handle a new line of industrial electronic measuring and control instruments. Applicant to work from factory in New England. Job involves travel, training field representatives and contacting major prospects. Experience in industrial instrumentation required. Salary open and commensurate with experience.

Representatives: Standard electronics reps, preferably handling computer components, servo components and/or systems. To contact aircraft, guided missile and control systems manufacturing companies. Areas to be covered: New England, Middle Atlantic, Midwest, Southwest, west coast, Canada.

[From Control Engineering, Around the Loop, October 1955, New York, N. Y.]

BIG INDUSTRIAL SHOWS GAVE PANORAMA OF NEW CONTROL DEVELOPMENTS

Two great shows in September gave control engineers a chance to evaluate new control developments across the span of industry.

In Chicago the machine tool show corraled the industrial mastodons, the first such roundup since 1947. A tangent of the tool show was the production engineering show, also in Chicago.

In Los Angeles, the Instrument Society of America's conference and exhibit displayed a year's progress in industrial control.

First stop in Chicago for control engineers was the production engineering show at the Navy pier. While the bulk of equipment consisted of machine shop accessories (or what the trade knows as automation, transfer devices and the like) perhaps a dozen booths featured equipment familiar to the closed loop: dynamic motor-control arrangements, tape-servo director system for machines, liquid state devices.

An oasis for the feedback minded was the cooperative exhibit by eight universities of control innovations originated by the schools. Around the loop described these in a previous issue.

Machine tool behemoths rumbled and clunked at the tool show out near the stockyards. To the naked eye there was little direct evidence of closed-loop applications among the 500 new machines shown.

Primary considerations were speed, and the ability to cut metal, reflected in the size of machine frames and the size of drive motors. The general impression was not one of automatic control gadgetry but absence of it. But control hardware was there, somewhat in the background. For example, numerically programed machines having closed-loop systems were present, but not actively promoted.

There are undoubtedly good reasons for the lack of emphasis on automatic controls, for example, reluctance on the part of manufacturers to believe their markets are ready to launch into the control era.

A Control Engineering editor supplies an analysis of machines employing control techniques displayed at the tool show: positioning servos—which drive the carriage holding the workpiece or tool an amount proportional to a control signal—were seen on 18 new contour tracing machines. Fifteen of these were hydraulic, only three electric. About one-half of the tracing actuators were developed by the tool maker. The remainder were subsystems supplied by an outside control manufacturer.

One of the most avidly discussed control techniques, numerical programing, was noticeable at the show for its scarcity. Only seven tape-controlled machines were observed. Three were developed by the manufacturer, four were supplied by outsiders.

Variable speed drives, replacing or augmenting gear changing, were more common. Electric, pneumatic or hydraulic clutches were utilized when gear changing was required.

More than 50 machines featured automatic transfer, loading and assembly, pointing up the prime interest of manufacturers in automation. And bearing out the reluctance of manufacturers to stress feedback, the major interest of machine users was in watching the chips fly—speed of transfer and loading and the volume of metal cut.

So on close look, machine-tool makers are starting to spend money in interesting quantities on control refinements. For people in the control field, the machine-tool industry looms as an area of enormous opportunity.

CONTROL ENGINEERS RULED ROOST AT INSTRUMENT SHOW

At the instrument show in Los Angeles there was no question of where the emphasis lay. Control was the big concern, and engineers skilled in control are well integrated into the process field.

The big trends noted were the emergence of a great many data handling and logging devices, and electrohydraulic process control valve positioners. The large companies are now talking systems engineering. An ardent interest was demonstrated in electronic instruments by people who have been exclusively pneumatic in outlook.

The products of 300 companies were displayed across 3 floors. While older, well-established firms were well represented, newer systems firms from the west coast occupied large booths and displayed an intriguing array of new control developments.

Exhibits could be roughly classified into those groups:

Transducers and measuring	42
Control component hardware (relays, switches, timers, etc.)	41
Testing equipment	38
Process control systems	34
Services for control	22
Analytical instruments	18
Data processing	18
Servo-type equipment	12
Computing and counting	10
Telemetering	8
Unclassified	22

The technical sessions indicated the control-dedicated nature of the occasion. There were 7 original studies in the dynamic analysis of elementary process control; 4 special sessions, 16 papers, on plant product analysis techniques; symposia on data handling, transportation, and nuclear instrumentation; daily clinics for engineers on computers and analytical measurements.

Few products exhibited stood out as individual developments. They seemed rather to be grouped to fill specific control needs. There were: At least 5 newly developed electrohydraulic valve actuators—to meet the need to match valves to fast electronic controllers; 5 major entries in data processing systems—indicating an eagerness of companies to join the competition: several new analytical instruments for in-stream use—in response to demands by advanced process engineers; 4 new flow computing devices—to provide linear analog and even direct digital output from nonlinear "workhorse" flow sensors.

Among developments having unique design features and promising futures were: A new ultrasonic type flowmeter by Fischer & Porter; Perkin-Elmer's new vapor fractometer; Honeywell's and Bristol's new high-speed strip chart recorders.

APPENDIX A-3

(Not available for inclusion as an appendix, but used as a reference, The General-Purpose Electronics Test Instrument Industry, an industrial mobilization and defense planning study by the Scientific, Motion Picture, and Photographic Products Division, Business and Defense Services Administration, United States Department of Commerce, July 1, 1956, available in subcommittee files.)

APPENDIX B

ISA expands its program of education and research activities. For several years the society has been working, through its education, and structure and planning committees, on the development of a comprehensive plan for improved society programs and activities with respect to instrument education and research. This work has been predicated on the fact that the society serves primarily as an educational medium and a stimulating agency for the benefit of its individual members and the instrument using and manufacturing industries.

The society's education committee, under the chairmanship of Robert J. Jeffries, prepared the first program proposals in 1953. The society's executive board at that time agreed with the necessity of such a program and referred the matter to the society structure and planning committee. This committee considered the content of the proposals and in September 1955, under the chairmanship of Phil Sprague, recommended to the executive board a broad program of activities in the areas of education and research, essentially as originally proposed by the education committee, but taking into account the possible administrative and financial growth of the society. The program was accepted, and, as recommended, a special presidential development commission was established to bring forth an organization, a specific program, and means of financing.

The first meeting of this commission was held at St. Petersburg, Fla., on February 28, with Robert Jeffries as temporary chairman. The success of this meeting is of great significance to every individual member of ISA and the industry in general. The progress of this commission and its "plan for action" means a new and positive approach to the single biggest problem facing the instrument and automatic control field—education and research.

CONSIDERING TODAY'S PROBLEMS IN INSTRUMENTATION

(By Dr. Robert J. Jeffries, technical planning adviser, Schlumberger Instrument Co., Ridgefield, Conn.)

(Condensation of the introductory address by Dr. Jeffries before the first meeting of the ISA Education Foundation Development Commission, St. Petersburg, Fla., on February 28, 1956.)

The purpose of my remarks is to provide a common vocabulary and basis for consideration of the problems and opportunities inherent to the task before the ISA Education Foundation Development Commission. I would also hope to provide, in some measure, a perspective on the scope and depth of the concerns of the society with respect to educational and research activities in the field of instrumentation.

This is a development commission. It is our job to give consideration to the many existing and anticipated problems relating to instrumentation, and ultimately, to focus upon those situations and the possibilities which, in our opinion, represent a practical compromise between what is most urgently needed—and what is most probable of accomplishment.

For our purposes, instrumentation research is meant to include: "The search for and quantization of fundamental phenomena which will make possible instrumentation techniques and equipments plus investigation of potential uses of instruments and systems."

Recognition of instrumentation as a science is belated and still far from universal. Lord Kelvin may be considered the father of the field as a result of his vision and perception as to the fundamental importance of measurement, but it wasn't until the 1940's that important attention was drawn to a broad view. Gradually and grudgingly has developed the appreciation of the existence of this new field which has yet to be universally defined. About 1942, the American Association for the Advancement of Science organized a committee to define the term. It brought back approximately 39 different definitions. In more recent years, educators, publishers, even organized labor, have adopted the word—pairing it first with feed-back control, then systems engineering, and most recently, automation, in an effort to imply in some measure the breadth of concern and scope of activities. Instrumentation today, in its broad sense, is fundamentally concerned with the development and application of instruments and instrument systems for purposes of measurement, computation and control.

Instruments and instrument systems exist fundamentally because of the desire for measurement. This desire for measurement is usually born out of necessity. When one is curious, in a scientific way, concerning a phenomenon or a condition, his curiosity is manifest in his desire to express quantitatively the factors involved. Science is measured knowledge. A fact is not a scientific fact unless it can be quantized in concept, form, or relation. In order for any science to advance, there is the continued pressure, the necessity for better measurement technique and equipments. It is this necessity, first in the sciences, then in engineering activities, and now in production activities, which has fostered the conception and evolution of our modern research and production instruments and instrument systems.

Fundamental to the conception or application of an instrumentation technique or equipment is an understanding of the problem. To intelligently conceive a solution to an instrumentation problem, one must acquire a detailed understanding of the circumstances of the situation, the environment, the medium, etc. One must have a thorough understanding of the various alternatives available within instrument technology; one must be able to apply to his solutions the yardsticks of feasibility, probability, performance, economics, and human nature.

Today's process control provides an illustration of the technical and economic problems in instrumentation. Consider a refinery. One may desire to control a temperature at the top of a fractionating column. The problem of the controller is the maintenance of the desired temperature. The problem of today's instrument engineer is to select an appropriate controller, matched to the plant and the process, to effect the desired dynamic performance. Ideally he should know the characteristics of the plant-process complex; he should know the characteristics of various modes of control—proportional, rate, reset, their combinations and interactions—and armed with this understanding, attack his problem with an intelligent first guess. Fortunately, the controller manufacturer permits him a second guess—he can readjust his sights after a near miss—with an empirical adjustment of the control knobs inside the controller case. The controller manufacturers have done a superb job of providing today's instrument engineer with a face-saving, soul-saving, job-saving feature of complete adjustability over ranges of hundreds to one. With this built-in margin, today's instrument engineer can overcome his lack of precise understanding of the dynamic behavior of the process and the plant. However, his plant pays for his ignorance. To provide this wide range of adjustability, the controller is not optimum for any given condition. It is an easily demonstrated fact that for a given control problem, a specific nonlinear type controller can be made to have a performance superior to any of the existing commercial linear-type controllers. The second, and perhaps more important penalty is improper plant design, which is the result of the instrument engineer's lack of understanding with respect to dynamics of integrated systems back when the plant and the process were in the planning stage. Because of this, plant designers are excessive and costly.

Understanding is, then, an important technical factor in instrumentation.

The second technical problem facing the instrument engineer, and of direct concern to the process designer and operations manager, is what should be the prescribed point about which control action is to take place. Out of experience, out of pilot-plant operations, out of balance-sheet analyses, there gradually emerges a preferred combination of operating set points which result in a salable product, manufactured hopefully at a profit, in a way which permits continual operation. The prescription of optimum controller set points is a static problem, mathematically speaking. Knowing the capabilities of the plant-process-controller complex, one could mathematically derive, either with paper and pencil or with the aid of computers, the optimum set points. To my knowledge, this has just been attempted by a few plants. The need is demonstrated by a familiar situation which exists today in most plants—every new shift of operators changes the set points of the process as they report for work, even though all shifts are making the same product from the same raw materials with the same plant and process.

The outstanding economic problem of the processing industry is the most effective employment of the plant, with its product-making characteristics, in relation to a dynamic market and raw materials situation, so as to maximize the dollar profit derived from the overall operation. This adds two more degrees of complexity to the problem of establishing optimum controller settings to produce a given product. It adds the question "what product," and the complicated factor of a variable input. A refinery exemplifies this problem. Its input is a continuously varying crude; its output must be tailored in type and quantity, from aviation gasoline to road oil, to meet an ever-changing market. The operations manager—perhaps a vice president—must, in essence, tell the operator what his controller set points should be—for it is these set points which determine the fractionating or cracking of the crude into salable products. There are techniques just now emerging in the field of operations research which promise to be directly applicable to processing problems of this type.

Why doesn't the process designer—the plant designer—the instrument engineer—the operations manager—know the facts required to select the best controller, the best set point, the best production schedule? The simple answer is that the necessary information isn't available to them. And yet, techniques and technology exist to furnish them with the information they would require. One of the greatest problems in instrumentation today is the necessity for communicating the advances in technique and technology as they are made to those who need them in a way in which they can be assimilated.

The mathematical and physical concepts necessary to predict exactly the type of controller to employ for any specified desired dynamic performance of a controlled system have been known for at least 40 years. Our chemical, mechanical, and instrument engineers have not, until just recently, been analytically and dynamically oriented. It is to be expected that "long hair" mathematics will be slow in filtering down from the ivory towers into the work-for-profit world. But this alone isn't sufficient justification for the high level of ignorance which prevails today. There are experimental, empirical techniques available which any instrument engineer could employ to get the information necessary to perform intelligent dynamic instrument engineering. The knowledge of these must be communicated.

Only within recent years has there been any practical revelation of the techniques and applications of experimental frequency response methods for the analysis of the dynamic characteristics of physical systems. Production plants and controller manufacturers have very few engineers competent in the technique. To my knowledge, few of the big consultant-construction companies—firms designing and building processing plants all over the world—have engineers who actually know how to use frequency response data to deduce the dynamic characteristics of a system.

This is an appalling fact since all of the necessary information has been available in literature since the early thirties. It has been taught in electrical engineering curriculums since the early forties. The mechanical engineers have just discovered it within the past 5 years.

Closely tied with the need for communication is the need for manpower efficiency. It is a criminal waste of time and talent for every research worker in medicine, biology, agriculture, in any of the sciences, to be forced to start from the bottom, so to speak, with respect to the instrumentation of his problems. It is still true that literally hundreds of physiologists, psychologists, medical doctors, geologists, chemists, and even physicists, struggle with DC amplifiers, slide-wire position transmitters, cathode-ray photography, while their own problems wait.

Practical, efficient means must be found to provide researchers in all fields with the necessary instrumentation equipments and skills—and this must be preceded, paralleled, and followed by a communication and understanding as to the availability and characteristics of modern instrumentation.

Let us now consider the roles of the instrument manufacturers and users in the evolution of techniques, products, information, etc.

With respect to instrument manufacturers, the situation is fairly clear—their efforts are directed toward the development of equipments which, in their opinion, will be profitable. They expend great amounts of time and money to ascertain potential markets for new developments. By and large, their research is rather product development. They will do little basic research, except insofar as it can be related to a potential financial return, particularly through achievement of a unique competitive position. Profit margins in the instrument business simply do not permit extensive basic research. I am sure that our marketed items are far ahead of our basic understanding of the how and why they work and their limitations. There is much room for catching up in a systematic, inquisitive way.

Instrument users, in general, might be categorized in several ways.

(*a*) *Instrument purchasers—with no inherent internal instrument interests.*—This group includes the bulk of the dollar-volume of instrument sales today, which buys and operates instruments as tools. They tend to follow instrument technology, buying what is offered, rather than leading in demanding new things or finding new applications.

(*b*) *Instrument purchasers—with internal instruments interests.*—This group includes major instrument-user industries, such as chemical, petroleum, missile manufacturers, and Government agencies. They attempt to meet these needs through instrument development within their own organization, through contractual relationship, and through legitimate pressure on instrument manufacturers for improved products. It is this group, by and large, which accounts for most of the new developments in instrumentation today. It is noteworthy that medical and biological interests are virtually unrepresented in this group. Military spending frequently provides money to undertake developments which could not be justified in a commercial sense. Large user groups such as chemical producing plants can afford and must develop new instruments concurrent with new products. Their developments usually prove to be relatively expensive equipments in which the value of the improved product justified the cost. It is an important and significant trend that most new analytical-type industrial instruments, such as recording refractometers, vapor-phase chromatographs, etc., are being born in users' laboratories, and then adopted by instrument manufacturers, who become, in effect, packagers and entrepreneurs.

(*c*) *"Would-be" instrument purchasers.*—This group includes individuals and organizations, principally engaged in research, such as usually are found in the biological sciences, whose immediate interests are in noncommercial areas in which they encounter situations which require new or modified instrumentation. Since their primary interests are usually not in instrumentation, they are either incapable or extremely inefficient in their approach to solution of their problem. They would, ideally, like to purchase a solution to their problem.

My final thought concerns the fierce struggle in the world today to capture the minds of men. The world is divided into two economic and political camps. Our hopes for survival and our ultimate hope for success in establishing our concepts of individual dignity and opportunity, lie chiefly in our prosperity and example. This requires that we have more better trained engineers to conceive and design more machines which incorporate the latest products of instrument technology. It requires that we establish a supply of highly skilled technicians to operate and maintain this equipment. It requires that we continually upgrade existing personnel to enable them to take advantage of, and keep pace with, instrument technology. Russia is turning out perhaps as many as 60,000 trained technicians a year, and between 40,000 and 50,000 engineers a year. In contrast, we may graduate this year 1,000 to 2,000 technicians and 20,000 to 25,000 engineers.

As businessmen experienced in the management of technical operations, I leave it to you—what are the inevitable technological results to be anticipated?

RESULTS OF THIS FIRST MEETING

At the conclusion of Dr. Jeffries' opening remarks Mr. Rex Bristol, vice president and treasurer of the Foxboro Co., was elected chairman of the commission.

Then followed much discussion concerning the objectives and plans for the commission. In the deliberations there was considerable sentiment expressed in favor of establishing some type of permanent ISA planning and coordinative group which would serve as a catalytic agent in bringing together those who have problems and the means for effecting solution to these problems. It was recognized that the ISA cannot possibly finance all the activities which might desirably be undertaken with respect tod instrumentation education and research. It appeared, however, from the initial considerations of the commission, that the ISA could function very effectively as the stimulant and mechanism for channeling the efforts of several groups toward the common goals of affording increased educational opportunities for individuals at all levels, improved communication and translation of technical knowledge into forms practical for assimilation and utilization in the working world by working people, and an increasing attention to research and development of improved instruments, instrument techniques, and practices.

Under Mr. Bristol's direction the commission will arrive at conclusions and recommendations with respect to:

(a) What specific activities in instrumentation education and research the society should undertake, and in what order.

(b) How these activities shall be organized and administered, and
(c) How these activities shall be financed.

It is anticipated that the commission will submit its report to the executive board by June 1. The work of this commission will undoubtedly have a direct bearing on the value of the ISA to every one of its members and its many supporters and friends in the years to come. The ISA Journal will carry a complete coverage of the work and recommendations of this development commission.

ISA EDUCATION FOUNDATION DEVELOPMENT COMMISSION

Rex Bristol, Chairman of Commission, vice president-treasurer, Foxboro Co., 58 Neponset Avenue Foxboro, Mass.
E. J. Albert, president, Thwing-Albert Instrument Co., Penn Street and Pulaski Avenue, Philadelphia, Pa.
Dr. Arnold O. Beckman, president, Beckman Instruments, Inc., 2500 Fullerton Road, Fullerton, Calif.
Warren H. Brand, vice president of eng., Conoflow Corp., 2100 Arch Street, Philadelphia, Pa.
Wm. J. Caldwell, director, research, Taylor Instrument Co., 95 Ames Street, Rochester, N. Y.
Hugh F. Colvin, vice president and general manager, Consolidated Electrodynamics, 1025 East Green Street, Pasadena, Calif.
Porter Hart, director of instrumentation, Dow Chemical Co., Freeport, Tex.
Dr. Robert J. Jeffries, technical planning adviser, Schlumberger Instrument Co., Ridgefield, Conn.
Barton Jones, president, Barton Instrument Corp., 1429 South Eastern Avenue, Los Angeles, Calif.
Thomas Roy Jones, chairman of board, Daystrom, Inc., 200 Elmira Avenue, Elizabeth, N. J.
Prof. Carl F. Kayan, head, department mechanical engineering Columbia University, New York, N. Y.
Dr. J. H. Lampe, dean, School of Engineering, North Carolina State College, Raleigh, N. C.
Edwin E. Parker, general manager, instrument department, General Electric Co. West Lynn, Mass.
Dr. J. Wayne Reitz, president, University of Florida, Gainesville, Fla.
Dr. John Ryder, dean of engineering, Michigan State University, East Lansing, Mich.
Prof. Earl J. Serfass, head, chemistry department, Lehigh University, Bethlehem, Pa.
Albert J. Sperry, president, Panellit, Inc., 7401 North Hamlin Avenue, Skokie, Ill.
Dean Joseph Well, University of Florida, Gainesville, Fla.
J. T. Vollbrecht, president, Energy Control Co., 5 Beekman Street, New York, N. Y.
Wm. A. Wildhack, Chief, Office of Basic Instrumentation, National Bureau of Standards, Washington, D. C., ISA education committee liaison
Prof. B. P. McKay, University of Tennessee, 62 South Dunlap Street, Memphis, Tenn.

APPENDIX C

EXCERPTS FROM A CHALLENGE AND AN ANSWER, A BROCHURE PREPARED TO JUSTIFY AND EXPLAIN THE NATURE OF THE FOUNDATION FOR INSTRUMENTATION, EDUCATION, AND RESEARCH OF THE INSTRUMENT SOCIETY OF AMERICA

THE CHALLENGE

The increasing productivity of American industry per man-hour is due in large part to the greater automaticity of modern production process. The continuing progress of science on all fronts is possible because of more advanced measuring apparatus and techniques. * * *

* * * These technical accomplishments are the product of man's technical training and ingenuity. Their effective use requires man's perception of need and intelligent application. America is currently experiencing a slowdown in its conception, development, and application of instrumentation equipment because of a shortage of approximately trained personnel at all levels of design and application in all areas of industry and science. This shortage presents a real

threat to an increasing standard of living and our national security, and its resolution constitutes a challenge to the best minds and resources of the Nation.

THE PROBLEM

To understand clearly the nature of the challenge which our evolving technology poses one must identify problems which exist.

Top management of manufacturing and processing industries do not, in many instances, understand sufficiently well, the fundamental characteristics and potentialities of modern instrumentation, to take full advantage of its capabilities.

Production layout and process design engineers do not understand sufficiently well, the dynamics of their problems to intelligently specify appropriate instrumentation.

Instrument design engineers do not understand sufficiently well, the more sophisticated theories and engineering data available, to effectively incorporate the latest knowledge in their designs.

Educators in our colleges and universities do not have the equipment nor the experience, in most cases, to incorporate modern instrumentation techniques and concerns into their curricula and student experiences.

Technical institutes and vocational high schools either are not aware, or do not have the facilities or staff to train the great host of subprofessional instrumentation personnel required to assist in research and man the highly instrumented plants of today and tomorrow.

The great quantities of instrumentation information and experience being acquired, that being published, and that available for the asking, is largely being lost for all practical purposes, for want of an efficient and effective system for storage and retrieval.

Scientists in all disciplines are functioning at only fractional efficiency because of their unmet needs for competent instrumentation services. * * *

ISA'S ANSWER

* * * The Instrument Society of America is an association of freemen in a free society, banded together for their mutual education and benefit. Their backgrounds include virtually all the traditional scientific disciplines—physics, chemistry, mathematics, medicine, all braches of engineering, science, business management, and education. It is the only technical society in America devoted exclusively and completely to the interests and problems of instrumentation and automation. * * *

* * * Through established machinery within the society, various groups of this Nation's outstanding men in instrumentation, industry, Government, and education have defined specific needs and outlined methods of meeting their needs. It is their considered judgment that the desirable objectives can be most effectively and efficiently realized through the mechanism of a noprofit foundation under the guidance of leaders from various areas of our society, supported by funds from those whom it serves, and oriented specifically to solve the solution of the instrumentation problems of our time. * * *

Chairman PATMAN. Thank you very much, Mr. Jones.

I was very much impressed by your statement, and I state flatly at this moment that automation is being held back and our national security is being jeopardized by the existence of lack of solution of these problems.

The problems you presented are similar to the problems presented by Mr. Sheen.

Mr. JONES. Well, we are in the same industry.

Chairman PATMAN. Yes, sir; you are in the same industry. And we cannot emphasize the solution of these problems too much.

On page 7 you talked about middle-sized business. In practice and effect, the Small Business Committees of the House and Senate assume jurisdiction over middle-sized business. In other words, every business that is not big, according to definitions that are generally accepted, is "small," including the middle-sized businesses.

We are not opposed to big business, those of us on Small Business Committees, but we just feel like the big businesses have good representation before the different committees, and their interests are looked after pretty well by people employed by big business for that purpose. They have lots of representatives here in Washington, and they are not frowned upon, they are welcomed in the office of any Member of the Congress that I know of. I know I welcome them, because I can invariably get information that I would not get any other way, and I know that they are very helpful to Members of Congress.

So, we are not against big business, we just feel like the little man is always represented here in the same way and manner as the big-business man is.

Mr. JONES. Isn't the little man usually defined as one who employs less than 500 people?

Chairman PATMAN. That is some arbitrary definition that some agencies have established. I don't think it is a correct definition at all. The term "small business" is a relative one, the way I view it. It depends upon the industry, sometimes. You take, for instance, Studebaker-Packard, that is a small business in comparison with General Motors and Ford and Chrysler. You take a steel company that is employing four or five thousand people and producing approximately a million tons of steel a year, although in itself it is a big operation it is small business in comparison to United States Steel or Bethlehem.

So I think the term "small business" is a relative one that cannot be disposed of by number of employees. You take 500 employees in the needle industry, or many other industries you could name, would be the biggest business in the industry.

Mr. JONES. Well, of course, my point is not that; it is that small business gets to a certain point, especially in this instrumentation, automation, and general technological field, and they run out of finances and they run out of management able to handle the larger problems, and they need to go somewhere to get under an umbrella.

My point was that if Congress sets up roadblocks to these avenues of escape for these small businesses, it not only injures those people who are owners of the small businesses but it injures the economy.

Chairman PATMAN. Yes, sir; I agree with you.

Now, on page 9 you have an interesting statement:

> This country's educational system simply is not geared at present to producing the numbers of people required with technological training to absorb and apply and develop the automation equipments which are possible, which are desirable, and which in many instances are basically necessary to our modern economy.

And you added there, you ad libbed: "The situation is frightening." And I agree with you. You also made a statement that has been brought up by Mr. Sheen which I think is very important, in which you said:

> I have been shocked at the amount of time spent in unnecessary manual labor, or even in doing nothing at all, by men of superior technical possibilities—

in the Army.

Mr. JONES. That is correct.

Chairman PATMAN. And that is where Russia has been getting ahead of us. You see, they have been using their men like you and Mr. Sheen have suggested. Russia has been doing that. So Russia has been outthinking us and outdoing us.

Mr. JONES. But the amazing part is that these services are the ones who require these men with the technical training.

Chairman PATMAN. Yes, sir. We can utilize the military service for that purpose, and it will be not only helpful to the country, it will be helpful to the men themselves.

Mr. JONES. Yes, indeed.

Chairman PATMAN. And you state here:

An appalling lack of scientific instruction of any kind exists in our high schools—

and I believe you added:

most of our high schools—

and I believe if you had left it pretty well like you had it, it would have been all right. But that is exactly the problem.

Your testimony is very much appreciated.

Dr. Moore, would you like to ask some questions?

Mr. MOORE. Do you have in your industry much in-service training in the industrial plants?

Mr. JONES. Yes, indeed.

We are doing that in my own company very extensively. We have a man in the top group, in the staff group, who inspires and leads the subsidiaries and branches in doing that very thing, and we will be setting up central schools for that in self-defense, in our own selfish interest.

Mr. MOORE. The industry of electronics and instrumentation seems to me to be characterized by the survival of a lot of small businesses—or perhaps they should be called middle-sized businesses. The big corporations are of course in the electronics business, but at the machine tool show and the instrumentation exhibition I was surprised to find how many virile, active small companies that there seem to be. Would you agree with that?

Mr. JONES. That is a very true observation.

Mr. MOORE. To what would you attribute that? Is it the newness or the immaturity of the industry?

Mr. JONES. It is newness. A group of young engineers who get bright, new ideas, maybe two or thre or four of them, will start a business, and it will grow and flourish. Most of them, I must say, do run up against managerial and financial troubles after they get, say, to a million and a half or $2 million of sales, and come running to some other company, such as my own, for an umbrella. It is quite frightening sometimes. They come in almost every day.

Mr. MOORE. They have the ideas, but not the money of their own to push them through, and so they are forced to borrow?

Mr. JONES. Well, management is almost as much of a science as engineering. And an engineer coming out of school is not necessarily prepared for management.

Chairman PATMAN. Thank you very much, Mr. Jones.

We will stand in recess until 2 o'clock this afternoon here.

(Whereupon, at 11:45 a. m., a recess was taken until 2 p. m., of the same day.)

AFTERNOON SESSION

Chairman PATMAN. The Committee will come to order.

As our first witness this afternoon we have Dr. Howard L. Bevis, Chairman of the National Committee for the Development of Scientists and Engineers, president emeritus of Ohio State University, Columbus, Ohio.

We are delighted to have you, sir. And you may proceed in any way that you desire. You have a prepared statement, I believe.

STATEMENT OF DR. HOWARD L. BEVIS, CHAIRMAN OF THE NATIONAL COMMITTEE FOR THE DEVELOPMENT OF SCIENTISTS AND ENGINEERS, PRESIDENT EMERITUS OF OHIO STATE UNIVERSITY, COLUMBUS, OHIO

Mr. BEVIS. I have a prepared statement. If I may, I will just read it. And, then, if you have any questions afterward I will try to answer them.

My name is Howard L. Bevis. For 16½ years I was president of Ohio State University. On the 1st of August I retired and I am now emeritus.

I appear here today as Chairman of the President's National Committee for the Development of Scientists and Engineers.

The creation of this Committee was due, I believe, in part, to the work of your subcommittee which last year held extended hearings on the general subject of automation and technological change, and, in part, to the interest of the Price Subcommittee on Research and Development Needs, with respect to scientists and engineers.

The President appointed the Committee—that is, our Committee—to improve our situation with regard to the education and utilization of highly qualified scientists and engineers.

The President recognized that, although the Government—that is, the United States Government—has a responsibility for increasing the supply and improving the quality of our technological personnel, the chief responsibility for solution of the problem, and this is the President's language, lies in the concerted action of citizens and citizens' groups.

To show the variety of groups represented on our Committee, I shall name them: American Society for Engineering Education; American Council on Education; American Association of Land-Grant Colleges and State Universities; Engineers Joint Council; National Education Association; National Science Teachers Association; National Association of Secondary School Principals; National Association of Manufacturers; United States Chamber of Commerce; A. F. of L.-CIO; Governor's Conference, Council of State Governments; United States Conference of Mayors; Council of Chief State School Officers; Social Science Research Council; American Council of Learned Societies; American Association for the Advancement of Science; and National Academy of Sciences.

Each group is represented on our Committee through its president or other chief officer.

I might say, in passing, that if the term of one such officer ends, his successor becomes a member of our Committee.

In order to maintain continuity, we have tried to keep the first man in some sort of touch with us, but membership in the Committee consists of the heads of the organizations for the time being.

I understand that your committee is to review developments in the general area of automation and technological change which have occurred since hearings on this subject were held a year ago.

Dr. Detlev W. Bronk, who is president of the National Academy of Sciences and in that capacity a member of our Committee, is to testify, I understand, tomorrow on the need for trained scientists as research workers.

In view of this, I shall only briefly mention the problem of need. Primarily, I want to indicate who we are, and what we are trying to do, and how much progress we have made so far in trying doing it.

The role of engineers and scientists in our economy is well recognized. Technology plays an all-important role in maintaining a rising standard of living for our country and in our efforts to remain strong in terms of national security.

Because of this role of scientists and engineers, we believe the work of the National Committee to be of prime importance.

Expanding technology and an expanding economy are constantly producing increasing demands for highly qualified scientists and engineers. It is not enough to plan for presently estimated needs, for the demand for scientists and engineers will accelerate as new discoveries open up new areas for further exploration and application.

The supply of many types of scientists and engineers is insufficient to meet current needs and future requirements, both civilian and military. In America, the indispensable combination of qualitatively superior military and civilian technology can come only through free, voluntary research.

Such research requres men and women possessing highly developed professional skills with the opportunity and incentive to use those skills.

In approaching the task given us by the President we are faced with a number of basic facts.

Because of low birth rates during the depression, the number of college age youth has been for a number of years past at a low ebb. We are now in a period where college enrollments are rising because of the higher ratio of eligibles that go to college, but we shall soon be in a period where the total number of college age young people will increase. So we will have the higher ratio applied to a larger base, beginning about 1960.

The number of teachers is still being adversely affected by this period of low birth rates. They were born during the period of low birth rates.

Chairman PATMAN. What do you consider the low birth era, about 1929 to 1942?

Mr. BEVIS. 1930, shall we say, to about 1941.

Chairman PATMAN. 1930 to 1941? Roughly about 10 years.

Mr. BEVIS. Roughly during the decade of the thirties.

Chairman PATMAN. That is right, yes, sir.

Mr. BEVIS. We must wait for those now in college to graduate before we can count on a real increase in the number of teachers.

That is a very real factor in our problem, how to find enough qualified teachers to take care of the increased numbers of students.

The rise in college enrollments is due not only to the fact that we are leaving the period when enrollments were being held down by low birth rates, but, also, because a higher proportion of young persons desire a college education. And increased family income enables more to go to college than in the preceding decade.

Added enrollments in the years ahead will put more strain on existing teacher shortages. In many schools, faculties and facilities already are inadequate for handling present enrollments.

Of course, we expect the enrollments to go up.

This committee is specifically charged with the responsibility for increasing the supply of engineers and scientists. Nevertheless it is, I want to register this note, important to increase the supply of highly qualified persons in all fields. We do not want to create an imbalance in education.

Sometimes there has been a suggestion that we are trying to raid other disciplines to get more scientists and engineers. That is not what we want to do. We want more scientists and engineers, but we also need more economists, more Government people, more philosophers, perhaps more poets.

The President in creating our Committee stated that it was an action group. He asked specifically that we do four things:

1. Assist the Federal Government in identifying the problems associated with the development of more highly qualified scientists and engineers.

2. Enlist the cooperation of all interested individuals and groups in analyzing the problem and developing programs to deal with it, and to take the lead in coordination of interested organizations outside the Federal Government.

3. Make available to all interested organizations information on effective ways of overcoming the obstacles to the training of more qualified scientists and engineers.

4. Publicize the problem and possible solutions in order to stimulate widespread public understanding and support.

Our first job was to identify the scope and character of our problems. It quickly became apparent that the problems were too many, and too diverse, for us to approach them all simultaneously. We had to set some priorities.

We have tried to stimulate action by local private groups. I have already pointed out the wide representation on our Committee. Because of this membership, we have been able to get help—effective help, very quickly.

In addition, because of the national interest in our problems, many local, State, and National groups have voluntarily offered their assistance. This has been invaluable.

Some groups, for example, have helped to publicize our problems and our efforts. One valuable form of cooperation has been for specific groups to lend us highly qualified persons for a short time.

It is in the area of local action that we believe we can make the most significant contributions. There are at present a number of efforts at the State and local levels that show what can be done when local groups—educators, industry, labor, government—attack a problem.

A notable example is found in Oklahoma. In this State a Foundation has been established, called Frontiers of Science, to raise the level of scientific knowledge and to increase the supply of competent scientific personnel.

I met with this group recently and was impressed by the wide scope and the effectiveness of their program. Other areas getting started along similar lines include some in North Carolina, New Jersey, Detroit, Cleveland, New Orleans, Pittsburg, Boston, and Milwaukee and other places.

The problems being attacked by these local groups include:

1. Improving facilities for teaching.
2. Providing more science and mathematics teachers.
3. Improving the technical training of such teachers.
4. Providing summer employment to enable teachers to acquire additional experience and at the same time increased earnings.
5. Upgrading teachers.
6. Improving teaching methods.
7. Stimulating student interest in science and mathematics.
8. Counseling students.
9. Improving curricula.

Stimulating State and local groups in getting started is a significant part of the work we are doing.

Such local-action groups need help—particularly in the form of ideas and organizational guidance. We are documenting experiences and ideas that have proved locally effective. These we are passing on to other local groups and organizations. We are formulating a general plan of attack.

As the Committee has come to grips with its problems, it has become apparent that we need to know more about the occupations and areas where shortages now exist and about the future outlook.

In cooperation with the Department of Labor and the National Science Foundation, programs are now going forward that will provide on a continuing basis the kind of labor market data that we need.

A representative of the Department of Labor recently met with the national Committee to present an appraisal of the existing situation and of anticipated future developments.

This material will be available in printed form in a few days. If this subcommittee so desires, I should be pleased to submit it as soon as it is ready.

It takes time to train an engineer or a scientist. About the only way to do something constructive immediately to ease existing shortages is to make more effective use of what we have.

One of our Committee's first acts was to appoint a task force to study the fuller use of technical aids to scientists and engineers.

This group, after careful study and analysis, has developed a program to assist industry in utilizing technical aids. As a result of this work we now have another task force working on the problem of improving the curriculums of technical schools.

Similar efforts are now being directed toward two other problems:

1. The adequacy of salary levels for scientists and engineers; and
2. The improved utilization of scientists and engineers.

In both of these cases the work is exploratory—designed primarily to ascertain whether it might be fruitful to setup task forces.

We also have a task force on the problem of improving science and mathematical education in elementary and secondary schools.

A proposed program of action has been developed. Primarily, action must come from the States and communities, but the program developed by this task force will be helpful to them.

A fundamental requirement for the Committee's success is the achievement of public understanding. Support and cooperation are necessary from industry, labor, scientists, and engineers, teachers, parents, and students, as well as from the general public.

Efforts to secure this support through publicizing our programs is being directed to the individual citizen through his local organizations.

Direct participation of individual citizens and local organizations will generate local news and community interest. The Committee's function in this area, we believe, is to supply the basic information with which others can carry out the major publicizing activity through established facilities and channels.

I hope that this brief statement will give you some idea of our problems and how we are approaching them.

I want to express my appreciation to this subcommittee for giving me the opportunity to tell you about the National Committee and the work that we are trying o do. I shall, of course, be glad to respond to any questions.

Chairman PATMAN. I would like to ask you, Dr. Bevis, what is the relationship of the National Committee for the Development of Scientists and Engineers, to the National Science Foundation?

Mr. BEVIS. Well, the Natlonal Science Foundation is very broad in scope. It is primarily concerned with the development of a national policy for the promotion of basic research and education in the sciences. It is, too, I take it, a contributing body of indefinite duration.

Our committee has as its objective the development of scientists and engineers, a very much narrower point of attack. The National Science Foundation Cooperates with us in our work, particularly by providing us with staff assistance and assists us in dealing with Federal agencies. And while we have no terminal date, I take it that it is obvious that our committee is not supposed to go on forever.

We will try to do our job in a reasonable length of time. And presumably, we will go out of existence. The National Committee is the focal point for developing action programs and for getting these programs working through organizations of private individuals.

But our point of attack is a small sector of the ground that is covered by the Science Foundation.

Chairman PATMAN. What is the relationship of your committee to the President's Committee on Education Beyond the High School?

Mr. BEVIS. Well, the President's Committee on Education Beyond the High School has a twofold function: first, to stimulate informed public discussion that will lead to action and, second, to make useful recommendations to guide citizens' action in cooperation with institutions and governments to reduce some of the major educational problems beyond high school. The President's Committee is concerned with educational problems of all persons after high school, whereas our National Committee is specifically charged with increasing the supply of scientists and engineers. Many of our efforts, for example, are directed at problems of the secondary and even the primary school level.

Chairman PATMAN. Would you comment on the success of Russia in the training of scientists, engineers, and technicians, Dr. Bevis?

Mr. BEVIS. Well, I think we have to recognize that the Russians have laid out for themselves a very significant program. They did it a good while ago, maybe thirty or more years.

They set up a vast apparatus for training technological people. The leaders of Russia, have grasped the significance of technological production. They are no longer depending on the geographical frontier. They are also looking toward the scientific technological frontier.

And so they set up a system of schools for technological training. From the ages of 14 to 17 all students devote about 40 percent of their time to physics, chemistry and mathematics. In addition they have taken measures to make science and engineering vocationally attractive. The living standards for both the teachers and the graduates in these fields are better than those of most people, relatively better in fact, than our engineers enjoy, I do not think their living standards are as good as ours, but theirs is higher than the rest of the Russian people; relatively higher than the living standards of our scientists and engineers compared with the rest of the people.

We know a few things about the Russians. They are apparently turning out now more technical graduates than we are. We do not know too much about how good those graduates are.

And I do not think we know, either, too much about how relatively efficient in the production process, a given number of Russian engineers may be.

But we do know this, they are putting out some pretty good ships, some pretty good planes. They have nuclear apparatus.

I do not think we can afford to sit by and assume that we shall continue to be better. I think we are better than they are now, but if we do not move ahead there is a possibility that they may pass us.

There is one more thing I would like to say about Russia. I believe they have passed the stage where they need to rely on foreign help. I think there was a time when they needed German scientists and German engineers. I believe they have reached the stage now where they can go on their own without such help.

Chairman PATMAN. Dr. Bevis, I believe that we all feel that President Eisenhower should be commended for setting up this Committee. I certainly feel that way about it.

And if you think it is all right, I would like to have inserted in the record at this point the President's charge to the Committee, which is addressed to you.

Mr. BEVIS. Yes, sir.

Chairman PATMAN. From the White House of April 3d.

Mr. BEVIS. I will be very happy to have you do that.

Chairman PATMAN. I will insert it in the record at this point.

(The President's charge is as follows:)

THE PRESIDENT'S CHARGE TO THE COMMITTEE

THE WHITE HOUSE,
April 3, 1956.

DEAR DR. BEVIS: For the last several years there has been a growing awareness within the Government and among private citizens in general that as a result of our continuing shortages of highly qualified scientists and engineers we are running the danger of losing the position of technological preeminence we have long held in the world.

Because of my own concern with this situation, I established some time ago a special interdepartmental committee to make an intensive study of the situation. This committee has now made recommendations to me on actions which might appropriately be taken by the Federal Government to improve our relative position.

At the same time, the special committee pointed out that the problem of increasing our supply of qualified scientists and engineers cannot be solved by Government alone. The committee wisely recognized that the problem required for its solution the powerful and concerted action of citizens and citizens' groups organized to act effectively.

As its major recommendations, therefore, the special committee urged that I establish a National Committee for the Development of Scientists and Engineers. They proposed that this be an action group, representative of major citizens organizations concerned with the education, training, and utilization of scientific and engineering personel. This group would consider ways of fostering the further development of scientists and engineers and would in all appropriate ways take action to promote a substantial growth in the supply of scientific and technological manpower.

I have accepted the recommendation of the special committee and I am establishing the National Committee which has been proposed.

It is my hope that the Committee will—

1. Assist the Federal Government in identifying the problems associated with the development of more highly qualified scientists and engineers.
2. Enlist the cooperation of all interested individuals and groups in analyzing the problem and developing programs to deal with it, and to take the lead in coordination of interested organizations outside the Federal Government.
3. Make available to all interested organizations information on effective ways of overcoming the obstacles to the training of more qualified scientists and engineers.
4. Publicize the problem and possible solutions in order to stimulate widespread public understanding and support.
5. Provide me, from time to time, with a report of progress.

It gives me a great deal of satisfaction to appoint you Chairman of this Committee. Under your leadership, I am convinced that this group can make a major and timely contribution to the economic and social welfare of the Nation and to the national security as well.

Sincerely,

DWIGHT D. EISENHOWER.

Dr. HOWARD LANDIS BEVIS,
President, Ohio State University, Columbus, Ohio.

Chairman PATMAN. Thank you again very much, Doctor Bevis.

Mr. BEVIS. Thank you, sir.

Chairman PATMAN. Dr. Moore, suppose you read into the record an introduction for our next witness.

Mr. MOORE. Dr. John J. Grebe has been a member of the Dow organization since 1924, where he served as director of the physical research laboratories since 1949. He holds more than 50 patents in electrochemistry, power generation, synthesis of organic compounds, and air conditioning, and is the author of numerous articles in scientific journals. He was a consultant in the Office of the Rubber Director during World War I and civilian observer at the Bikini tests. From 1948 to 1949 he served as chief technical adviser to the Chief of the Army Chemical Corps. In 1953 he was appointed to the position of director of nuclear and basic research department of the Dow Chemical Co. This department is currently engaged in a very diversified program in research. Dr. Grebe.

Chairman PATMAN. We are very glad to have you, sir. And you may proceed in your own way.

STATEMENT OF DR. JOHN GREBE, DIRECTOR, RESEARCH AND NUCLEAR DEVELOPMENT, DOW CHEMICAL CO., MIDLAND, MICH.

Mr. GREBE. Thank you very much, Mr. Chairman.

This subject of automation is one dear to my heart, for back in the 1920's a group of my associates and I devised some of the first automation instruments to be applied to the chemical industry.

I well remember the struggles we went through to design the instruments and to test them and eventually to find the manufacturers who would and could build them for us. We are still working hard on new and vital instrumentation research.

May I digress for one moment to say your work so far, the Report of the Joint Committee on the Economic Report to the Congress of the United States of January 5, 1956, is a wonderfully sound statement of the problems to be solved. It emphasizes that education, the development of our human resources, is the most important single problem facing us as a nation.

May I explain what automation means to me? We have had automatic machines for many years, particularly in hydraulic turbine speed control. These machines did a job automatically which in former times a man would do manually.

Now the difference is that complete automation replaces the operator of the automatic machine with a device that observes or feels the variants to be controlled and makes the proper adjustments so that the automatic machine regularly operates in proper balance.

This eliminates much human error. I do not mean that it creates unemployment, for, as I later point out, it is quite the reverse, but it does make it possible to do with machines what human beings could not do quickly and accurately enough, nor continuously.

The chemical and the petroleum industries are outstanding examples of the application of instruments and controls to increase productivity and to maintain product quality.

You will forgive a reference to my own company as an example, but my company is typical, I believe, of a very diversified chemical operation. To this degree it can serve as a good cross section or example of chemical industry methods of manufacture and automatic control.

Our chief chemical raw materials are water, salt, oil and coal. Water is brought a distance of 75 miles, from Lake Huron. The salt, as a brine, is pumped from deep wells. Coal, as the energy source, is transformed by boilers and condensing turbines into electrical energy and process heat.

Power and chemical people well understand that water is not a simple substance, but rather H_2O complicated by a vast complex of impurities. Even the term "pure water" has a meaning dependent on the application.

The elaborate plant installed to treat the process and powerplant water at Midland cost over $1 million. Mechanically, it is a complex aggregate of tanks, pipes, valves, and pumps.

Operationally, it is almost completely automatic. A central control room receives signals of measured quantities from all parts of the system. Changes in all the important variables such as impurities, flow rates, et cetera, are transmitted and recorded automatically.

The control instruments then send back orders to servomechanisms which open and close valves, adjust weights, pressures, temperatures, and so on.

Practically no brawn is required in a plant of this sort, only complex mechanism and enough brains to run it. A single operator, backed up by maintenance crews, keeps the production on the beam.

In the powerplant we find another complex assemblage of instruments and controls. These measure temperatures and the chemical constituents of the stack gas, temperature of water fed to boiler, pressure and temperature of the steam produced, the precise speed of the turbine, et cetera.

They control and allocate loads on the various machines, watch bearings for overheating, check condensers for leaks, and so on.

All this is only a start. Let us look at an average chemical plant. To a large degree it consists of fluid transportation—liquids and gases—flowing through a system of piping and tanks. At hundreds of points, instrumentation must measure and adjust pressure, temperature, flow rate, and composition.

Some of the more complex processes require controls that will replace and improve on human judgment. The central brain receives signals from many instruments and meters. It studies their relative values and tests them against prescribed criteria built into the machine.

From these it reaches decisions on what's to be done, sends out electronically the orders to servomechanisms, which execute these orders.

Finally, another device, known as feedback, reports the extent to which the ordered action failed to create the effect desired. The central brain then sends out corrective reorders.

This feedback is the mechanical equivalent of what one does in driving a car around a curve. As one enters the curve, he turns the wheel an estimated amount. This is never exactly right. His eye notes the car edging toward the shoulder or toward the center and feeds back, or relays, this information to the brain which then estimates the required correction and signals the steering arm to turn the wheel slightly left or right.

Thus, in industrial apparatus, fluid chemical systems, or aggregates of pipes, tanks, valves and pumps, the direct sensing and controlling elements are connected to meters, valves, and pump motor controls on pumps, to produce the desired changes.

With these examples in mind we can then proceed to look into the additional operations existing in a chemical plant. We can find instrumentation for recording and controlling such basic operations as crushing, grinding, filtering, precipitating, distilling, evaporating, crystallizing, et cetera, which result in a more uniform product, a reduction in product cost, and an increase in product quality.

A large and constantly growing percentage of the money spent on new plants of many chemical companies go for advanced instrumentation. This year there will be spent many millions of dollars on instruments of all types, including the highest percentage ever for automatic control components.

The importance of instruments to today's plant is shown by the fact that a moderately sized manufacturing plant in the chemical industry will use from 5 up to 20 percent of its cost for instrumentation.

In addition to our outside purchases of instruments that meet our normal demand and needs, we spend a substantial part of our research dollar on the engineering, design, and fabrication of special purpose instruments.

About one-third of the work at testing and engineering laboratories is devoted to research on automatic control components.

The chemical industry, as a whole, is more dependent on automatic control than any other large industry. We won our spurs in our industry by doing things automatically that could not be done otherwise.

It might be of interest to enlarge on this point, but time would not permit.

Keeping track of hundreds of variables and making necessary process adjustments in time and with safety, is a job which can be handled only by automatic control. In the long run, automatic control, like every other technological improvement, will stimulate employment.

The whole field of nucleonics is a special case of an industry entirely dependent upon instrumentation. Except for the discovery at the University of Michigan that the water spider somehow senses and knows enough to dodge gamma radiations, we know of no living organism that is directly sensitive to nuclear radiations, unless the rays are intense enough to produce "sensible heat," or obvious physical damage.

Indirect sensing through instruments, however, has made possible an extension into qualitative and quantitative analysis that was undreamed of before the invention of the Geiger counter.

It, and its many counterparts and improvements, is capable of telling us things about a few atoms out of the 10^{24}—that is millions of millions of millions of millions, beyond comprehension—(10 with 23 ciphers behind it) number of atoms in an ounce of water.

The growth of this industry will continue to follow the lead of automation, particularly the segment consisting of instrumentation, because it is difficult to depend on human beings to do the right thing when they cannot directly see, hear, feel, taste or smell any of the things that are going on behind the necessary shielding.

So when you go to see a nuclear development anywhere, you can recognize without instrumentation it could not be. It is just that positive.

For a concrete example in productivity, let's look at the experience of one chemical company.

In the past 10 years, its total employment has doubled, but the physical output has increased more than fourfold.

Year	Employment	Output as reported	Output at 1946 values
1946	13,500 men	$101,000,000	$101,000,000
1956	28,072 men	565,000,000	420,000,00

Even figuring in 1946 values the output has more than increased 4 times in 10 years with roughly double the number of men.

These same 10 years have seen increasing use of instrumentation. During this period, automatic control equipment was used on a large percentage of its manufacturing processes.

This resulted in a reduction in the amount of direct operating labor. This was not all net gain in efficiency, however.

It required skilled workers to make and install the control instruments and other highly skilled maintenance men. Many of the former operators have been upgraded to these maintenance jobs.

In the chemical industry, the instrument groups search the world for the best instruments they can find, and they are encouraged to use vision in planning for the future. They are also encouraged to develop new special instruments not on the market. The total of men employed in this field is large indeed, running surely into the thousands.

There is one additional subject that is most difficult to present. It is bound to be misunderstood and raise hard feelings.

We have been speaking about productivity in our industrial output. We have been thankful that our engineers and scientists have made it possible for our nation to increase its material conversion by a factor of two, every 25 years, but on the effort of converting human resources we have had no similar increase in efficiency. Some even say a decline.

This is well presented by one of our colleagues in instrumentation, Dr. Arnold O. Beckman, in U. S. News and World Report, November 30, 1956. I think it was referred to this morning.

There are, however, many examples of the very best in educational methods and facilities that have reduced the man-hours required to accomplish definite objectives in educating, training, and broadening individuals.

The newest methods and facilities have in common the objective of making higher paid teachers free to be a friend and inspiration to the students, leaving all formal presentations to what the best lecturers can do with films; and the giving of tests, grading, and bookkeeping to machines and student assistants and other nonprofessional people.

The full utilization of such technology would greatly increase the flexibility of our educational systems, making it possible to keep all students challenged sufficiently to maintain keen interest without overtaxing and discouraging them.

Much of the new and better is being introduced by private and corporate sponsorships. Examples of this type can be found all the way from Ding Dong School, Mr. Wizard, Our Mr. Sun, and other TV programs, as well as interesting church, and Boy and Girl Scout activities, little leagues, on-the-job-training, contest, camps, civic activities, on through the methods of graduate schools.

Graduate schools give an excellent example of what is needed.

Movies, educational toys, models, and hobby shops accomplish wonders. Museums, like the Rosenwald Museum of Science and Industry at Chicago, are most important. The really great developments in these fields, however, are still to be made.

We have not started yet.

The best example of what has been, and should be done, is given by our Armed Forces. The military services improved on old practices in selecting men by a factor of two during World War I; again, they doubled the efficiency of utilization of the men in World War II.

Now we need another doubling to make the 2 years of service the most worthwhile, the most broadening and educational, in the lives of our youths. It is being done by the military in spots.

The S. P. P. program, which uses specialized professional personnel in the armed service at the level and on the jobs that fit the training the men have had, is of tremendous value. They apply the experience they have had, and extend their training by research and development, in badly needed fields of activity.

For example, some of the most highly specialized work in the services is being carried out by draftees in the United States Army Chemical Corps, at its various installations. Seminars are held by the men to broaden their interests and education. Their physical training and buildup is also much appreciated.

An inventory of the capabilities of a person before and after military service could, and should, show a rounding out of personality and experience that cannot be attained in any other organization.

Measuring this effort and accomplishment alone would lead to new demands being supplied and balanced out in new ways to meet the needs of the complete man.

It is an automatic control technology using instruments that may not yet have become a part of the recognized field of instrumentation and automation.

I have talked to many men who were proud of the way the services used them, and thankful for the training. This can and must become the rule for all service men and women, if we are to keep up with the pace set in many specific instances by the rest of the world.

On the other hand, there may be many sergeants, who would say with the Scotsman, philosophizing: "If it gives you pleasure, it's a sin."

Next, we need better motivation for human advancement that will reach more people. The living standard of the average American is on a par with that of the upper fraction in most other countries.

Hence there is less incentive for the average individual to try to improve himself. The young Russian shift workers who work at night and study college texts in the library during the day have two incentives that we do not have. They must make more of themselves, in order to rise above, in freedom and self-expression, the lot of a serf, and second, to gain the differential in pay and privileges accorded for increased responsibilities.

We have all but lost differential pay incentive in our country, and are thankful that the hunger for freedom is so strange to us that it is hard for us to understand.

And so three-fourths of our young people quit school too early, to reap the benefits produced by the other fourth, who develop themselves further.

Finding and thoroughly establishing a good method of human motivation, and better methods of education, can be the key to the success of attaining our needs in the development of our human resources.

One possibility is to develop a movie presentation of the growth of man, showing how from early youth an individual gradually fills out great fields of knowledge and capabilities in reflexes, thought, and feeling in all the lines of human abilities.

One first develops physically, extending coordination, muscular strength and endurance, in this wide plane of possible applications. It is the first tier of a great pyramid that one builds of himself.

Next, there is communication in many ways, including speech, vocabulary, languages, and the like. Finally, one broadens into many other fields, such as music, mathematics, art science, religion, and the many specialized fields of human activity and employment.

At best, a person is "well-rounded," much like a Christmas tree that grew uniformly and completely.

However, no one can possibly extend his background, training, and abilities in any one plane without sacrificing somewhere else. When the going gets tough in one direction on one plane, there are all the other tiers to work on.

Of the total range of human capabilities, one could not hope to attain more than a few percent. Having a clear picture at any age, of what one has attained and some inkling also of what one might attain currently, would help all of us appreciate one another more—and also, to understand our own limitations.

Growing tall and rounding out and bearing much fruit on specific branches could become a greater motivation for self-improvement than any other inducement that we have left.

A beautiful illustration of the national need for this was presented by Dr. de Bordenave, at the celebration of the 250th birthday anniversary of Benjamin Franklin.

I am sure Walt Disney and Cecil B. De Mille would not shy from this job, even if it had to be done in 10 stages to be understood by all the different levels of maturity.

Here is a copy, if you should care to refer to it further.

(The document is as follows:)

[Reprinted from Journal of the Franklin Institute, January 1956]

OUR POLITICAL CRISIS—AND FAITH

(By the Reverend Ernest A. de Bordenave,[1] Christ Church)

FOREWORD

"Benjamin Franklin was a religious man who practiced his religion through tolerance, unselfish service, and love of his fellowman. Since he attended Christ Church and is buried in its grounds, we hope that you, the present rector of Christ Church, will prepare a paper on religion for our Franklin issue. The title, 'Faith—the Crystallization of Our Hopes' is listed on the attached plan, but this is only a suggested title and you are free to change it at will. We visualize this paper not so much a record of Franklin's religious beliefs as a history of the changing practices of religion during the past 250 years."

This is one paragraph of the letter from the editor of the Journal of The Franklin Institute, Dr. Henry B. Allen, inviting me to write this article and indicating its nature.

According to the invitation, and I hope, in the spirit of Benjamin Franklin, the title has been changed and the content of the paper attempts to deal with the deepest problem facing man today—himself and his political behavior.

Direct quotations, footnotes, appendixes, and bibliography have been purposely omitted in the hope that this paper may be read by others than scholars, who do not need such.

Although my indebtedness to the works of others is much greater than can be listed, it is hereby humbly and gratefully acknowledged. There is a special indebtedness to a series of lectures entitled "Christianty and the Crisis of Secularism," given by the Reverend A. T. Mollegen, S. T. M., D. D., in the Washington Cathedral Library in 1950 and 1951.

It is a privileges and honor to have this participation in the 250th anniversary of Franklin's birth, especially so since I am no longer the rector of Christ Church in Philadelphia. For this privilege and honor I thank Dr. Allen and the Franklin Institute.

E. A. DE BORDENAVE.

MIDDLEBURG, VA., *May 1955.*

The political crisis of our time is the split between the so-called free nations and those nations that are dominated by Soviet Russia. This crisis is so acute that at best it will keep us living under the threat of war for years ot come. At worst it will plunge us into an armed conflict that will threaten the survival of man's civilization, if not the existence of man himself in many parts of the world. Our thinking and writing cannot but be aimed at a resolution of this conflict, assuming a resolution is possible. If history proves a resolution not to have been possible, then our thinking and writing should have helped to prepare us to stand fast when the deluge comes. This paper, therefore, has as its purpose to help us understand the crisis of our time and to help us meet it, no matter how it confronts us.

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[1] Rector of Christ Church, Philadelphia, Pa., 1950–55.

A first thing to note about our political crisis is that the split is not between East and West. It is a split within western civilization itself. Secondly, it is not a crisis that was created in our time, rather it roots deeply in the development of western civilization. Its origins can be traced back 250 years to Benjamin Franklin's time—and back further still. In fact, the political crisis with which Franklin wrestled was only one phase in the development of the crisis with which we wrestle. Our crisis began with what is commonly called the modern period of the West. It cannot be understood with any profoundity except as it is understood in its context of the developing modern period of western civilization.

Therefore, our first task is to try to trace out the rise of our political crisis. Only after we have done that can we talk with relevance about faith and about the relevance of faith to the political crisis of our day.

The simplest way to trace this development is in terms of he major ideas that have marked the turning points. If anyone objects that ideas are too abstract a route to pursue, he needs only to be reminded of how seriously the ideas of one man, Karl Marx, have affected the life of all of us, and Marx has been dead only 73 years. Ideas furnish us as good an understanding of what has happened as can be had from any other source.

I

We must begin with the Middle Ages.

For a long time man's thinking about himself and his world had been dominated by concepts that had come into the Christian Church from Greek philosophy. These emphasized a great and unbridgeable contrast between good and evil and between the spiritual and the material. That which is good was identified with that which is spiritual. That which is evil was identified with that which is material or physical.

Since man is both spiritual and physical, hence both good and evil, he was confronted by a serious problem: how to be free from evil? This problem could be solved only by his getting away from the physical, even from the physical which was a part of himself. This would happen to him finally at death but in the meantime he was told that he could get partly away from the physical and its concomitant evil by losing himself in contemplation, meditation, prayer, and other mystical practices.

Man's attitude toward the physical, material, universe was determined by this dualistic understanding of the universe. He felt that anything physical or material was his foe. It was something alien to his true being, which was good. Man felt that physical nature was his enemy, something to be escaped from or to be delivered from. His only interest in the material world was to get away from it. This attitude toward the material and physical world is always characteristic of all people whose culture is informed by a mystical religion.

In the West, however, a change had begun to take place by the beginning of the 13th century. St. Francis of Assisi (1182–1226) affords us a good example of this change. The material world had ceased to be man's foe. For St. Francis all of nature was his friend; it was not to be shunned but to be courted and loved. The birds and bees, the flowers and trees, the sun and the moon—all of these were objects of St. Francis' affection.

This was a new attitude toward nature. It was the result of the Hebraic-Christian idea of creation overcoming the Greek idea of an irreconcilable dualism. A few men began to assert that God had created all things, therefore they must be good—these include material things, which are essentially good and not evil. Nature is to be taken unto man, because it is God's nature. It is not alien to man. It is a part of God's creation and man is a part of nature and all of it is God's.

This victory of the Biblical idea of nature over the Greek idea was of the utmost importance to the development of western civilization. No longer was it necessary for man to flee from nature; now he could turn his face toward nature. He could ask questions about it. Indeed, he should ask questions about it, because it was God's nature.

It should be noted that this was not the position of those who governed the church at Rome. This attitude arose primarily among the Franciscans, but St. Francis had trouble with the authorities at Rome. It made no difference, however, because these new ideas were abroad in the church and they could not be stopped.

Here was an important turning point in the development of western civilization: when the Biblical idea of creation emerged victorious over the Greek idea. It was this victory of the Biblical attitude toward nature which made possible the whole development of empirical science. It is no accident that science as we know it did not develop in any other culture. It could develop only in the West where the influence of the Hebraic-Christian attitude toward the material universe became the dominant one. This was the first turning point of western civilization into its modern period.

II

Nicholas Copernicus (1473–1543) was a canon of the Cathedral in Frauenburg, in East Prussia. He also practiced medicine and speculated about astronomy. He reduced his theories to writing in a treatise entitled "De revolutionibus orbium coelestium" and stated therein his conviction that the sun is the center of a great system of heavenly bodies, and the earth is only one of several planets that revolve around the sun.

This treatise was probably finished by the year 1530. But the church officially frowned on any idea that intimated that the earth is not the center of the universe, hence Copernicus would not publish his treatise. It was not finally published until 1543 when he lay on his deathbed. Nevertheless, this new idea of Copernicus became the foundation upon which modern astronomy has been built.

Galileo (1564–1642) attempted to demonstrate the truth of the theories of Copernicus and had some success. It was Galileo's persistent investigations of the laws of nature that laid the foundation for modern experimental science. Like Copernicus, Galileo was called on the carpet by the authorities of the church at Rome. He assured those authorities that there was no intention on his part to undermine or contradict the teachings of the church. He was confident in his own mind that truth discovered by experimental science was God's truth, which man could accept with confidence. It was truth about God's creation. So, in spite of the church's pressure upon him to desist from his researches, Galileo continued his experimental investigations until his death.

One of the most significant results of Galileo's work was his distinguishing between those properties of matter which can be reduced to mathematical formulas and those properties which are known through the senses. He argued that the properties such as weight, volume, size, and speed of physical nature could be reduced to mathematical formulas and thus be known by man in a precise way. These facts could be discovered by patient, scientific inquiry and be known exactly. On the other hand, the taste, smell, color sound or feel of physical objects, which are perceived through man's senses, cannot be reduced to mathematical formulas and this means that knowledge of these properties of physical nature cannot be exact knowledge. The sun, for instance, appears to man's sense to move across the sky each day but this could be demonstrated not to be the case.

Galileo thus created a distrust of knowledge that is known through the senses and which cannot be reduced to mathematical formulas. He also established a new kind of cleavage between the knowing subject and the known object; and he opened the way for the doubt that the knowing subject can really know the object. Thus, he opened the way for doubts and questionings about all knowledge.

Needless to say, the procedure of gaining knowledge by applying doubts and questionings was not acceptable to the Church but it could not be stopped. The procedure of doubting and questioning was adopted as the new path to new discoveries, and it was indeed a fruitful path. The more serious the doubt and the more rigorous the questioning, the more sound the answers, it was thought.

René Descartes (1596–1650) was a brilliant man who breathed this atmosphere. Although he was a mathematician he was also a philosopher who applied the principle of doubt and questioning to everything. He rigorously doubted that anything existed. He wrestled with the implications of this complete doubt and concluded that he had to grant that the doubt itself existed, and if the doubt existed, then the existence of the one who doubted had to be admitted. Thus he came to his famous statement, "cogito ergo sum"—I think therefore I am.

That which is primary to all existence therefore became the human mind, the rational faculty, man's power of reason. Human reason is basic and is the bar before which all other existences must be tried. Nothing could be accepted as having existence unless and until it so confronted human reason that it had to be accepted by that reason. God so confronts human reason, said Descartes, hence God has existence. God is to be trusted, He will not fool people. The outside world, the physical universe which appears to exist, therefore can be accepted as actually existing. So, Descartes gives us the knowing mind, God, and the physical universe, as having existence.

Here we come to the second great turning point as western civilization moved into its modern period and form. It occurred whtn Descartes made human mind, human reason, the basis of everything that exists. The human mind takes precedence over God. In fact, it decides whether or not God exists. Human reason becomes the final arbiter, the primary existence.

Although Descartes, like Galileo, had no intentions of upsetting the faith of historic Christianity, he did in fact turn it upside down and it has not yet wholly succeeded in righting itself. The God of the Hebrew-Christian faith is the ground of all being. He is the Creator and judge, the beginning and the end, of all existence. His existence makes possible man's existence and the existence of man's reason itself, which is part of man's being. Man is related to God whether he likes it or not and whether he knows it or not. God is Being itself.

Descartes changed all this. Man's mind became the basis of all existence. Man put his final trust in human reason and its judgment. Man's reason is trusted to determine even God's existence. Here, man's reason becomes God, in the sense that man places his final trust in it. Man's faith has a new object. It is no longer the God of the Hebrew-Christian tradition, the God who is Being itself. Man's faith is in a new God, human reason. Reason is trusted in all things and trusted ultimately.

This new kind of ultimate faith in human reason began with Descartes. Although it is thus not more than 300 years old, its influence in the succeeding centuries of western civilization cannot be overstated. Had one been able to have foreseen in Descartes' day how great this influence would have been, such a one could have foretold the present political split in the West, which is the crisis of our time. That split roots in Western man putting ultimate faith in human reason. One side of the split puts its ultimate faith in collectve human reason. The other side has put its ultimate faith in individual human reason. In both sides, however, it is ultimate faith in something less than God, therefore both sides are putting ultimate faith in a false god. And false gods always betray those who worship them.

III

Descartes was a century ahead of Benjamin Franklin, whose life was contemporaneous with the early settlements in the American colonies. The citizens of those colonies had few books and little time for reading. They had the task of conquering the trials and hardships of a wild frontier. They were laying foundations upon which a new society would be constructed. Not many Americans of the 17th century ever heard of Descartes, but his influence was working itself out in Europe. It is, for instance, in the materialism of Thomas Hobbes (1588–1679) and in the reaction to him of the Cambridge Platonists. It was affecting the intellectuals of Europe even though it had little influence in America before the 18th century.

John Locke (1632–1704) was the person of the 17th century who probably had more influence on the century of Franklin than any other one person. Locke was the apostle of "common sense." He seems to have taken the position that any problem which could not be solved by common sense was not worth worrying about.

By the use of common sense Locke proved the existence of God. He observed that everything that happens in nature is caused by something that preceded it and caused it. The chain of effects and their causes cannot be endless as one traces them back. There had to be a "First Cause," and this was God.

So God became the "First Cause" who set in motion the endless chains of causes and effects, and who has nothing more to do with the processes of nature. Locke recognized that this God had disclosed Himself by revelation but this was only for the illiterate masses of men. Those whose common sense was mature, like Locke's, did not need revelation. In fact, they had to use their reason to decide whether revelation was true or not. The subject to be studied was nature and this would reveal to man's reason the processes begun by nature's God.

Thus John Locke is the turning point into the 18th century when nature was relied on so heavily. Locke died just 2 years before Franklin was born.

David Hume (1711–76) took seriously the empiricism of Descartes and Locke. They had insisted that the only true knowledge of external reality was gained through empirical science and was expressible in mathematical formulas. Hume analyzed the knowledge thus gained and raised the doubt that there was any necessary correlation between the "knowledge" thus accepted by human reason and the external objects that are thus known. Hume says Descartes only proved that there is an idea of a self that experiences unknown and probably unknowable reality. Thus Hume shatters Descartes' assurance of the existence of the self, and any assurance of the existence of God and the physical world.

Immanuel Kant (1724–1804) was shocked by Hume's work, though he had to admit the validity of his arguments. He recognized the impossibility of arriving at knowledge through pure reason which was consciously or unconsciously presupposing the existence of a God who is knowable by man's reason. Kant said that this is not the way man knows God. Instead of knowing God by reason, Kant says that man knows God by the sense of obligation to do the right which is implanted in every man. The right is whatever a man would agree is right for every other man to do in the same situation. Man can know what is the right and therefore it can be asserted that since man can know the right, he also can do the right. And there is implanted in every man the sense that he ought to do the right. It is this sense of "ought" where God is known. God is the author of man's sense of "ought to do the right." God is the author of man's rule of behavior and the Rewarder of the men who obey His rules.

Thus with Kant, not only does God degenerate into a giver-of-rules of conduct but Christianity itself ceases to be an intellectual matter. It is now a moral matter, a matter of enunciating rules of behavior and living by them, in the assurance that God rewards those who do this.

Locke and Kant together give us the religious atmosphere that dominated the 18th century. The God who was the "First Cause," who began the processes of nature, cannot be known by man, nor does man need to know Him. Man studies nature, which is the resulting cause and effect sequences flowing from the First Cause. But this remote God is not absolutely indifferent to man. He makes man have a sense of ought-to-do-the-right and has somehow ordered causes and effects so that men who do the right are rewarded. It remained for man to work out his codes of conduct and live according to them. Deeds were more important than creeds.

This was the 18th century "faith" for intellectuals—and Benjamin Franklin was foremost among intellectuals!

IV

The emphasis on nature of the 18th century was spurred on by man's steadily increasing control over it. As man learned more and more of nature's secrets it seemed to open up ever new promises for man's future. Man had a profound trust in nature and in human reason's capacity to know nature and to aline itself with nature's meaning and the harmonies inherent within it. "Nature" for the 18th century intellectual meant the objective universe. It was a universe that had within itself a meaning, and this meaning included a knowledge of God and of morality. Human reason applied to nature could discover, codify, and obey rules of behavior sufficiently to guide men into political, economic, and social organizations which in turn reflect the harmony in nature itself.

In spite of this kind of thinking, however, there were deep political splits during the 18th century. Those splits were not only between the great and powerful nations of the world; there were also splits within those nations. There were splits between those nations and their colonies and also between the colonies themselves. In short, the "harmony" so faithfully trusted had not manifested itself in political relationships.

Jean Jaques Rousseau (1712–78) was a French philosopher who was profoundly disturbed by the political problems of his day. He was not just a philosopher but was also a political analyst and theorist. He shared the current faith in human reason and nature and felt that the harmony of nature included man himself. He felt that there was within man a natural friendliness that would have made for good and peaceful societies had it been able to express itself. Rousseau felt, however, that man's structures of civilization and his organizations of society had disrupted the natural harmony; that this disruption had been so complete and in effect so long that the only hope was to break, to overthrow, the social and political structures of society and to discard them. When nature was thus freed from these corrupting influences its harmonies would have a chance to express themselves. The result would be a political and economic harmony that would overcome conflict and would produce liberty and justice.

Rousseau was profoundly aware of the contradiction between the demands of individual liberty and those of order and justice. He was confident, however, that the social and political structures that distort and corrupt the harmony of nature also distort and corrupt the harmony that is within man; that if those structures are overthrown and discarded then the natural harmony within man also would express itself; that this was primarily a natural friendliness, and this friendliness would overcome the contradictions between personal freedom and social justice.

Thus, liberty (personal freedom), equality (social justice) and fraternity (man's innate spirit of friendliness) became the slogan and the hope of the French Revolution.

Adam Smith (1723–90) shared Rousseau's faith in the harmony of nature and applied this faith to the economic realm. He insisted that every individual should strive for his own self-interest, that each striving would thus act as a check on other men's strivings, and the end result would be harmony in the economic sphere. It needed only that restrictions be removed from individual man's self-seeking to have the perfect economic order manifest itself. Smith felt that the law of supply and demand was a part of the economic harmony of nature and that it worked to restrain and level off the worst effects of individual self-centered actions. He knew nothing of economic situations where monopoly has gained control of supply, nor does he indicate any concern with the fact that demand has to be coupled with purchasing power in order to become effective as an economic factor. But these should not be labored too strongly against Smith. He was concerned primarily to prevent the aristocratic government from using its political power to prevent the rise of the new middle class that was appearing in the western world. His faith was in individual reason, motivated by self-interest, moving in step with the harmony in nature to produce the economic utopia. It would be a society dominated by the then rising middle class of merchants and bankers and other radicals of that day.

V

At this point it may be helpful to try to illuminate the nature of the contradiction between the demands of freedom and of order. The contradiction can be expressed in many ways: liberty versus equality, or individualism versus justice, but it is the same problem no matter how it is expressed. It is the basic problem with which every society must wrestle.

On the one hand, people are so created that they must possess a certain measure of freedom, liberty, self-determination, individualism, if they are to be persons and not automatons or lower animals. This quality is a prerequisite of human beings. No matter how regimented or how totalitarian a society may be, it has to grant a sufficient measure of this necessary quality at least to an extent that will keep the people from rebelling.

On the other hand, no society can survive unless it establishes and maintains a sufficient measure of order to enable individual persons to live together in relative peace. There have to be rules and regulations and these have to be enforced. The enforcement, however, must be administered fairly to the individuals, and the ultimate measure of fairness is that each be treated equally. This will produce justice for all the members of a society. A society has to achieve at least a sufficient measure of justice to keep the people from rebelling.

The contradiction arises from the fact that as soon as one single rule has been promulgated and enforced in the interest of order, justice and equality then the rights of freedom, individualism and self-determination have been encroached upon. And every exercise of human freedom and liberty that encroaches upon the rights and liberties and freedom of one single other person is an encroachment upon the demands of order, justice and equality. This contradiction is inevitably a part of every society, whether it be the simple unit of a family or whether it be the larger unit of nation or world.

Every society must struggle to overcome this contradiction or at least to ameliorate its worst results. Every political organization of a society promises to do these things. Every society promises to give the greatest measure of personal freedom and the best and most just order. Rousseau and Adam Smith were certain that if individual man applied his reason to the problem, the harmony of nature would be discovered and each reasonable man would bring himself into line with that harmony, thus resolving the contradiction. Rousseau thought that man's inherent friendliness would bridge the gap between Liberty and Equality. Smith thought that man's sympathy—that is, man's ability to put himself in place of the other fellow—would bridge the contradiction. Both of these now appear to have been somewhat naive.

The American Declaration of Independence, framed by a committee that included Benjamin Franklin, recognized the contradiction. It affirms the fact that men are created equal. It affirms the fact that government is necessary to insure that individual men have the right to life and liberty and to pursuit of happiness. The Declaration, however, does not have any factor comparable to Rousseau's "fraternity" or Smith's "sympathy," which factor might be expected to bridge the gap between the demands that the Declaration so clearly recognized. We can assume from other writings of Thomas Jefferson that he felt that "educated" individual human reason could be trusted to perform this function, although the Declaration itself does not indicate this.

We can be grateful that men with profounder understanding of human frailty and pridefulness wrote the Constitution of the United States. Franklin was also a member of the Constitutional Convention and it is fair to assume that he had grown in wisdom since the Declaration was written. Madison had become the stronger influence from Virginia and John Adams from the regions of New England, which regions were deeply imbued with the Reformation understanding of human nature. Thus the Constitution not only recognizes human egoism and pridfulnes but it provides safeguards against the inordinate expression of these by any one branch of government. It does not eliminate the contradiction in society, but it does make possible some reconciliation of the legitimate but opposing demands of freedom and order.

VI

Every society promises freedom, liberty and personal self-determination on the one hand, and order, justice and equality on the other. This was true in both America and Europe of the 19th century. Man's advances in speculative science had been accompanied by the application of that knowledge to the controlling of nature and bringing it more and more into the service of man. The good society was being produced and being produced by individual man using individual reason. Liberty and justice were assured. The Industrial Revolution was moving swifty ahead to the benefit of large segments of society. But there was another side.

Karl Marx (1818–83) examined the results of the society that was being produced in Europe and pronounced that the procedure was not producing justice and equality, that individual men were exploiting their fellow-men to their own benefit without the exploited having a chance of enjoying the fruits produced by their labor.

Without going into the details of Marx' thoughts, it can be noted that he was a Jew and as such was familiar with the writings of the Old Testament. Also, he knew Hegel's dialectical theory that spirit expresses itself in history, that this produces its opposite and this in turn produces a synthesis of the two. Marx also knew Rousseau and his theory that it is the structures of civilization which have corrupted history and which should be overthrown so that the natural harmony could assert itself.

Marx took something from each of these sources but changed them. He said that there is the dialectic of history which Hegel had recognized but that it was not spirit actualizing itself. Rather the dialectic was within the materialistic, physical stuff of which the universe is composed. The revolution which Rousseau called for had to be actualized by the victims of the prevailing injustice, which was the working class. The rulers of the capitalistic society would surely be overthrown because of the dialectic of history but it would be the privilege of the working class, the proletariat, to be the instrument through which this would be accomplished. This would be because this was the class that suffered from the injustice of the capitalist structure of society. When capitalism is overthrown and its form cast off it will be succeeded by a dictatorship by the proletariat; this will rule in the new form of society where competition is eliminated; with competition gone, wars will cease because men will no longer have that acquisitiveness which is bred into them by the competitive capitalist form of society.

Working man is the vastly more numerous class of men; it is mass man. Under the dictatorship of the proletariat, mass man will apply collective reason to the solution of man's problems—will use the techniques and implements which science makes available and will bring in still another order of society; this will be a society in which there will be no classes—there will be justice and equality for all. Since there will be no acquisitive instinct among men, and hence no inclination to exploit one's fellows, then the power of the state can "wither away"—it will voluntarily evacuate.

It is true than man yields up his individual freedom, but only for a time and only to achieve an order of justice and equality and peace. When this has been attained, when the classless society has been brought into being, then the rights of individuals to personal freedom and liberty can be granted. This can be done because the individual will have become a new kind of being who can be trusted not to use his freedom and liberty to exploit his fellow man or to upset the equality and justice that will then prevail.

Two things should be noted in particular about this Marxian picture. First, it promises a society of justice, equality, and peace, with finally the gift of personal freedom. Second, this society is to be achieved by applying collective human reason to the solution of man's problems, and the solution is guaranteed by the dialectic of history.

There is no final difference in the promise made by communism and the promise given by the free nations. There is no final difference in the means by which the two sides of this political split say they will use to achieve this promise. Both plan to do so by applying human reason to the problems of man and history. The only difference is that communism plans to apply collective human reason and the free nations plan to apply individual human reason.

The ultimate faith of both of these is in human reason. Both have their faith in something that is not ultimate: human reason. Not being ultimate, it is an idol, a false god. It is faith in the same false god on both sides of this political split.

Thus both sides of the political split of our time promise the same things, to be achieved by different kinds of use of human reason. For the most part there seems to be no inclination on the part of the majority of Russians to adopt the individual use of reason that the majority of Americans assume to be the best method of achieving the best society. On the other hand, there is no real evidence that the majority of the people of the United States are apt to adopt the Communist method of using collective reason to achieve this end. The political split is not acute insofar as the vast populations of the United States of America and of the United Soviet States of Russia are concerned. Each of them goes their own way without ever meeting. Each assumes that the other is evil and wrong. At least, each seems constantly to be told by press, radio, and other means of communication that the other is wrong. The people seem to accept this as truth, even though the average individual in the masses of either country would perhaps be fairly inarticulate as to reasons for his conclusions.

So if the political problem of our time were only the split between the United States and Russia other people of the world could relax and let these two giants writhe in the disappointment of a stalemate. They could argue at long distance—the one insisting that the way to the "good" society is through collective reason, first binding individual reason until a society of justice and equality is achieved and then giving back to the individual person his right to be a person; the other insisting that the way to the "good" society is by maintaining and protecting the greatest measure of personal liberty, even if it temporarily precludes justice and equality, in the faith that individual human reason will eventually overcome the opposition in man and achieve these social goals.

The political split of our time, therefore, is not between a nation that has faith and one that does not have faith. They both have faith and the only difference is between faith-in-individual-human-reason and faith-in-collective-human-reason. The object of both faiths is the same—human reason—and it is a false god that could come into being only after Descartes.

VII

The seriousness of the split between these two sides of a false and materialistic ultimate faith in human reason is not, then, in the conflict between the peoples and the geographical units of the United States and the U. S. S. R. These giants, however, live in a finite and limited world that also includes many other peoples and geographical units. The seriousness of the split of our time arises out of the meeting of the promises and influences of the United States and the U. S. S. R. in other countries. They meet in weaker countries, in countries that are underdeveloped, in countries that have been subjected to political domination and economic exploitation by other nations, in countries that have suffered from the ravages of war, no matter whether they were on the side of the victors or the vanquished. The conflict between the two types of struggle for the "good" society, as symbolized by the secular faith of the United States and the U. S. S. R., has taken place and is taking place in these kinds of countries and it is a struggle unto death. Neither will admit defeat finally.

Yet, those of us who cherish the vritues and values of the so-called free nations would be less than candid with ourselves if we did not admit that in this struggle in these countries the U. S. S. R. has been winning since the end of World War II. During this time the people whose lives have come under the dominance of the

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faith-in-collective-reason are innumerable. The nations that have been organized and are now controlled by the adherents of this faith are many. The fact is that the faith that is dominant in the U. S. S. R. has been proving more powerful than the faith that is dominant in the United States.

This is the fact that should prove more disturbing to the people of the United States and of the free world than any other single fact. It should be more disturbing because communism has not been victorious due to its possessing more or better guns or ships or planes. The free nations have had more of these. The reason for the communists' successes must be sought in other than its materialistic resources. It must be sought in the realm of the spirit.

The question then becomes: Why is the Communist faith more powerful than the faith of the free nations? The two faiths have the same object—or god—namely: human reason. So it cannot be the god they worship. Its superiority must lie in the difference in their ways of using reason. The one believes in collective reason, the other in individualistic reason. What does this mean?

It means that the Communists say to people: "look at the injustice, the inequalities, the divisions that separate people—a separation that is so deep that it finally ends in war. Give up your individual liberty, your personal self-determination, and cast your lot with us in a great effort to eliminate the injustices, the inequalities, the evil and enmity from among men. Collectively we can do this. Give your life to the group for the betterment of mankind and his lot on earth. We are bound to win this effort because the thrust inherent in the material world is such that it guarantees that this end will be accomplished. You yourself can become a part of this movement of history toward its inevitable and glorious end. Even though you lose your life in the effort, your life will have had significance and meaning. That which you give your life for will be carried on to its successful conclusion by the group of which you are a member. It will collectively apply reason in the best scientific ways to the attainment of the perfect society in which there is no enmity, no classes, no strife. Your life has ultimate significance in the cause of communism and it has comradship now with kindred people who also are self-committed to this high and noble cause."

On the other hand, the secular faith-in-individual-reason of the free nations says to people, "the utimate meaning of your life is to be found in the preservation and use of your personal freedom and self-determination. Your right to exercise these is threatened today by communism. You must sacrifice in order to preserve your right to use your individual reason. You may even have to sacrifice your life itself in this cause."

But that would be the end of meaning for the individual! If the ultimate meaning of my life is found in my individual reason, my personal liberty and freedom, than if I give up my life I no longer have these things—my life loses its meaning. So, instead of fighting communism and risking the losing of my life, which would be the end of meaning for me, it would be better for me to avoid that conflict, or at least to give my life to something that will be carried on to a successful conclusion even if I die.

Although perhaps never expressed in these words, this is the choice that seems to confront people in lands where faith-in-collective-reason symbolized by Russia, and faith-in-individual-reason, symbolized by the United States., meet and struggle for acceptance. Faced with only these two alternatives, it should not be surprising that the faith which offers comradship now and ultimate meaning through the group exhibits a greater power to gain adherents than does the faith which offers a separated individualism whose meaning ends with death—whether that death comes in the mud of a Korea or in the wreckage of a convertible.

Unless and until the free nations have faith in a God that offers more meaning than this, and faith in a God that produces more sacrifice for the achieving of the good society for all men, they are doomed to continue being defeated.

VIII

Defeat for the free nations in the realm of faith and its works need not be the fateful result of the political split of our time because ultimate faith-in-individual-reason need not be the faith that determines the decisions and actions of the free nations.

The United States of America is not only the symbol of these nations but it also is the most powerful of them. And the leaders of the political life of the United States give signs of sensing the truth that faith-in-individual-reason is inadequate. There are signs that these political leaders are seeking some other and more adequate object for their faith. Many indications of this can be cited: no political leader makes a speech without including a "nod to God"; the President not only opens his tenure of office with a prayer but he gets baptized and joins a church; his Sunday golf is delayed until after attendance at worship; Cabinet meetings are opened with prayer; Members of Congress of both parties attend Bible breakfasts and discussion groups; the pledge of allegiance to the flag is altered to read "one nation under God, etc."; the national motto "In God We Trust" is rediscovered and printed on a postage stamp; political meetings are opened with prayer; a room is set aside in the Capitol Building for legislators to use for meditations; and politicians are even found speaking from pulpits.

These signs in our political life can be multiplied. They have their reflections, or are themselves reflections of, a phenomenal interest in religion all across the Nation. People are large seem to sense in some dark and hidden way that the faith upon which they have been depending is inadequate and they seem to be groping toward something more profound. Churches and synagogues are being built at a faster pace than ever before in history, and they are filled with worshippers. Crowds of unprecedented sizes listen to evangelists, who speak in such improbable places as Madison Square Garden and football stadia. Religious articles appear regularly in press and periodicals. Religious programs are popular on radio and television. Religion is the topic of conversation at cocktail parties and all gatherings of intellectuals. In fact, it has become "chic" to be conversant with and interest in religion.

It is hard to access the depth of the new faith to which these signs point, but it may be that this popularity of religion and its assurance that Americans have "faith" is significant for the political crisis of our time. It is doubtful, however, that its signficance will be very great unless this new "faith" moves to a deeper level than is yet indicated in either its political or popular manifestations. So far, the teme song of this new development is that Americans have faith in the future became Americans have faith. Americans are no longer so crass as to think that other nations of the free world will follow American leadership just because Americans have greater wealth and power. Now, however, other free nations can follow America's lead because America deserves to be followed—it deserves to be followed because it has faith.

What this is saying finally is that America has now put its faith in faith. The object of faith is no longer reason, neither individual nor collective, nor is it God—the object of faith is faith.

As naive and immature as this religious state may be, it still may represent an advance for western man. At least it reflects a vague and uneasy awareness that there is some power beyond the power of dollars and guns, even atomic ones. It also reflects a vague and uneasy awareness that human reason is really not the ultimate God of the universe. The most respected of scientists are saying that their question "How?" will never enable them to penetrate the mysteries of the meaning of existence. Philosophers, artists, and writers of prose and poetry are admitting that even though they can raise questions about the meaning of existence, the answers to their questions must be religious answers.

All of this means that there has been at least a partial unseating of reason from the throne that belongs only to ultimate Being. Perhaps ultimate Being has not yet been enthroned but at least some sweeping out has been done in the palace!

IX

And it may yet be that the God whose self-revelation is recorded in the Bible will move into the vacuum that has been created by faith having no object other than itself. It may yet be that this God will move in quickly enough and with sufficient power to enable us to stand the years of pressure that can be predicted as lying ahead for us if war is averted. It may yet be that this God can give us fidelity and meaning worthy of sacrificing even life itself if war is not averted.

Even though we cannot know Him completely, He has revealed enough of Himself to us to enable us to admit that He alone is the God who is the source of sufficient strength to give us meaning in our crisis and sufficient power to help us emerge victorious. He has revealed that He is the God who created the universe and who created man—who gave man his powers of reason. He not only gave man the power of reason but He gave man a quality of self-transcendence, a capacity to rise above the determination to which all the rest of physical nature is subject. He gave man this quality which separates man from all other animals. It is this quality that enables man to ask questions about himself and about the meaning of his existence. It is this quality that enables man to know that he is going to die.

This is the capacity that raises man above being just animal but it is also the capacity that makes man protest against the limitedness that he knows he is subjected to—the limitedness that ends with death. In the face of the fact of death, man tries to arrange for himself some kind of immortality. Since man lives in a limited world his arrangements for his own immortality are always at the expense of his fellowman. This is where conflict arises and not from an acquired sense of acquisitiveness. Man's attempts to make arrangements for his own immortality arise out of self-love. But this same self-love is possible only because of the quality that makes man higher than all other animals.

It is this quality that enables man to know God and love—neither of which is known by reasoning processes only. It is this capacity given to man alone of all the animals that enables him to find a ground for his being in a relatedness of love—self-committal to—ultimate Being.

This is the quality in man that finally is free—not determined. It is a freedom given to man that he might be man, in order that he might enjoy the relatedness of love to ultimate Being. But man uses this freedom to love himself instead—he uses it to try to create his own immortality. This creates opposition between man and man—ending in war and rumors of war. But it also creates opposition of man to God because man is making himself God. This is the human situation.

God, however, set Himself to overcome man's opposition and divisions. He set out to do this by means that would not take away from man that freedom by which he is a man. God's method was self-disclosure to man—making Himself known in ways which man could apprehend—and accept or reject.

This was the God who revealed to Moses His demand that men be free from bondage. Moses experienced a demand upon his life that he go back into Egypt and lead the children of Israel out of slavery. It was not a logical demand. Moses did not apprehend the demand through his reason only. In fact, he presented some reasonable arguments why he should not go back to Egypt on this errand. But the demand persisted. It was not backed up by political, economic, or sociological arguments, yet Moses recognized it with his whole being. When he sought the source of the demand he got the answer that it came from the God whose name was "I am that I am"—from the God who is self-existent, ultimate Being, whose very nature demanded that men be free. It was in obedience to this God and His demand that the struggle for human freedom began. It is in obedience to this God and His demand that the struggle continues.

This is the same God whose self-disclosure to man in the fullness of time took the form of a man. Had men been placing their faith in reason, either collective or individual, they could have measured this God-man in every way known to science and yet not have known him any more than a man can know the love of his wife by scientific measurements. But the men of that day were not yet rationalists. Their weakness was only that they were interested in building for themselves an immortality through obedience to religious laws. The God-man, Jesus, told them they could not do this for themselves—neither by obedience to laws nor by any other way—because death mocked their every self-centered effort. They retaliated by inflicting on Him the worst death they could devise.

And He willingly bore it—loving them.

He bore the worst that they could do rather than overrule the freedom by which they were doing it—that same freedom which makes man man. God bears the worst we can do rather than make us cease to be people. He wants men, not automatons.

His bearing of the worst that men could do—His bearing it and still loving men—elicited from some men the acknowledgment that only God could love like that. This was a freely given response—and it carried with it a self-commitment to Him as the source of meaning for life, the measure of value in human affairs, and Ultimate Being in human form.

This is faith in God.

It may be that this same God—the God of Abraham, Isaac, and Jacob, the God who acted for man in Christ's death and resurrection, the God whose personal influence operates in the lives of men today—it may be that He will assert Himself as the object of the faith of Americans. It is He that can inspire us and guide us in the meeting of today's political crisis, give us humility to admit our share of guilt, give us courage to accept our share of responsibility, give us steadfastness to do what we must do and wisdom to know what that is, and give us friends who trust us as friends who are trustworthy.

A faith in the God who gives these things is essential to enable us to meet the crisis of our time. The God who would thus become the object of our faith, to whose ways we would commit ourselves, is the God who would rather die on a cross than to overrule that personal, individual liberty and freedom of self-determination with which He has endowed men—that they might be men. Yet, He is also the same God who so ordered creation that man as a distinct, separated individual person cannot exist except in relationship with others. Each person has to be born into a blood-related family. Each person is born into political, economic, and social structures of society and cannot help but be related to other persons in these ways and within these structures. God ordered it this way. It is He who ordained that there be order in society, so that men might live together at all. It is He who so ordered society that justice is necessary for men to live together in peace, and so that equality is finally the standard of justice. He is the God who not only has so ordered life in this world but also He is the God who promises life beyond death to individuals only as members of a fellowship.

In faith commitment to this God we can so value the personal that we give even our life to protect and preserve liberty and freedom. In faith commitment to this God we are freed from the shackles and shibboleths that make us afraid to admit that we recognize the necessity of community, and can admit that we are the best planners and executors of social schemes aiming at justice and equality.

In faith commitment to this God we will constantly admit and reexamine the contradiction between the demands of the personal and the demands of the social. In humility we will admit our weaknesses in resolving it and with high heart set ourselves to achieving a new measure of solutions.

Faith commitment to this God may not enable the free nations of the world to turn the tide of communism and emerge victorious from our present political crisis. Then again, if such faith commitment is in sufficient depth and soon enough, it may.

In either case, God is God—and man and history remain His.

Mr. Grebe. In this direction, the doubling or even tripling of the private and corporate efforts now amount to about $538 million—as determined by Dr. Killian, president of MIT—would multiply the rate of development of new methods that accomplish more, in less time.

There is no reason to doubt that educational developments can be made by the people who have doubled our instrumentation and automation every 5 years. Tax reductions, to permit these private expenditures currently to be increased, are to be recommended.

There we come to a very unhappy problem. Very few of us like the idea of having any special tax treatment of any one subject or any one field of national or human need.

On the other hand, there are two fields in which one can argue very strongly for them.

The first is in the tax problems of small industry. All of them are under a very severe strain to gain capital. And so long as the money is spent wisely and effectively to produce new developments, new instruments, new apparatus, new devices, new jobs, for carrying on the growth of the Nation it would be a marvelous thing if the suggestion that was made this morning would be practically applied to our industry of exempting, say, the first fifty or one hundred thousand dollars of income that is to be spent on new capital facilities from immediate taxation.

It will all come back in the end. But at least it would carry the rapid writeoff a little bit further for the lower brackets of income or profit.

Chairman Patman. In other words, some special allowance like the depletion allowance for oil companies?

Mr. GREBE. That is right, but not exactly—not quite that sort of a thing because after all, that is an expense for rediscovering and developing the oil resources that are being consumed.

However, in this instance, it would be a faster writeoff than is even currently allowed.

And the same thing, I feel, is necessary in this particular field of education and human resources. Many, many thousands of different approaches by different people, who feel strongly enough about this matter to spend their own corporate and private money in these lines of new education and technology are needed. There is a total of around $500 millions spent by them. Those people should be encouraged to do more of it, because somewhere out of that diverse effort there will come the new developments that will double the effectiveness of education as a whole. That would mean an awful lot, much, much more than we can recognize, because after all the military alone is using up about $8 billion worth of time of our manpower each year by the draft.

Let us get much more out of it.

Our colleges are using a number of billion dollars worth of time. Let us get more out of it than we are getting.

Of course, our high schools and grade schools could be tremendously improved by such technology.

It costs money, but some place there has to be an incentive to do something new. It cannot be done by the hard-working teachers who are already overburdened with limited funds.

The chemical industry specifically has been the most potent in applying modern technology, in multiplying productivity, in making it possible to increase wages in my 30 years of activity by a factor of 6, while the cost of the products that were being produced in quantity has gone up very little.

In other words, right within my productive lifetime wages have been commercial without modern automation and new instrumental analysis and control.

In other words, right within my production lifetime wages have increased sixfold over the corresponding prices in that industry. It is remarkable.

While the cost of our production plants per dollar output has remained about constant despite inflation, the application of automatic control equipment has multiplied.

Variables have been detected and eliminated that defied analysis only a few years ago. In all of my experience, the upgrading of the manpower working with me has always been the major concern and objective.

Even now, with all that has been done to destroy incentive nationally, our youth has retained the spirit of progress.

Notwithstanding the lack of dire necessity as an incentive, 80 percent of our basic research group—the most prolific inventors—are taking part in advanced training programs, currently mostly on their own time. Operators, helpers, as well as engineers and scientists take part.

Each man knows he has no external limitation to keep him from getting up to a doctor's degree with continuous pay, even during the "in residence" period at a university.

But all this is still not enough. We are continually limited by the lack of able men in our objectives for doing new things and making new products for new uses to create new human values and new employment. The perpetual relay race is on. We enjoy it. We need more and better men to carry the torch.

Chairman PATMAN. Thank you. We appreciate your testimony.

Let me see if I did not make some notes.

In your operation on Lake Huron, I do not suppose you have any salt water?

Mr. GREBE. We get our salt water from below the ground. At the 1,200-foot depth we get a salt brine. And at about a mile depth we get solid salt, which we can dissolve out.

Chairman PATMAN. I certainly agree with what you said about the improving of military training. I think that is a point that we should continue to advocate.

Thank you very much, sir.

Mr. GREBE. Thank you, we appreciate it.

Chairman PATMAN. We will place in the record the document that you gave us a while ago.

Mr. GREBE. Thank you very much.

Chairman PATMAN. Professor Easton, we are glad to have you here.

Mr. EASTON. Thank you.

Chairman PATMAN. You have a prepared statement, I understand. You may proceed in your own way, sir.

STATEMENT OF ELMER C. EASTON, DEAN, COLLEGE OF ENGINEERING, RUTGERS UNIVERSITY

Mr. EASTON. My name is Elmer Charles Easton. I am dean of the College of Engineering at Rutgers University, the State University of New Jersey. I am speaking today, as an individual, on the subject of engineering education for the American economy.

My knowledge of the subject has been gained through 22 years of experience as an engineering educator. At present I am privileged to serve as chairman of the engineering division of the American Association of Land-Grant Colleges and State Universities, as a member of the executive committee of the Engineering College Administrative Council, as chairman for region I of the education and accreditation committee of the Engineers' Council for Professional Development, as a member of the Council of the American Association for the Advancement of Science, and as a member of the general council of the American Society for Engineering Education.

I am a member of the American Institute of Electrical Engineers, a member of the National Society of Professional Engineers, and a registered professional engineer.

My remarks do not necessarily reflect the opinions of my university or of any of the organizations of which I am a member.

I should like to present my testimony in three stages: first, to show that it is necessary for the United States to have greatly increased industrial productivity; second, to consider the factors which control productivity; and third, to study the educational problems involved in developing those factors favorably. I will conclude with several suggestions for possible action by the Federal Government.

For the next decade, largely because of the low birthrate during the depression years, the population of the United States will grow in such a way that there will be a relatively large percentage of elderly retired persons, a relatively large percentage of children, and a relatively small percentage of workers.

Chairman PATMAN. Do you agree with the preceding witness that the period you speak of, the depression years, so far as the birthrate, was from 1929 to 1942?

Mr. EASTON. That is correct. I was listening to that, and I agreed with him when he said it.

As a result of this unusual distribution of age groups, it will be necessary for each worker to support many nonproductive people. The productivity of every worker must increase if we are to improve or even maintain the present standard of living. In the event of a war which would draw men from the working force, greatly increased productivity of the few remaining workers would be essential for survival itself.

The number of elderly people in this country seems destined to increase for some time. However, the rising birthrate since World War II indicates that we shall gradually assume a more normal balance between children and workers.

At the same time, it is to be hoped that world tension will subside and the men now under arms will return to civilian pursuits. Hence the impending shortage of workers will be reduced.

If we increase the productivity of each worker in the next few years so that we can support vast numbers of unproductive children, elderly people, and military personnel, it is apparent that we shall face problems of adjustment when the shortage of workers comes to an end.

How shall we employ the men who are now supplying the military needs of the Armed Forces when these forces are greatly reduced? How shall be employ the men released from military duty? How shall we employ the increasing fraction of youngsters who reach working age?

We cannot put them all to work producing the normal goods presently available for nonmilitary needs because the workers already in those fields will be able to meet most of the demand. The ability to solve this problem by shortening the workweek is very limited.

Suppose, for example, that we were to try to employ twice as many men to produce our present civilian goods and services by cutting the workweek in half. Obviously, there could be no reduction in salary for any of the workers, for then they would be unable to buy the products of the system. Thus the labor cost for all items would double, and the prices for all items would have to be greatly increased. However, the increased cost might put most items out of the reach of the workers, and hence the system would collapse.

As I see it, there is only one way to absorb the increasing percentage of workers without upsetting the economy; and that is to employ them on new products and new services for which a demand has been created.

A new worker producing a new product or service poses no threat to an old worker producing an old product. On the contrary, such a new worker becomes a customer of the old worker. A shorter workweek for all then becomes possible as each worker becomes more productive.

The problem, then, is a changing one. First we must increase the productivity of every worker to supply normal consumer demands and military needs during the years when there will be a relatively small percentage of workers in relation to elderly persons and children. Later we must increase our productivity of entirely new products and services in order to maintain full employment when the percentage of the population in the labor force increases.

Let us consider now the factors which influence productivity. The most obvious factor is machinery. The more automatic machinery a worker has at his disposal, and the greater his skill in using it, the more he can produce.

If we are to increase productivity, we must have more machinery and more integration of this machinery through automation.

Given the machines, we must have energy to drive them. We need coal, oil, gas, nuclear fuels, and solar energy.

Given the machines and the energy to run them, we must have materials with which to produce useful goods. If we secure adequate supplies of these elements, and if we educate our people to use them, we shall be in a position to increase our productivity for normal needs and for defense in the years when the labor force is relatively small.

Now, what is the outlook for obtaining these elements?

The President's Materials Policy Commission reported in 1952 that with regard to many basic materials the United States is rapidly becoming a have-not nation. According to the Commission, in 1950 this country produced 9 percent less materials—other than food and gold—than it consumed.

It is estimated that by 1975 this deficit may be 20 percent. The time will come when we shall have to develop substitutes for many of the materials which we consider essential today. Furthermore, we must develop completely new materials with new properties to meet the demands of such advances as supersonic flight and nuclear power.

I say that we must "develop" these things. Obviously, they do not exist in nature. They must be compounded out of abundant ingredients which do occur naturally. This compounding cannot be done by some uneducated person mixing batches of material at random. It can only be accomplished through the systematic and persistent application of all of the known laws of physics, chemistry, biology, and mathematics.

Progress will depend on the development of these sciences and on the number and competence of the people who are familiar with them.

In the last 50 years mankind has consumed as much fuel as was consumed in all previous time. Half of that fuel was used in the United States.

At the rate we are going, I estimate we shall consume all of the coal, oil, and gas in the world in about 1,000 years. Some responsible engineers believe that for all practical purposes the supply will be depleted in 300 years. Long before the fossil fuels are gone, the cost of producing them from low-grade sources will become very great.

The very existence of civilization as we know it depends on the development of new fuels and means of using them. The most promising sources are the energy from the fission and fusion of atomic nuclei and from the radiation which we receive from the sun.

Think of the difference between the obvious procedure of burning coal to produce power in a steam engine, and the process of obtaining energy from an atomic pile. The idea of obtaining energy from the fission or fusion of atomic nuclei was not obvious and was not conceived by man until he had learned to use the most advanced concepts of physics, mathematics, and chemistry. The concept was predicted theoretically before it was observed in the laboratory.

The development of devices using atomic or solar energy will depend entirely on the quality and quantity of our engineers and scientists.

The nature of the machines which are needed for this age of automation is far different from the equipment which was in general use 15 years ago. Until quite recently, machinery used in production was of a rather obvious type. Each machine might perform a single operation, and do so in a manner which could be readily observed from an examination of its parts.

Today, machines are being interconnected through electronic control systems—through systems of instrumentation and control—so that the operation of any one device will affect in some predetermined way the operation of every other unit of the system.

The design of such automatic systems requires the use of incredibly complex mathematical analysis as well as a thorough knowledge of the basic principles of electronics, mechanics, chemistry, physics, and the other sciences. There is nothing stereotyped about designing for automation. Knowledge of current or past practice is not as important as ability to apply engineering principles to produce novel solutions to new problems.

The development of the new products which will be needed to employ an expanding labor force also depends on the application of very complex mathematical and scientific principles.

As an example of a new and strange product which engineers are now developing to create new jobs, consider the electroluminescent light source. This lamp is in the form of a sheet of material which glows uniformly when electricity is applied. To the casual observer it looks like a simple piece of colored glass. There is no filament, no moving parts, or any apparent source of light. The design of this lamp is not obvious.

Its operation can be understood only by a person thoroughly versed in the most advanced theories of solid state physics and mathematics. This disarming appearance will characterize most of the new products which the next generation will see. The need for competent engineers and scientists to design them will increase.

It should be obvious that the quality of our engineers measured in terms of their ability to create new processes and materials is of paramount importance to the security and economic well-being of our Nation.

It is true that we shall need large numbers of such personnel, but quantity cannot overcome a deficiency of quality. One good engineer with an adequate knowledge of the basic principles involved can design a new product like an electroluminescent lamp or a new system of automation. A thousand poorly prepared engineers could not duplicate the feat.

I am happy to report to you that the Nation's engineering colleges are alert to this need for quality of competence in scientific know-why and are taking positive steps to meet it.

In 1952, the American Society for Engineering Education established a committee on evaluation of engineering education to peer into the future and try to determine the type of education needed to prepare our young people for the tasks which may face them 25 years hence.

This committee, which was composed of educators and practicing engineers, enlisted the aid of many local committees throughout the country. On June 15, 1955, the committee published its report (copies available from Prof. Leighton Collins, secretary, American Society for Engineering Education, University of Illinois, Urbana, Ill.).

Shortly thereafter the education and accreditation committee of the Engineers' Council for Professional Development—this is the group that accredits engineering colleges—adopted many of the recommendations from this report as criteria for the accreditation of engineering curricula.

Since the report appeared, almost every engineering college has reexamined its program of instruction with a view toward raising the competence of future engineers. It is interesting to note that the accrediting agency now, more than ever, encourages experimentation with new educational methods.

No longer is an effort made to restrict engineering curricula to a few major fields. Now an institution may set up any type of engineering program. It will be considered for accreditation only in terms of its ability to impart competence in engineering analysis, design, and systems.

In brief, the present trend is toward more scientifically oriented engineering curricula. For example, the amount of mathematics taught to the average engineer will be increased. In a short time, practically every engineering college will require a knowledge of differential equations for all students, and will require much more advanced mathematics for undergraduates in such fields as electrical and chemical engineering.

There will be increased breadth of coverage of a wide variety of basic and engineering sciences so that an engineer will be able to work with the great diversity of problems such as those which arise in a system of automation.

This trend reflects industry's increasing demand for men who can solve unusual problems and who can design novel equipment and systems. The attitude of industry is indicated by a remark which a corporation president made at a recent meeting of the American Society of Mechanical Engineers. He said, "Teach your students the basic principles which will never change. Don't teach them current engineering practice. If you teach them current practice, the chances are that it will not be the practice of my company, and if it is, the practice will be obsolete before the students can use it."

Today there is a growing awareness on the parts of both industry and the colleges that the complete education of the engineer must be a joint venture. The colleges constitute the best medium for imparting the unchanging scientific principles which have guided the operation of machines and processes in the past and which will forever govern the operation of machines and processes yet to be invented. To acquire knowledge of current practice there is no substitute for industrial experience. There is no way to develop mature engineering judgment other than by growing up in the proper industrial atmosphere.

The engineering profession is learning what the medical profession has learned, that formal education must be supplemented by internship. As an example of this recognition I call your attention to the fact that the Engineers' Council for Professional Development now sponsors programs to direct the young graduate's development during the first 5 years after leaving college. Literature on these programs may be obtained from the Engineers' Council for Professional Development, committee on professional training, room 13–217, 3044 West Grand Boulevard, Detroit 2, Mich.

These postgraduate development programs are conduted by groups of industries and by sections of the professional societies. They involve integration into civic life as well as continued education in social and technical fields. Since this movement started only a short time ago, there are only a few organized programs in operation. There is a real need for widespread adoption of this type of engineering internship so that the young graduate may obtain his practical experience in an organized way from the people best suited to provide it.

On the whole I am encouraged by the prospect of better education for the engineering student who completes his work for the bachelor's degree and who then receives enlightened professional guidance from industry. I am not at all happy about the situation which is developing in the graduate schools of our colleges and universities.

There is great need for increased numbers of engineers who have thorough graduate training through the master's and doctor's degrees. Unfortunately, the present shortage of engineers has prompted many industries to lure students away from the campus as soon as they receive the bachelor's degree. Some companies which are located near universities encourage young engineers to go to work and then take graduate courses during the evening or at odd hours during the day. Other companies entice students away from the universities through promises of graduate instruction provided at the plant by occasional visiting professors.

The result of these practices is that too few American engineers are receiving any kind of graduate training. Furthermore, a growing fraction of those who are studying beyond the bachelor's degree are part-time or off-campus students whose training, while undoubtedly valuable, is not equivalent to that which they could obtain as full-time resident students at a university.

Of additional concern is the fact that the scarcity of graduate students on the campus seriously curtails the programs of basic research through which the universities add to man's knowledge.

So much for the quality of engineering education. Now, what about the quantity? It has been estimated by various sources including the United States Office of Education and the Fund for the Advancement of Education that this country will need approximately 50,000 to 60,000 new engineers annually by 1970.

We produced 25,500 in the accredited engineering colleges in 1956. Let us look into the possibility of expanding our output to meet the anticipated need. Obviously we shall need a large number of qualified applicants from the high schools, a large number of faculty members to teach them, and adequate facilities in which to accommodate them.

Assuming that the distribution of intelligence among the population will remain as it is, we may expect that approximately one-third of the people in the United States will be mentally qualified to study engineering at least through the bachelor's degree. The number of potential engineers should be sufficient to meet our needs. It remains to give these people the necessary education and then to utilize them efficiently. This education must include the study of science and mathematics in the high schools.

The actual status of mathematics and science in the high schools is the subject of much discussion, and, I might say, very little factual information.

Those who wish to show the picture in its worst light quote figures on the percentage of all high-school students who are studying a particular subject at any given time. Thus, Rear Adm. Hyman G. Rickover, Chief of the Naval Reactors Branch of the United States Atomic Energy Commission, speaking at the Sixth Thomas Alva Edison Foundation Institute in November 1955, said that in 1900, 23 percent of all highschool pupils studied physics, while in 1950 only 4 percent studied this important subject. According to Admiral Rickover, in 1900 chemistry was studied by 10 percent of all high-school pupils, while in 1950 the figure was 7 percent. The figures for algebra are 52 percent in 1900 and 27 percent in 1950. For geometry, 27 percent in 1900 and 13 percent in 1950.

Those who wish to show the picture in its best light quote percentages of various classes rather than percentages of all pupils. Thus, Robert H. Carleton, executive secretary of the National Science Teachers' Association in the April 1956 issue of the Science Teacher reports that in 1954–55, the number of pupils taking physics was equal to 23.5 percent of the 12th grade enrollment, and the number taking chemistry was 31.9 percent of the 11th grade enrollment.

At first glance it seems more encouraging that 23.5 percent of the 12th grade enrollment studied physics in 1954 than that 4 percent of all high-school pupils studied physics in 1950. Actually, these two sets of figures are almost identical, although they do show a slight improvement between 1950 and 1954. In many schools the senior class will be approximately one-fifth of the total enrollment. Thus 23.5 percent of the seniors represents about 4.7 percent of all the pupils.

It has been pointed out that despite the decline in the percentage of students studying mathematics and science, the number of such students has increased greatly. In 1900 only 1 out of every 10 children of high-school age attended high school in the United States. In 1954, almost 8 out of 10 of this age group were in high school. According to figures prepared by Commissioner Raubinger of the New Jersey State Department of Education, 98,000 pupils were enrolled in a high-school course in physics throughout the United States in 1900, whereas 302,800 were enrolled in such a course in 1954.

At first glance this is a most encouraging increase. However, there are two basic reasons why the current situation is not satisfactory. In the first place, even though it may be argued that all high-school pupils may not require instruction in physics it seems reasonable to assume that at least those who go on to college should be so prepared.

Since approximately 700,000 students enter American colleges each year, it is apparent that not half of them study physics in high school.

Secondly, many of the high schools offer such shallow survey-type courses in physics that the preparation is not adequate for college. As a guess, it may be said that not more than one-third of the entering college students have had as much as 1 year of adequate training in physics in high school. The situation is much the same, although the percentages are different, in the other science areas. It is from this limited group that the engineering students now come. It is from the same limited group that students in all the other scientific fields must come.

Fortunately, during the last few years several influential groups such as the Engineering Manpower Commission, the Edison Foundation, and the American Association for the Advancement of Science have conducted powerful campaigns to improve high-school preparation and to motivate students to enter engineering.

These movements have been successful to an encouraging degree. Although the problem of adequate preparation is far from being solved, there is an increasing awareness of the importance of science and engineering among school boards, PTA's, and high-school faculties.

With regard to stimulating interest in engineering, the campaigns have been remarkably successful. Despite the fact that the college-age population is now at a minimum, the number of applicants to engineering colleges has risen to the point where many institutions are forced to turn boys away. The number of bachelor of science degrees granted by accredited engineering colleges has increased from 19,700 in 1954 to 25,500 in 1956. It is estimated that this figure will rise to 30,500 in 1957.

We have now reached the point where most engineering colleges are operating at maximum capacity. May I emphasize that many colleges are now getting along only by using temporary barracks buildings which were erected to handle the great influx of veterans after World War II. It is obvious that we must utilize every means of making the best use of the limited facilities which we have. In my opinion, we should raise the admission standards so as not to use valuable space and valuable faculty for students who will never graduate. In this way our colleges could produce more engineers without adding significantly to the plant or to the faculty.

However, even though we resort to every possible expedient, I believe that if we are to increase our output of engineers from the present 25,500 per year to the needed 50,000 per year in 1970, and if we are to provide engineering education for the growing college-age population which will increase 66 percent by 1970, we shall have to expand the physical plants of our colleges. In this connection may I point out that if any of the proposed Federal scholarship programs are adopted they will aggravate this already critical space problem.

It should be obvious also that there is a growing need for engineering teachers. Most of our colleges are short of staff now. The general shortage of engineers and the overpowering competition from industry makes the faculty situation the most serious problem now facing the colleges.

Assuming that the colleges will produce the needed number of engineers, every precaution must be taken to utilize these men effectively. Fifty thousand engineering graduates put to work at nonengineering tasks will not meet our needs. Each engineer must be utilized for creative engineering design. He must be adequately supported by technicians who will relieve him from the routine phases of engineering activities. The engineer must be aided by technicians just as the physician is aided by nurses.

It has been estimated that there should be 3 to 5 technicians for every engineer. Although exact information is lacking, it is probable that the average ratio is approximately 1 to 1 in the United States at present. A recent survey of 18 oil and chemical companies conducted by the Engineering Manpower Commission showed an average of 0.9 technician per chemical engineer.

There is a very great need for increased numbers of technical institutes which will provide the 2-year terminal programs for technicians. Unless we get a much greater number of technical institute graduates in the near future, the full effectiveness of our engineers will not be realized. On the other hand, in my opinion, if we had a really adequate supply of competent technicians, we might get along with 40,000 rather than 50,000 new engineers per year by 1970. I recommend that the campaigns which have been so successful in producing interest in engineering now be turned to the technician.

As our machines and processes become more complex we shall need increased vocational training for the people who will operate and maintain them. Furthermore, provision must be made for the continuing education of all workers to enable them to keep up with the rapid changes which will occur. Automatic machinery does not take care of itself. The more automation we have, the more skilled our workers must be.

Now let us summarize the needs which I have mentioned above.

1. The Nation's engineering colleges must obtain additional staff and additional facilities to increase the output from the present 25,500 per year to 50,000 per year by 1970.

2. More engineering students must remain in college for graduate study.

3. More industry-sponsored programs must be established to guide the professional development of young engineering graduates.

4. The number of technical institutes must be increased to provide 2-year terminal instruction for technicians. The present ratio of approximately 1 to 1 should be increased to about 3 technicians per engineer.

5. High-school training should include the mathematics and science necessary to prepare students for further education as scientists, engineers, and technicians.

6. Vocational school training should be made available to more of the young people who will operate and maintain our increasingly complex equipment.

7. Adult education programs must be expanded at all levels to enable all workers to keep abreast of changing conditions.

Finally, permit me to suggest some ways in which the Federal Government might aid in solving our educational problems.

1. Most engineering colleges have ROTC programs, and most of these schools provide the space for this instruction. The Government could construct new and adequate quarters for the ROTC thus freeing the present space for other educational purposes.

2. In order to help colleges provide living quarters for the students, the Government could reduce the interest rate on housing loans.

3. Let me introduce this suggestion by saying that I am very strongly in favor of higher salaries for engineers. I am pleased to see the recent trend toward higher salaries because it reflects the great value of the work which engineers do. The shortage of engineers has

accelerated this trend as companies bid against each other for the services of the limited personnel. This is a natural operation of the law of supply and demand. What I should like to mention is a practice engaged in by relatively few companies in which cost-plus Government contracts are accepted before adequate engineers are available to handle them. In some cases the holder of such a contract will raid a college faculty and will attempt to entice men away from teaching with exceptionally high salaries which can be charged to the Government. I feel that colleges must face the competition of legitimate industrial demands. This is one natural way in which professional salaries can be raised, and I am all for it. However, the practice to which I refer seems somewhat illegitimate. This practice is bad for the taxpayers and bad for the colleges. The Government might investigate the situation.

4. Much basic research of the type which colleges can do well is now being assigned to industrial concerns under Government contract. If more of this research were directed to the colleges, it would constitute an inducement for faculty members to remain on the campus—they like to do this sort of thing—and it would afford part-time income and good educational experience for graduate students on the campus.

5. The utilization of the many engineers now in Government service should be increased by the employment of as many technicians as possible.

6. Wherever the Government employs a large concentration of engineers it might establish a development program for young engineers after the pattern recommended by E.C.P.D.

7. Wherever possible, the training programs of the Armed Forces should be patterned after the 2-year technical institute curricula—or a portion thereof—to add to the supply of technicians.

8. Federal aid could be provided for the adult education of nonagricultural workers in much the same fashion as that already provided for farmers. A bill, S. 4160, intended to achieve this purpose was introduced at the close of the last Congress by Senators Hill, of Alabama, and Smith of New Jersey. This bill, which is supported by the American Association of Land-Grant Colleges and State Universities, will be reintroduced in the new Congress. I recommend its support.

Please note that I have spoken of the needs of the United States with no reference to a possible threat from Russia. I understand that this was discussed at the previous hearing. The best analysis which I have ever seen of the Russian educational system was presented by Dr. C. J. Lapp, Deputy Director of the Office of Scientific Personnel, National Research Council, at a meeting of the American Association of Land-Grant Colleges and State Universities held in Washington, D. C., on November 13, 1956. Dr. Lapp's paper should be required reading for all Americans who are concerned about education.

I have one copy of that paper with me, Mr. Chairman, if you would like to have it left for the record.

Chairman PATMAN. We would like to have it inserted in the record, if you please, Doctor.

(The paper referred to is as follows:)

Little Ivan Goes to School

(By C. J. Lapp)

PRIMARY AND SECONDARY SCHOOLS

My neighbor Johnny Johnson starts to school when he is 5 years old, but his counterpart, little Ivan Ivanovitch, who lives near Moscow, starts to school when he is 7 years old. So do all the other children in the U. S. S. R. Johnny will develop his elementary and secondary education in 12 years, probably divided 6–3–3 and will likely finish senior high school when he is 17 years old. Ivan will develop his elementary and secondary education in a system divided 4–3–3, 10 years in all. His school will be free, coeducational, and compulsory through the seventh grade. He also will graduate when he is 17. During this period his school will offer as much training as he can absorb. He goes to school 6 days a week, receives instruction 33 weeks a year, and is expected to do plenty of homework, which is prescribed as 1.5 hours a day in the second grade, increasing to 3.5 hours a day in the seventh grade. His homework is so heavy that the Soviet Government recently thought it necessary to decree that his teachers must not assign homework to be done on Sunday.

For the first 4 years he will wear a uniform furnished by his parents which will make him look exactly like all the other Ivans and will help him get the idea that education is a mass job controlled by the state and that he cannot expect much preferential treatment. During grades 1–4 inclusive, he will study reading, writing, arithmetic, and social science as part of a curriculum designed and supervised closely by the state. On the morning Ivan goes to class and is instructed in the art of long division, he gets as much comfort as possible from his sure knowledge that at that same hour on this same day of the week all the other Ivans in Russia in his grade will be studying long division.

During the first three grades his teacher will decide if he may pass into the next grade. However, at the end of his primary education in the fourth grade he must pass an examination conducted and supervised by the state. There probably will be three examiners, one of whom will be his teacher. These examiners will conduct both written and oral examinations for all the students in his class. These examinations cover the whole year's work, which will be divided in about 50 parts. For the oral examination, Ivan, along with the other children, will draw a card from a deck. Written on his card will be 2 or 3 questions which may relate to any part of the year's work. Ivan will have 30 minutes to develop the answers which he will give orally before his fellow students and the examiner.

When Ivan enters the intermediate grades (5–7, inclusive), he must choose a foreign language, the study of which he will continue for 6 years. Here he will have some choice; he will have an opportunity to choose the only elective he will have among all the subjects in his secondary education. English, the language of science, is probably the most popular. Homer and Norton Dodge, who in 1955 spent several weeks studying higher education in the Soviet Union, reported no difficulty in finding Russian students who could speak fluent English.

Being now well grounded in reading and writing, Ivan's solid education in background subjects will begin in earnest. Besides a foreign language, beginning with the fifth grade, he will also start the study of history, from ancient history in the fifth grade to history of Russia and the peoples of the U. S. S. R. in grades 9 and 10. An introduction to physical geography starts in grade 5 and continues to world economic geography in grade 10. Biological sciences starts as a survey of nature in grade 4 and continues through botany, zoology, human anatomy, and physiology, principles of Darwinian theory and Soviet genetics, grade 9. Physics starts in the sixth grade; chemistry starts in the seventh grade; mathematics is studied from the first day he enters school until he graduates. His study of algebra will start in the middle of the fifth grade. Before he finishes the 10th grade he will have studied plane and solid geometry and trigonometry with special emphasis on its applications to physics and engineering.

When Ivan is ready to appear before the examining board at the end of the 10th grade, among other things he has had are 6 years of history, 6 years of a foreign language, 5 years of physical and economic geography, 10 years of mathe-

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matics including trigonometry, 5 years of natural science and biology, 4 years of chemistry, 5 years of physics, and 1 year of astronomy. From grades 5 to 10, inclusive, 47 percent of his instruction was in science. In a paper read before UNESCO Institute for Education in Hamburg in late October 1956, A. Shibanov, head of the department for polytechnic education in the Institute for Teaching Methods in the Pedagogic Academy, stated that the science content of the curriculum for the 8th, 9th, and 10th grades was being revised upward 15 percent.

Besides the basic work outlined above, Ivan also has some extracurricular duties, required but not considered part of his basic course: singing, the absolute minimum of which is to learn by heart the hymn of the U. S. S. R., drawing, introduction to technical drafting, physical culture, and sports, military training in target practice, map reading, tactics, antiaircraft, and antichemical defense. In this extracurricular work grades are given but do not count toward graduation.

In his primary and secondary education Ivan has had approximately 10,000 class hours of instruction. In Russia an instruction hour is 45 minutes. Putting this in terms of our own system and counting 25 class hours of instruction per week, Johnny Johnson also receives about 10,000 class hours of instruction by the time he graduates from high school. During his first 10 years of education Ivan's average student-teacher ratio as of 1950 was 23. This ratio has been steadily decreasing and as of 1955 is probably less than 20. During his 10 school years in the grades, Ivan's report card carried the numbers 1 to 5. These numbers were of great concern to Ivan's parents because they know from long and bitter experience that education offers the main avenue for advancement to those who do not belong to the tiny minority holding party membership. Ivan hoped the numbers would be 4's or 5's, for if he could maintain grades mostly of 5's he could graduate as a medalist. This would mean that he will have a better chance of passing the rigorous entrance examinations when it is time for him to go to college. A grade of 1 meant failure, while 2's and 3's meant that he might not be permitted to pass his grade. There always was summer school to which he could go to review his work and try another examination just before the beginning of the new school year. If he failed the second time he had to repeat the whole year's work.

Between the seventh and eighth grades is the first major break in the Russian school system, a break corresponding to our break between the eighth grade and high school. At the end of the seventh grade Ivan's examinations are searching, for this is the terminal point for the low 10 percent—in our vernacular those whose IQ is 80 or less. After all, the educational system in the U. S. S. R. is set up to give the training a student can profitably use.

At this point all of the very best students are encouraged to stay in school but some of the others will have an opportunity to leave the grade-school system and enter a technicum—a special type of middle professional educational institution in Russia for which we have no counterpart. These will be described later.

In the Soviet equivalent to our high school—their grades 8, 9, 10—the student plays for keeps and the mortality is high. The prize to be won is the opportunity to go on to college. Since the low 10 percent of the students have all been removed, the tempo of the program can be increased. All students through all three of these years study a foreign language, history, physics, chemistry, mathematics, in addition to several other subjects of 1 or 2 years in length. It is perhaps worth noting that syllabi and textbooks used in the last 2 grades (9 and 10) of the Soviet secondary school in such subjects as physics and chemistry compare favorably with our college freshmen introductory courses in these subjects. In addition to curricular instruction, the pupil's interest in science is further stimulated by all sorts of extracurricular activities, such as science clubs, hobby shops, and so on. All this makes for very early and intense exposure to science, which in turn creates very favorable conditions for the future selection of candidates for higher education in engineering and science fields.

In the United States, according to Dael Wolfle, Director of the Commission on Human Resources and Advanced Training, in its report, America's Resources of Specialized Talent, Harper & Bros., 1954, roughly 80 percent of our students enter high school and 60 percent graduate. In the U. S. S. R. about 80 percent enter the upper secondary school but fewer than one-fourth of these who entered 10 years earlier succeed in passing the stiff state examination at the end of the 10th grade. If Ivan is really both bright and lucky and has studied hard enough to receive a straight A, that is "5's" in all subjects, he will receive a gold medal. To do this he must stand in the upper 1 percent of those who graduate. If he has no more than 3 grades of B (4's) he will receive a silver medal. Many finish the 3 last years but fail the final examination. These students are given certificates in which they take great pride. The rest of the group is dropped at the end of the eighth or ninth year. Some of these find their way into technicums. In 1956 there were about 28 million students in the first 10 grades; 1,100,000 graduated. This indicates that the number attending grade school in the lower grades is increasing rapidly.

COLLEGES AND UNIVERSITIES

There are 760 institutions of higher education in the U. S. S. R. that we would call colleges or universities, not counting any of the technicums. Thirty-three of these are full fledged universities. In addition there are 220 specialized institutes giving advanced degree training. The leading university in Russia is the University of Moscow. This university, housed on a new campus, in a huge recently finished building with a 33-story tower is, next to the Kremlin, the most impressive structure in Moscow. Senator Benson reports that the Russians spent 3 billion rubles on the new campus, "more than has been spent on any but a handful of American universities." Unlike our larger universities that may be fragmented into a dozen or more colleges, divisions, and institutions, Soviet higher education is everywhere divided into 5 branches:

1. Engineering-industrial
2. Agricultural
3. Socioeconomical
4. Education
5. Health

These 5 branches are in turn divided into a total of 24 fields which in turn are subdivided into about 300 specialties. Not all of the collegiate institutions have all 5 branches but whatever branches an institution has it will be divided into the same fields and specialties as other institutions.

To illustrate, the engineering-industrial branch, as of 1953–54, is divided into 16 fields as follows: Geology and mining exploration, exploitation of mineral deposits, heat and electrical power, metallurgy, electrical and electronic design and manufacturing, chemical, machine building, food technology, wood processing, light industry, printing, geodesy and cartography, meteorology and hydrology, civil, transportation, communications.

With some minor exception in fields like Soviet law which is a 4-year course, Soviet universities offer a 5-year course with a major in science, based on 5,200 to 5,400 instruction hours of 45 minutes each. In general, such majors as of 1952 have a time allocation of about 6 percent for political and social science, 27 percent for general science, 67 percent for special field science. Although minor adjustments are frequently made, this arrangement has been relatively stable since 1938.

Political and social science subjects consist primarily of indoctrination in the present official version of Marxism; general science subjects include foreign languages, general physics, analytical geometry and calculus, biology, general inorganic chemistry, geology, theoretical and applied mechanics, etc. The subjects in the first two groups are usually taken in the first 2 or 2½ years. Special field instruction occupies most of the last 3 years.

Let us specifically consider chemistry at the University of Moscow. Here Ivan as a chemistry major will receive about 2,700 hours of instruction in chemistry alone. Two-thirds of this will be in basic inorganic, organic, analytical, and physical chemistry. In this basic work he will have on the average 1 hour of class work for each 3 hours of laboratory.

In the one-third time spent on specialized courses, the ratio of classwork to laboratory is smaller. In evaluating Ivan's training in college chemistry it must be recalled that he had 4 years of chemistry before he came to college. Nicholas DeWitt states: "If one compares the training of Soviet chemists with our own, one fact is immediately obvious. As far as instruction time is concerned, the Soviet university chemistry major spends at least one-third more time on chemistry subjects than our own chemistry major in a college with a good department of chemistry. At most, our college chemistry majors during 4 years of study take 10 full courses in chemistry with a probable maximum of some 2,100 instruction hours. As far as the range of subjects goes, there is no radical difference between those which may be, but often are not elected by our own chemistry majors and those which are required of the Soviet student. * * *

"Even when we are admittedly optimistic concerning the scope and quality of our own training of undergraduate chemists, we are faced with the probability that Soviet training is not only comparable, but somewhat more extensive than our own, although as far as the teaching of certain selected topics is concerned there are undoubtedly various reservations. The sheer size of the workload, as well as the process of enforcing certain standards in grading and the number of examinations and tests, exercise considerably greater pressure on the Soviet university student majoring in science than they would upon our own college student. Furthermore, aside from the requirement to learn chemistry subjects proper, the Soviet student is required to learn more about other sciences, such as analytical geometry and calculus, physics, thermodynamics, mechanics, strength of materials, etc., all of which are a part of his curriculum * * * Our chemistry majors do not venture extensively into these subjects except at the expense of chemistry courses. This may perhaps be considered an additional element of strength in the Soviet training program."

DeWitt continues: "Soviet university training culminates in state-accrediting oral examinations conducted before a public audience, and given by a special committee of several professors set up for this purpose. The examinations cover the entire course of study in the field of the student's specialty * * * This procedure of requiring final examinations in public of all graduates which cover the entire program of study is unknown in our educational practice as concerns ordinary college degrees." [1]

The training of chemists analyzed briefly above suggests that the Soviet university chemistry major has training probably comparable to, or with some reservations—somewhat more extensive than, our chemistry bachelor of science degree holder. The Soviet university-trained chemist from the larger universities such as Moscow, Leningrad, and Kiev are probably as well trained as our master of science chemist.

Engineering education in Russia follows, in general, the same organizational pattern as in science, except that most science majors come from the universities while most engineers graduate from specialized institutes. The course is 5½ years during which time the student receives about 5,200 to 5,500 instruction hours of 45 minutes each in 35 to 40 individual subjects. This compares favorably with the 3,700 to 4,000 instruction hours and 22 to 25 subjects which is normal in United States practice. Each engineer has political indoctrination, physical training, and military instruction for about 15 percent of his total course work. The rest of the curriculum is in general about equally divided into three parts (1) between a broad training in science, (2) general nonspecialized engineering and (3) narrow specialized engineering. The distribution of engineering students between the various branches is quite different from the distribution in the United States where electrical engineering constitutes the major group. In the Soviet Union mechanical engineers form the largest group.

Specifically, the mechanical engineering curriculum based on the 1946 course of study, the latest complete one available for analysis, is 5 years with 5,054 instructional hours divided about 50–50 between lectures and laboratory practice. The general science background covers foreign language, mathematics, physics, chemistry, descriptive geometry, drawing, and theoretical mechanics. The general engineering consists of physical metallurgy, strength of materials, theory of machines and mechanisms, machine components, metallography, nomography, electrical engineering, fluid mechanics, tolerances and measurements, thermodynamics and heat-power engineering, and study practice. In the specialized engineering, Ivan studies lifting machines, machine tools (general), kinematics of machine tools, design and calculation of machine tools, technology of metal cutting, cutting tools, technology of machine building, welding, machine foundings, drives, cold stamping, structures and their design, machine-shop layout, electric equipment, automatic machine tools, heat treatment (tempering), organization of production, cost accounting and norms, and fire prevention and safety. A study of a recent Soviet engineering curriculum found in Engineering, February 10, 1956, a British publication, indicates that in the past 10 years the curriculum has not changed significantly.

Says DeWitt: "If, for example, Soviet mechanical engineering training with narrow specialization in machine tools is compared with the Massachusetts Institute of Technology's bachelor of science degree in mechanical engineering training with a broad specialization in materials and material processing, it is found that Soviet institutes require about twice as many subjects and over 2,000 more hours of instruction time. In general, the scientific and engineering subjects taught at MIT are included in Soviet curriculums. Most of these subjects cover nonspecialized engineering. Thus, broadly speaking, the range of general subjects in the two programs is quite comparable." [2]

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[1] Nicholas DeWitt, Soviet Professional Manpower (Washington, D. C.: National Science Foundation, 1955), pp. 111, 112, 113.

[2] Ibid., p. 121.

The American student of mechanical engineering probably spends more time studying general chemistry and physics than Ivan, probably mainly due to the fact that when Ivan entered college he had already studied 4 years of chemistry and 5 years of physics. Judging from Soviet textbooks, there is no outstanding difference in material covered, although perhaps there is more extensive use of calculus in physics in the Soviet case.

Again according to DeWitt: "In higher mathematics the portion of the curriculum in mechanical engineering is substantially greater in the Soviet program (United States, 180; U. S. S. R., 340), but it perhaps covers the same ground as the American program. By the end of the second year, the Soviet student is expected to know analytical geometry, calculus, differential equations, elements of the theory of complex variables, and the fundamentals of vector analysis. Theoretical mechanics covers about the same ground in both programs, but again the time input is greater in Soviet training (United States, 135; U. S. S. R., 204). In theoretical and technical mechanics the Soviet programs of instruction place greater emphasis upon graphic solutions than upon advanced mathematical statistics or operational calculus." [2]

As in the United States there is undoubtedly variation in the quality of engineering training in the Soviet Union. It is an axiom that the quality of training in any curriculum is dependent on factors such as the quality of the teaching staffs, training facilities and equipment, ability of students and the process of selection, etc. It should be noted in summary that the teaching staffs as well as equipment and facilities in Soviet engineering training establishments are usually better than in other fields of Soviet professional education.

"The reason for this is that priorities are given to engineering establishments over other fields of study. As a rule, higher priorities are given to institutions training engineers for key industries, industries directly related to armaments production. Thus, institutes training aviation engineers, communication and electronics engineers, specialists in certain fields of mechanical, chemical, and civil engineering have not only more rigorous training programs, but also enjoy better student-teacher ratios, better facilities and equipment; and they have better opportunities for selecting candidates. These interinstitutional differences account for the fact that there are some engineers with excellent training and some with inferior training. However, in spite of these variations, Soviet engineering training programs are in general substantially sound and are probably not inferior to our undergraduate engineering training." [3]

Each engineer culminates his training with a diploma project which takes his full time from 4 to 6 months. During this time he does not take any courses. "In most cases, the diploma project serves as a test of the student's ability to perform engineering calculations, to execute charts and technical drawings, and to apply existing norms and specifications, designed primarily for production engineers. Generally speaking, the Soviet engineering thesis, though consisting of engineering design and computations, is based primarily upon the use of already existing components, norms, specifications, etc. It therefore fits into one of the basic aims of Soviet engineering education which is to train production engineers." [3]

One of the outstanding characteristics of Soviet engineering education is its intense training in narrow fields of specialization. One may view the excessive stress placed on narrow technological specialization as a hindrance to the development of creative scientific knowledge. However, on the whole the development of Soviet industry in the past 25 years has been based primarily not on original discoveries made within the Soviet Union but largely on discoveries, modifications, and adaptations with occasional improvements upon models, types, and practices developed in social systems outside the Soviet Union with more advanced industrial technologies. Present Soviet Union engineering education seems well adapted to meet the needs of their present industrial development.

Since 1954 the Soviets have been continually introducing limited changes into their engineering programs which tend to reduce the narrow technological specialization and give more theoretical and experimental scientific and engineering courses.

One may wonder how Soviet higher education succeeds in giving more than 1,000 instructional hours per year. Recently the Government decreed that not more than 36 instructional hours might be given per week. About half of these require preparation of 2 to 3 hours each. Thus the workload of a science or engineering student is probably from 70 to 90 hours per week. It is a well-

[2] Ibid., p. 121.
[3] Ibid., p. 125.

established tradition in Russian education to place a heavy burden on the student at every educational level. This burden is readily accepted because both Ivan and his parents know that education offers the one practical avenue for advancement.

At the end of each university semester Ivan must stand stiff examinations, written or oral or both. The examinations are extensive in scope and the consequences for failure are harsh. By Government decree he presently need not stand for more than 10 per year. If Ivan flunks a course he is put on probation which must be promptly removed. The process is rigorous but it serves to select and motivate the able students and to enforce academic standards.

Before leaving the subject it should be stated that when Ivan applies for entrance to a Soviet institution of higher education he specifically identifies the area in which he proposes to specialize. This decision stands. On it Ivan sinks or swims. The Soviets have demonstrated no tolerance for students who would waste both precious classroom space and teaching time by not being able to decide what they wish to do. Under these conditions, out of 100 students who enter higher education, only about 60 succeed in graduating. In 1956 the colleges and universities in the U. S. S. R. graduated 250,000, of which 71,000 were engineers.

TECHNICUMS—SEMIPROFESSIONAL SCHOOLS

Last May I had the privilege of addressing a group of engineers and scientists from one of the large military laboratories near Washington. In the discussion period afterward the most persistent question was, "How can we get some good competent assistants—some intelligent people who can help us and thus free our time so that it can be used at our higher levels of training?"

This problem has also plagued the Russians and they have done something about it by establishing middle-grade or semiprofessional schools called technicums which have no exact analog in our educational system. The Russians have about 3,500 of these with a present enrollment (fall 1956) of about 1,900,000. These schools are operated, financed, and maintained by the various individual ministries in charge of the various branches of the Soviet economy, but the curricula, textbooks, and instructions are controlled by the Ministry of Higher Education.

The technicums are a kind of three-way cross between our technical institutes, trade schools, and our on-the-job training programs, and hold a place of major importance in the Soviet program of higher education. These schools offer training in more than 1,000 specialties that serve every phase of the Soviet society.

Students who have graduated from the seventh grade may apply for entrance into a technicum. If at least 75 percent of all Ivan's secondary grades are 5's and the remaining ones are all 4's, Ivan may enter without examination; otherwise, he must pass entrance examinations in three subjects. If Ivan enters from the seventh grade his course is sure to be 4 years in length. If he enters from the 10th grade certain curriculums are less than 4 years. In 1956 about 200,000 entered the technicums from the seventh grade.

There are still a few engineering technicums that can be entered from the seventh grade; however, they are rapidly being abandoned. Hence, if Ivan wishes to enter an engineering technicum, he should plan to finish all 10 of the secondary-school grades.

Let us specifically examine the curriculum in mining engineering at a Soviet technicum. It is 4 years with 6,100 instruction hours, 27 percent of which is class work, 15 percent laboratory and computation, with 58 percent practical work. During the 4 years in this semiprofessional training school Ivan studies:

General courses: History of the U. S. S. R., Russian language and literature, mathematics, physics, chemistry, foreign language.

General technical courses: Drawing, technical mechanics, electrotechnology, machinery, technology of metals.

Special courses: Geology, mining, geodesy and mine surveying, mining machinery, mine transportation, mining mechanics, mining electrotechnology, fundamentals of enriching coal yield, economics and organization of production, calculation (cost accounting), rules for technical exploitation, mine safety, plus some workship, field work, military training, and physical education.

Upon graduation from a technicum the student is immediately assigned work for a period of 3 years, after which he presumably has somewhat more influence on the place and nature of the work he is to do from then on. The tremendous development of these semiprofessional institutes in Russia is, of course, made possible by the tight control by the state of the educational system and is motivated by a desire to develop high technical capabilities in the less gifted individuals so as to be able to increase the effectiveness of the fully trained professional worker.

In 1955 industrial technicums training industrial technicians and supporting personnel for industry, construction, communication, and transportation, graduated 122,000. Altogether during the period 1951–55 Soviet industry, transportation, construction, and communication got 462,200 technicians and semiprofessional supporting personnel from technicums.

This fall the technicums are reported to have accepted 480,000 new students, of which 60 percent were 10-year graduates.

GRADUATE AND ADVANCED DEGREE TRAINING

Soviet advanced degrees may be earned not only at the universities but also at research institutes as well. Russia has a vast complex of research institutes and laboratories under the jurisdiction of the industrial ministries, the Academy of Science of the U. S. S. R., and the various republic academies. About 60 percent of the advanced degrees are awarded by the universities and about 40 percent by the various institutes. The degree "kandidat" corresponds closely to our Ph. D. and is awarded in 18 "fields of knowledge."

Training for this degree may be taken by individuals under 40 years of age who have completed their higher education and who can pass oral entrance examinations in (1) their specialized field, (2) one foreign language, (3) and in the principles of Soviet idealogy. Training is organized on the industral study plan. A ranking professor supervises the study of from 2 to 5 students. At the end of the first year a dissertation must be selected, and at the end of the second year he must pass a battery of qualifying examinations, including two foreign languages.

The entire third year is usually devoted entirely to work on the dissertation, a defense of which is publicly made before the academic council of the sponsoring institution. If the defense is successful, the degree "kandidat" is awarded by the institution and confirmed by the Government.

Soviet sources state that a dissertation for a "kandidat" degree should reveal general theoretical and special knowledge of the topic on which it was written. It should demonstrate the ability to perform independent research and present new scientific findings. These dissertations for an advanced degree are usually an integral part of a larger program centrally supervised. The larger program can be appraised only in terms of the general quality of Soviet work in a given area of science. Consequently, one would expect a wide variation in quality. However, there can be little question but that research in some branches of Russian science is advanced, extensive and of good quality. In 1952 there were about 5,500 "kandidat" degrees granted, not substantially different from our own rate of production of doctorates.

GENERAL DISCUSSIONS AND SUMMARY

The present Russian Government has made it abundantly clear that it has a high regard for education as one of its most effective tools to be used in its drive for world domination. Although professing the aims of general education, the Soviet educational system in reality is uniquely geared for the training of specialized manpower. The individual must be educated but the individual's education is to be used to make the state more powerful. The present Government has clearly indicated that it intends to furnish education to each individual commensurate with his potentialities to contribute to the state.

Higher education is entirely tuition free and all successful students receive monthly living allowance stipends, which range from one-third to one-half of the prevailing average industrial wage. In addition, outstanding students receive bonuses. The stipends are differentiated so as to favor engineering and science students. The Soviet wage structure also heavily favors scientific and engineering occupations, with wage ratios for these occupations ranging anywhere from twofold to tenfold above the prevailing average wage of salaried workers and employees.

The Soviets operate by well-known 5-year periods. At the beginning of the present plan 1955–1960, 10 grades or primary and secondary education were available to only 70 percent of the population. Their goal is to have it universal by 1960. Their educational purpose is indicated by the intense teacher training program, and the high percent of their graduates of higher education turned back into teaching. At the present time it is reported to be 50 percent. The salary levels of teachers indicate that the Soviets are playing for keeps. President Homer Dodge reports that the salary of an experienced upper grade teacher is about the same as an experienced doctor and three-fourths as much as a factory foreman. The salary of a professor is four times that of a skilled mechanic. Furthermore, as of 1956 all tuition and fees have been removed for study at every level in higher education. Practically all students are supported by fellowships, the stipends of which depend upon the course of study, the level and the quality of achievement to date. Thus by means of mass persuasion and bold incentives, the Soviet state makes every effort to channel the best available talent into engineering and scientific professions.

To enter a college or university one must either be a gold medalist, a graduate from a technicum in the upper 10 percent of the class or pass searching entrance examinations. In engineering and scientific fields, for example, these examinations usually cover five subjects: physics, chemistry, mathematics, the Russian language, and a foreign language. These entrance examinations may be repeated as frequently as one wishes until one is 35 years old.

Because it is their only practical hope for advancement, probably no people in the world are so sold on education as those of the Soviet Union. That is why 56 million of them are presently engaged in some sort of educational enterprise for self-advancement and why the sicence reading room in the public library in Leningrad is full 24 hours a day, the night workers occupying it by day and the day workers by night. The Soviet Government is also sold on education. That is why it is spending more than 5 percent of the gross national product on education.

The slogan of the late master, Stalin, that cadres of specialists—their number, their quality and competence—will decide the outcome of the industrial build-up essential for Communist victory, is now guiding his heirs more than ever before. Many scholars in the Western World have studied and made pronouncements upon Russian education particularly as to the quality of their engineers. It all adds up to the fact that the Soviet state by and large succeeds in attracting its ablest talent, channeling this talent where the State thinks it is most needed—namely in science and technology. The education of their engineers may be somewhat different from the education of engineers in the Western World, but we may disregard the quality of their training only at our peril. Also, presently they are being trained at about twice the rate of engineers in the United States.

Mr. EASTON. Thank you very much, gentlemen, for permitting me to appear. In closing, let me say that I speak as an individual and not in behalf of any of the institutions I have mentioned.

Chairman PATMAN. We have enjoyed your testimony, and I wanted to ask you just a few questions.

You consider adequate quarters the principal shortage right now?

Mr. EASTON. I said, I think, faculty, No. 1, adequate quarters coming close to it.

Chairman PATMAN. Faculty, No. 1. And you object to taking them away from the college campus?

Mr. EASTON. If in order to do so they charge the taxpayers an exorbitant rate for the service.

Chairman PATMAN. It doesn't seem like a fair practice. I wonder if there is some way you could bring that to their attention?

Mr. EASTON. We in the colleges have certainly done so, Mr. Chairman.

Chairman PATMAN. Maybe we could do something about it here. I think if it is brought to their attention in the right way they would not persist in it. Do you think so?

Mr. EASTON. I am not sure. Let me give you one reason for my doubt——

Chairman PATMAN. The profits motive is there, of course, they take these contracts at cost-plus.

Mr. EASTON. I had one experience which shocked and rather saddened me. Last June at our annual meeting of the American Society for Engineering Education, I met a man whom I had known as a college professor at the previous meeting. I asked him how he was getting along, and he said, "Fine, but I am no longer with the college, I am now working for a company on the west coast."

I said, "What are you doing?"

He said, "I am recruiting, my official job is to recruit at meetings of college professors."

And that was why he was there. I thought he was a bit of a traitor to the cause.

Chairman PATMAN. That is serious. I didn't know it had gone that far.

Mr. EASTON. That is the extent to which it has gone.

Chairman PATMAN. I think we should give it more attention.

Mr. EASTON. I think so.

Chairman PATMAN. About the quarters, housing; do you think we should build more houses? You said a lower interest rate, you didn't mean that the students themselves would build houses, you meant that the colleges would build them?

Mr. EASTON. That the colleges could build from the college housing loan program which is already in existence at a lower rate.

Chairman PATMAN. We have the program now, and it is going along nicely. I wonder what the interest rate is now. I don't recall.

Mr. EASTON. I am not sure.

Chairman PATMAN. It is about 3 percent, I think.

Mr. EASTON. The reason I mentioned this, it was discussed quite extensively at a recent meeting of the American Association of Land-Grant Colleges, and a move was made at that time to request a lower interest rate.

Chairman PATMAN. Yes. I think it is justified, and I think you could solve a part of this if we could get more housing by raising the standards as you suggest.

Mr. EASTON. I am sure of it.

Chairman PATMAN. There is hardly any point in keeping the people in scarce housing when there is no sincere effort made by the students to finish or to properly pursue the courses.

Mr. EASTON. That is right.

Chairman PATMAN. And I think that is a good point. The colleges themselves would have to do that, or the associations.

Mr. EASTON. I think so. But the general climate would have to be so as to make it possible. You see, in this democratic society everyone appears to be entitled to a degree. One college president recently made the suggestion that on every man's birth certificate in the United States we should confer upon him the doctor's degree, then maybe we could get on with the serious business of education. There is too much of the thought that everyone is entitled to go to college.

Chairman PATMAN. Yes, we couldn't set up a screening committee to say, "Now, this boy is entitled to go and this boy is not," we couldn't do that. But I think on the basis of their ability to pass certain tests would be fair.

Mr. EASTON. I think so.

Chairman PATMAN. I am disturbed by what you said about the college professors not only leaving the campus but going out to help recruit others.

Mr. EASTON. I hope that is not too widespread. I gave that as one example.

Chairman PATMAN. I hope it is not too widespread. I was just thinking about some possible remedy for that without a law. It is something that is awfully hard to legislate on. I wonder if the Secretary of Defense couldn't make sure in entering into these contracts that some provision would be made against that.

Mr. EASTON. The gentleman sitting behind me whispered to me as I went back to my seat, "Did you know that there was a hearing on this very question in this building today?"

And I said, "No, I didn't."

Chairman PATMAN. Which committee, do you know?

A VOICE. The House Civil Service Committee, the Davis subcommittee, is going into this question.

Chairman PATMAN. Well, that is fine. That is very good. But don't you believe that the Secretary of Defense could possibly do something about it?

Mr. EASTON. I should think so, because these are mostly defense contracts.

Chairman PATMAN. They can put all kinds of provisions in the contract, they can always add another proviso. And provided, of course, these engineers are not—I don't know just how it could be done.

Mr. EASTON. It is a difficult thing, because I wouldn't want it in any way to impede the normal law of supply and demand. I don't think it would be wise to attempt that.

Chairman PATMAN. No. But where they use the Government's money in a cost-plus contract to induce people away from colleges, that is serious. And I think I will send Secretary Wilson a copy of your testimony and invite his attention to that and ask him if he will try to find some way, at least minimize it, if not stop it.

Mr. EASTON. I am sure the colleges will appreciate it.

(The following was received from a witness who was unable to be present in person because of conflicting engagements:)

STATEMENT OF DR. ERIC A. WALKER, PRESIDENT, THE PENNSYLVANIA STATE UNIVERSITY

My name is Eric Arthur Walker. I am president of the Pennsylvania State University. I am speaking today, as an individual, on the subject of engineering education and what it can do to meet the challenge of modern shifts in American technology. My knowledge of the subject has been gained through 23 years of experience as an engineering educator. I am a member of the Secretary of the Army's Scientific Advisory Panel and the Naval Research Advisory Committee, and am vice chairman of the Committee for the Development of Scientists and Engineers, appointed by President Eisenhower. I serve as chairman of the National Research Council's Committee on Undersea Warfare and am directing for the American Society for Engineering Education a comprehensive study of the Nation's needs for research in engineering. I am a member of the American Society for Engineering Education, and from 1952 to 1954 served as vice president of the society. During the same period, I served as chairman of the Engineering College Research Council and as chairman of the National Science Foundation's Advisory Committee for Engineering. I am a fellow of the American Acoustical Society, American Institute of Electrical Engineers, American Physical Society, and the American Institute of Physics, and am a member of the Institute of Radio Engineers, the Newcomen Society, Society of Sigma Xi, and Tau Beta Pi. I am a registered professional engineer in Pennsylvania and Connecticut. My remarks do not necessarily reflect the opinions of my university or of any of the organizations of which I am a member.

From a technological point of view, automation is not new and presents us with no new strictly scientific or engineering problems. The history of the use of automatic or semiautomatic machines to replace manual labor goes back almost as far as we have records of human activity. As man has discovered new forces and phenomena and has learned how to use them to his advantage, they have been incorporated in his machines. As a consequence, the machines themselves have become, on the one hand, more complex and intricate and, on the other, more efficient in performing increasingly subtle tasks. This change, however, has been achieved through an evolutionary process, not a revolutionary one.

Dr. Vannevar Bush pointed out to this subcommittee in its hearings last October that automation is simply one phase of technological change and that technological change is not a new phenomenon. Only two things are new in this area: (1) the word "automation" and (2) the accelerated pace with which the principles and techniques of automation are being applied in industry. The term "automation" is so new that the 1950 Webster's unabridged dictionary fails to list it, and the fact that the word has come to be so widely used and understood in just a few short years is one indication of the tremendously increased significance of automation to industry.

Dr. Bush further pointed out that automation "is a part of a very important general movement, namely, the planned application of scientific results in an economic manner for the increase of man's physical well-being." It is this movement—its implications and its demands—that provides both our problems and the framework within which we must seek their solution.

The movement is significant not simply to our technical community but to the whole of our social and economic structure. Even though, from a technical point of view, the changes that are occurring are more a matter of degree than of kind, their importance probably cannot be overestimated. The effects are felt at every level of our society and have actually changed the structure of it. We can plot, for instance, the rapid change from a basically rural society to a basically urban one. In 1900, the dream of almost every man was to own his own business; today, one out of every two employed workers is on the payroll of a large corporation. In 1900, our discoveries were made by lone inventors working in their cellars at night or in an ill-equipped laboratory on a college campus. Today, they are made by teams of specialists working in the best laboratories Government and industry can provide.

We cannot help but see the significance of this change in our daily lives. To this point, I should like to quote Mr. Mitchell Wilson, whose dual careers as a novelist and physicist have won him fame in both fields: "Americans today—whether they earn their livings in offices, factories, stores, or farms—either make machines, plan new machines, sell the raw materials for machine-made products, or feed, represent, amuse, educate, heal, or bury the people who work on or with machines. * * * I am not talking here about the machines and mechanisms used in the American home, but about the social rules, the social aims, the social strifes that are developed in a society based on machinery and mass production."

Changes as fundamental as these cannot help but cause concomitant shifts in our manpower needs, and the shifts themselves can tell us something about the changes that are taking place and give us some hints of what we must do about them. A great number of statistics indicative of these shifts were presented before this subcommittee at its hearings last year; I shall give a few general ones simply to serve as a review. Between 1940 and 1950, the total labor force increased by about 35 percent; during the same period, the number of farmers decreased by around 27 percent, but the number of research workers increased by almost 100 percent and the number of engineers by about 200 percent. Between 1947 and 1955, output in the electrical manufacturing industry increased by 87 percent, but the number of production workers increased by only 14 percent. In contrast, the number of nonproduction employees, which includes the engineers and scientists, increased by 40 percent. In 1900, about 300 factory workers were employed by industry for each engineer; today, the average is about 50 to 1, and some industries find it necessary to employ 1 engineer for each 10 factory workers.

The significance of figures such as these are perfectly clear, I think. American industry is becoming increasingly dependent upon science and technology for its continuing expansion. In your hearings last year, some fear was expressed that, should this trend increase, it might result in a serious unemployment problem. It is not my purpose in this statement to deal with the sociological problems resulting from automation, but I might note that we have today almost no unemployment. At least part of the reason for this lack of unemployment is no doubt the continued expansion itself; approximately half our labor force today is employed in businesses engaged in producing or selling products that were generally unheard of in 1900.

It is my purpose, rather, to point out our increasing dependence upon highly trained professional manpower for the health of our economy, for our continued technological and scientific advance, and for the maintenance of our ability to protect our way of life. Further, I wish to explore some of the things our colleges and universities can do to meet the challenge of our shifting manpower needs.

This shift was inevitable in automation. By definition, automation replaces unskilled labor with machines that do the work faster, more accurately, and less expensively. But it requires a high level of both intelligence and training to design the machines and keep them running, to prepare the information for them, and to interpret the results they produce. In a sense, we replace large numbers of our least talented, least expensive labor with smaller numbers of our most talented, most expensive labor. This fact, combined with our continued expansion, has created a shortage of professional workers that threatens our entire economy. The fact of this shortage has been dramatized by the desperate search for talent being carried out by industrial organizations. In 1954, 40,000 engineers were needed; our colleges and universities provided only 22,000. The shortage, of course, is accumulative; in 1955, about 80,000 were needed, and we graduated less than 23,000. In comparison, Russia graduated 53,000 engineers in 1954.

This shortage of engineers and scientists is felt throughout our social structure and not just in the industrial world. Undoubtedly, it accounts in part for our severe shortage of teachers; some experts estimate that our supply of teachers is dropping behind demand at the fearful rate of 60,000 a year, and that the deficit may reach 520,000 by 1966. Industry, by outbidding our schools for the best talent, is draining off a large percentage of our superior teachers and, by doing so, may be guaranteeing that the shortage will last for many years to come. The number of teachers qualified to teach physics, for instance, has decreased by 74 percent in the last several years, and the well qualified high-school science teacher has all but disappeared.

Some find encouragement in the population statistics. They point out that probably twice as many prospective students will seek admission to our colleges and universities in 1970 as did in 1954. To provide for this number of students is going to be a tremendous job. For one thing, as many academic buildings will have to be erected in the next few years as were built in the previous 300 years of American college history. We shall have to almost double our faculties. And to do these things, we shall probably have to spend $8 to $9 billion annually, about 3 times as much as we now spend.

To wait for the college-age population to catch up with demand, however, would be to invite disaster. By this slow process, we could not graduate enough engineers to supply the annual demand until 1970, if the demand did not increase from the present figure. By that time, the backlog of needed engineers would number about 200,000 and our economy would probably be permanently impaired.

It has been pointed out that each year that about 200,000 high-school graduates in the top 25 percent of their classes—potentially good college material—fail to continue with their education. In fact, only 7 out of 10 high-school graduates in the genius class—those with I. Q.'s of 163 and above—go on to college. About half of these, the studies show, drop out of school because of financial reasons. To reclaim these, we would need from 60,000 to 100,000 additional scholarships. The other half drop out because of a lack of motivation to continue. The underlying cause here is more difficult to identify and correct, because it may involve the home situation and the attitude of the parents, local racial and religious biases, the attitude of the community, and individual differences. Perhaps the most obvious and easily controlled factor is the lack of proper teaching and counselling in the primary and secondary schools. Corrective action requires increasing the pay of teachers, improving buildings and facilities, and up-dating our school programs.

Certainly, these steps must be taken, and I'm sure they will be taken. But they call for long-range programs that can't begin to solve the immediate problem. And if we don't solve the problem facing us right now, the long-range problem may have been solved by default before the solution has had an opportunity to have become effective.

The immediate problem must be solved largely by the colleges and universities through the application of just those methods we are trying to teach those who will become the leaders in our professional, technological society. We cannot solve the problem by multiplying the number of technical courses or curricula we offer. We do have some courses added in this area at the Pennsylvania State University to keep abreast of recent scientific and technological advances:

Advanced electronic analog computers and digital computation and control, for example, are offered by the department of electrical engineering and automatic control systems is offered by the department of mechanical engineering. But the addition of these courses is not, we feel, even a partial answer to the problem. It must be remembered here that there is nothing basically new in automation.

The core of the problem, it seems to us, is the tremendous shortage of engineers capable of the highly creative type of work demanded by automation and by research and development. The important thing to remember is that automation and modern-day research, although based on principles and techniques that we have been teaching for years, is not circumscribed by the traditional curricular boundaries. The design of a computer, for example, requires the skills normally taught and the knowledge normally acquired in several traditional curricula: electrical engineering, mechanical engineering, physics, and mathematics, to name a partial list. To meet problems of this sort, we have come to employ teams of experts in specialized fields, who approach the problem by what we call "systems engineering.' This approach stresses overall integrated design to avoid, say, good electronic design coupled with inefficient or incompatible mechanical features. Our traditional curricula can provide the various members of these teams. However, they are poorly oriented for providing the project engineers who must supply the basic creativeness, the imagination, and the ability to analyze and synthesize the problem as a whole and to direct and coordinate the work of the others.

In the past, our methods of identifying individuals capable of, and preparing them for, these positions of technical leadership have been haphazard and wasteful. In fact, the superior individual has been identified in the past only through the recognition of the quality of his work on routine jobs. This process takes time, it depends on the perception and good faith of a supervisor, it presupposes that employment is held in a firm that provides an opportunity for demonstrating this type of creativeness and can use it when it is identified, and it puts basic responsibility for education in fields other than that in which the original degree was granted on the engineer himself. This last factor is important, because most of our curricula and at least the earlier positions stress depth, rather than breadth, of training.

Because of these considerations, the Pennsylvania State University has pioneered an engineering science curriculum designed to prevent this slow, capricious, and wasteful process by identifying these gifted young men and women and providing them with an education deliberately aimed at preparing them for these more advanced scientific engineering positions and for graduate work. This curriculum, which is open only to the top 25 students of each freshman class, is definitely an honors course.

In this curriculum, all students follow a uniform course during the freshman year. At the end of that year, the top 50 students are invited to apply for the engineering science program. From the applicants, 25 students are selected. The program followed in the next 3 years is broader than that of the traditional professional curricula; the student is given work in all major engineering sciences, with special emphasis being given to the fundamentals (mathematics and basic technical science) and the relationship between the various sciences. The curriculum is more demanding than the others and is expected to be more rigorous. It is designed to present the gifted student with a challenge sufficiently strenuous to encourage the development of his full potential.

We feel at Penn State that such a program will help in two ways: it should eliminate the wastefulness of our present process of identifying and training our technical leaders, and it should result in a more efficient use of brainpower. In this connection, I should like to quote from a talk made last April by industrialist Crawford H. Greenewalt:

"Behind every advance of the human race is a germ of creation growing in the mind of some lone individual, an individual whose dreams waken him in the night while others lie asleep.

"We need those dreams, for today's dreams represent tomorrow's realities. Yet, in the very nature of our mass effort, there lies this grave danger—not that the individual may circumvent the public will, but that he will himself be conformed and shaped to the general pattern, with the loss of his unique, original contributions. * * * The great problem, the great question, is to develop within the framework of the group the creative genius of the individual. * * *

"I know of no problem so pressing, of no issue so vital. For unless we can guarantee the encouragement and fruitfulness of the uncommon man, the future will lose for all men its virtue, its brightness, and its promise."

Since we cannot, in the foreseeable future, meet our brainpower needs through numbers alone, it is important for us to improve the efficiency of our engineers and scientists. This approach is consistent with the mores of a country that has come to expect fewer workers, whether on the farm or in the factory, to produce more of a better product at less cost. It is also sound engineering practice. I call your attention to the fact that were we to increase the efficiency of our engineers by 10 percent—if we can reclaim by some means 4 hours of their time a week—we will have, in effect, added 50,000 engineers to our work force.

We think the engineering science curriculum will help to increase this efficiency by eliminating waste. Actually, the 1-tier educational program that colleges and universities normally offer is extremely wasteful of brainpower. Not all young men and women have the same capacity for education, just as not all students have the same capacity, for example, of learning to play the piano. By forcing all of those who come to our schools into one educational mold, we fail to provide the most gifted ones with challenges sufficiently vigorous to develop their full potential. We lose the less talented ones altogether.

To reduce the loss of these less talented students, the Pennsylvania State University is also pioneering 2-year associate programs aimed at reclaiming those students with genuine technical interests and aptitudes but with limited preparation or analytical ability by preparing them to relieve our professional engineers of many routine assignments. The savings are twofold: We save for important, valuable work a force that would otherwise be lost, and we improve the efficiency of our engineers by relieving them of subprofessional chores.

These courses are offered at the off-campus centers, our junior colleges located in industrial areas scattered throughout the State. These courses—the original ones were electrical technology and drafting and design technology, but three new ones are soon to be added: Medical technology, surveying technology, and production technology—are aimed more directly at "how to do it" than are regular courses. The courses offered in these programs fall into five categories: Mathematics and basic science, the technical specialty, related technical subjects, English and speech, and socio-humanistic subjects. The difference between these programs and the 4-year programs is one of emphasis, as much as anything else. For example, 37 percent of the electrical engineering curriculum is given over to mathematics and basic science, but only 22 percent of the electrical technology program is so devoted. Thirty percent of the electrical engineering curriculum is devoted to subject-matter specialty courses; 47 percent of the electrical technology curriculum are specialty courses.

These differences reflect the unique aims and objectives of these 2-year terminal programs. They are intended to be more specific in purpose and not to require a broad understanding and application of higher mathematics and basic science. Graduates of these programs are prepared to assume many routine assignments to become an important auxiliary in the modern engineering team.

There is one other important consideration that caused the engineering school faculty to recommend the new 2-year programs. During the next 10 years it is inevitable that applicants to engineering colleges will increase rapidly. In the very near future, enrollments will exceed the capacities of existing institutions. Furthermore, experience shows we must assume that many of those who apply will not possess the intellectual capacity for professional work. The technical institute is the answer for furthering the training of these students.

We feel these changes are important steps toward the removal of the inefficiency of the one-level college curriculum. We have yet another program that we feel can help to improve the efficiency of our professional people and, consequently, to ease the tremendous shortage of brainpower that is threatening our technological progress. This program consists of a series of seminars held in the summer months for graduate engineers to help them keep abreast of the most recent scientific and technical changes. By this program, we hope to reduce the inefficiency that occurs because our engineers and scientists, rushed to keep up with their mountainous daily chores, are unable to keep informed of the most recent developments.

This program was started on a pioneering basis in the summer of 1953. Its success has made it a regular feature of the Penn State summer program, and we now offer annually about eight such seminars. In 1956, 548 engineers and scientists took advantage of this opportunity for self-advancement, and we expect the number to grow. The nature of the seminars changes from summer to summer so that we can provide updating for engineers and scientists in Pennsylvania and the adjacent States in a wide variety of technical fields. The seminars run from about 3 days to 2 weeks, depending on the complexity of the material to be covered.

This past summer, these seminars covered two areas of specific interest to the problem before this subcommittee: Automation and creative engineering. One hundred and seventy-six enginners and scientists participated in the automation seminar and 73 in the creative engineering one. These numbers are close to capacity attendance. Other seminars offered last summer included electrical contacts, electrostatic precipitation, industrial engineering for smaller industry, statistical methods in material research, technical report writing, and torpedo engineering.

It sometimes appears this age is determined to prove historian H. G. Wells' statement that "Human history becomes more and more a race between education and catastrophe," We can be saved from catastrophe today only by reevaluating our educational systems to devise methods and means of eliminating the fearful shortage we now have a highly skilled, professionally trained manpower—or, if you wish, brainpower.

SUMMARY

Automation is part and parcel with modern-day technology, and the health of our national economy and the strength of our ability to protect our American way of life depends upon the vigorousness of our scientific and technological progress. This progress is today threatened by a critical shortage of the highly trained professional manpower, brainpower, upon which this progress depends. The expected increase in college and university enrollment cannot eliminate this shortage for many years to come, and, without the requisite number of students, the addition of new courses cannot help, especially since the principles upon which automation is based are not new.

The colleges and universities can help by reevaluating the traditional one-level curricula. By failing to provide challenges strenuous enough to stimulate the superior student to his fullest possible development and by eliminating the less gifted student altogether, these curricula contribute to inefficiency and wastefulness in the use of presently available manpower. To reduce this loss in efficiency, the Pennsylvania State University has pioneered an engineering science program and several 2-year technical institute associate programs.

The engineering science program is aimed at eliminating the slow, capricious, and wasteful process of identifying and training gifted young men for positions of technical leadership. In this program, the top 25 engineering students in each class are given special training in the fundamentals (mathematics and basic technical science) and in the relationship between the various sciences.

The associate programs are designed to reclaim for useful work those students with genuine technical interests and aptitudes but with limited preparation or analytical ability. By concentrating on how-to-do-it training, we prepare these less gifted young men and women to relieve the professional engineers of many time-consuming subprofessional chores.

In addition to these two programs, we provide a means by which graduate engineers can keep abreast of latest technological advances through an annual summer series of engineering seminars. We feel that such updating is important in improving the efficiency of our engineers and scientists.

The colleges and universities can do much to ease the present vital shortage of technical brainpower by reevaluating their programs to provide: (1) an adequate training for the gifted student; (2) engineering aides to perform routine assignments, and; (3) stimulating refresher training for practicing engineers and scientists. If we can improve the efficiency of our engineering force by 10 percent, 4 hours a week, we can, in effect, increase the force by 50,000 engineers.

Chairman PATMAN. Thank you very much, sir.

Mr. Sheen, I believe you were wearing a hat this morning as president of the Instrument Society of America, and since you have put on your other hat as president of your own company, we shall be very glad to hear you.

STATEMENT OF ROBERT T. SHEEN, PRESIDENT OF MILTON ROY CO., PHILADELPHIA, PA.

Mr. SHEEN. Thank you, Mr. Chairman, as you said, I have now turned my hat around, and I am appearing in a bit different capacity. I am now making my presentation as president of Milton Roy Co., entirely apart and separate from my presentation as the 1955–56 president of the Instrument Society of America.

I do this to relate specifically my testimony in this second capacity to the problems of the small- and medium-size business and in the relief that your committee is specifically interested in the role of small business in instrumentation-automation. I will respectfully offer, as president of a small business, additional recommendations for consideration by your committee.

The problems of small business in the instrumentation-automation field may be briefly summarized under two headings:

1. The procurement of trained men.

2. Grow or die, and the effect of our tax climate on our ability to grow.

Milton Roy was founded in 1936 as the partnership name for Milton Roy Sheen, my late father, and myself. At the time I was engaged in consulting chemical engineering in the field of water purification and industrial waste treatment. The trade name "Milton Roy" was selected to avoid any conflict with my consulting practice.

The first products that we manufactured were known as controlled volume chemical pumps, in reality flow-control instruments for metering specific quantities of chemical to a process. They found their first application in handling water treating chemicals. From a humble beginning in my Dad's basement and with capital of less than $1,000, the business grew to a point where, in 1946, we changed from a partnership to a corporation. Profits were constantly returned to the business to finance the ever increasing need for growth to meet the demand for our products. In this year of 1956, our shipments will total $3,600,000 and we now have a total of 200 employees.

Today, even though we are small business, we are the largest single manufacturer of controlled volume pumps in the free world and have licensees in Germany and Japan. We are now starting diversification with other lines of instruments including instruments employed for continuous chemical analysis of liquids and gases.

I had the privilege of testifying before the Congressional Committee on Ways and Means on June 8, 1953, on the extension of the so-called excess-profits tax, to show the punitive effects of that "antigrowth tax" on a growing small business and how difficult it was to lift ourselves by our financial bootstraps. Many of the problems of financial growth outlined in my testimony at that time are still with us today in our present tax climate. The net results on small business are readily apparent from the increased number of sell-outs, mergers and consolidations that are necessary for continued existence.

The United States Department of Commerce data for the first quarter of 1953—the latest figures that we have been able to obtain—reveal that a total of 3,863 total reporting units in Code 38, instruments and related products industry group, only 2.8 percent of these companies had 500 or more employees. This is graphically shown in the chart that accompanies this presentation. 94.6 percent of the companies, less than 250 employees and 82 percent less than 50 employees.

If the tools of automation are to be made available to meet the rising demands from the multitude of instrument users, it is obvious that the problems of small business are of specific and vital concern.

First, let me speak only briefly on the subject of education of trained manpower inasmuch as I have covered that need rather fully in my previous testimony and here I will simply add the relationship between this problem and that of the small business in this field, that of the difficulty of procurement of trained men.

The problem today is tough enough for big business, but it is even more difficult for the small businessman. The glamour of working in the larger organizations together with the training programs, fringe benefits and experience that can be offered present really tough competition when it comes to procurement of young men directly from our colleges. The small businessman has little time in addition to his many other duties to personally visit college campuses. He seldom can afford the advertising spreads for technically trained manpower used by the larger organizations, to say nothing of radio and TV plugs for job opportunities.

To every recommendation I gave in my previous testimony, speaking in my capacity as 1955–56 president of ISA, for programs to give more trained manpower I can only add an emphatic "amen" from my viewpoint as a small-business man.

The very newness of this field of instrumentation-automation has attracted the entrepreneur and the inventor in great numbers. A feature of the recent Instrument Society of America exhibit in New York City in September was a booth devoted to individual inventors in a contest to submit their new ideas for new instruments and new solutions to problems. This contest was quite a success and this idea will become a continuing feature of the annual exhibit.

How are these inventors to merchandise their ideas? The biggest limiting factor and the one possibly most responsible for the increasing trend to sell our or merge is the question of capitalization, the lack of capital to take an invention from the idea stage through to successful manufacture and sale.

Present considerations for a change in the rate of corporate income tax on the first $25,000, from 30 to 22 percent and then applying the 30 percent rate to all over $25,000 will, of course, help, but this is only a small step in the right direction.

The most difficult capital for any businessman to raise is the capital I will call brick-mortar-tools capital, or what the accountants call "fixed assets." This is true because after making an investment in this form of capital, business is only permitted to charge to its operations a small portion of this investment each year, called "depreciation" and must then pay taxes on so-called profits immediately before recovering the cost of the bricks-mortar-tool money.

Actually, there is no money to bank as profits until the cost of the fixed asset is recovered.

Here, I have a specific recommendation to make, a recommendation that, if followed, would do more in one step to assist the small- and medium-sized business to grow and to stabilize and do more to stop the trends toward mergers and well-out than any restrictive legislation that might otherwise be considered. In other words, this recommendation is for permissive legislation in the tax field to improve the tax climate to permit growth.

My proposal is this, permit any business to expend its first $50,000 of capital investment in any one year choosing its own method of depreciation on capital expenditures up to that amount. Business could choose to expense such expenditures should it so desire. The interesting part of this proposal is that the only cost to the Government would be the interest on the money that would ultimately be paid as taxes in later years.

If a capital expenditure for a tool is made in 1 year and written off the books as an expense, the profits made on that tool or expenditure would be subject to income taxes in a following year. Such a step would not be discriminatory, as this option would be available to any business and of any size but limited to $50,000 in any one year.

It would be of the most value to small- and medium-sized business and would probably go further toward solving the problem of bricks-mortar-tools capital for small business than any other one step that could be taken. This would obviously require an inclusion in accounting methods of a listing of such assets on the books of the business with reserves for future taxes such as is now recommended and practiced by accountants where certificates of necessity are employed.

This proposal would, in effect, grant a certificate of necessity to every businessman on his first $50,000 of capital expenditures with the exception that instead of being permitted to depreciate over 5 years, he would be free to choose any period for depreciation or be permitted to expense, should he so desire. Any bricks-mortar-tools assets purchased under this provision would naturally be scheduled on the company's records. In the event of a future sale the income from such a sale would be fully taxable at normal corporate or business income tax rates. The beauty of this aid to small business lies in its comparative simplicity.

I have two other recommendations to make, both in the tax area and in this case, both referring to our educational needs.

The first of these, which I believe has been proposed by others, would allow any individual an income tax exemption for tuition costs at—and here I specifically mention tuition costs—at technical schools. Here, this exemption might be said to be discriminatory in favor of the technical schools. However, it would be an admitted impetus to accelerate and encourage the training of technical manpower so desperately needed in our country today.

The second proposal may, I believe, be now made for the first time. Corporations are permitted up to 5 percent of their net income for charitable and educational deductions. I propose that for the period of the next 5 years, corporations be permitted a credit against taxable income of $1.50 for every $1 of contribution to educational institutions. This, in effect, would mean that the Government would share with the corporations the cost of making additional contributions to meet the educational needs, but it would also be permitting the corporation the initiative to decide where such contributions would be made and not have the contributions made as a direct Government subsidy. For example, as a possible answer to our previous witness' suggestions, where more money is needed to build facilities and more money is needed for teachers' and professors' salaries, this sort of a suggestion would help to provide the money to do that particular job.

Many companies today cannot afford to donate amounts approaching the 5 percent of net income. This is, again, particularly true with the small organizations who need every dollar they can retain for their continued growth. Where such dollars, however, would have such additional credits to help solve another major problem, the shortage of technical manpower, such incentives would undoubtedly generate a vastly increased schedule of giving and aid in solving our educational problems.

To sum up, the role of small business and its healthy growth is a vital one to the future of instrumentation-automation. Small business has great need for technically trained manpower and still greater needs for the improvement of the tax climate that will permit growth and not demand death. Small business can then grow to become the medium and the big business of tomorrow while doing its part in furthering the growth of instrumentation-automation for the benefit of all.

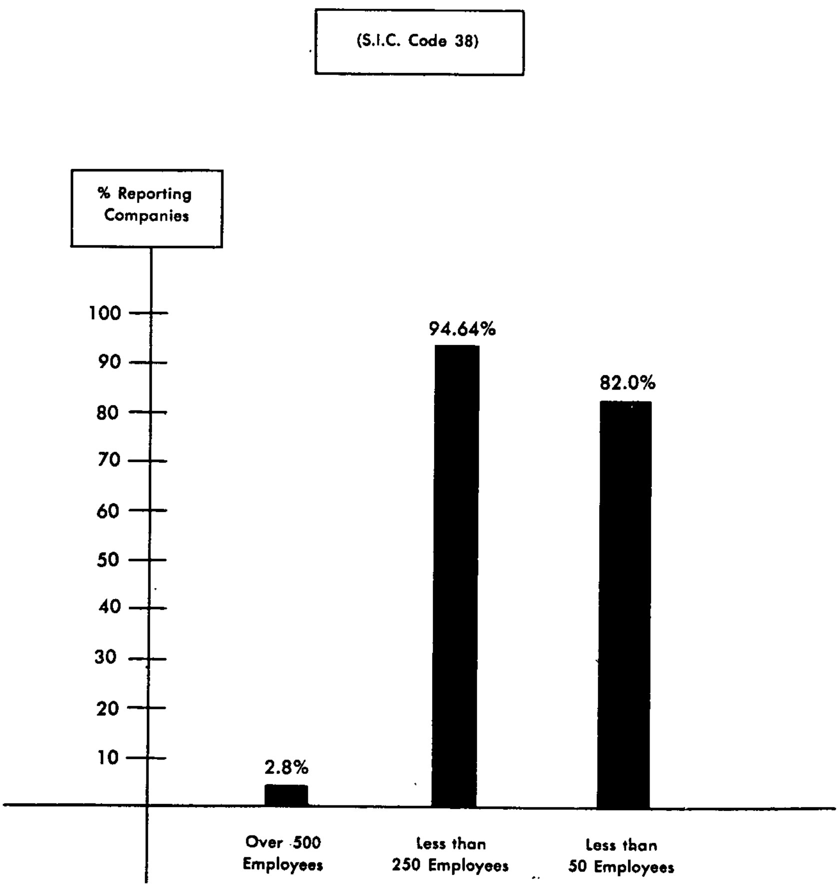
Thank you, sir.

Chairman PATMAN. I assume that you would like to insert the chart in the record, too, along with your testimony?

Mr. SHEEN. I would, yes.

(The chart referred to is as follows:)

NUMBER OF EMPLOYEES IN INSTRUMENTS AND RELATED PRODUCTS INDUSTRY



Chairman PATMAN. I am very much impressed with your suggestion, Mr. Sheen; $50,000—that is, of course, not large as we count money in taxes or in business. You think that will even be better than a reduction in the tax rate from 30 to 22 percent on the first $25,000, and I agree with you that it would. The bill I have would raise that $25,000 up to a much larger figure. And I have already prepared that bill for introduction. And it will be introduced the first day. And I hope to get action on it. And I would certainly not object to a consideration of a proposal like you have suggested here.

It is possible that I will make sure that it is considered by having a bill prepared.

Would that be better than having a 27.5 credit to a small-business man?

Mr. SHEEN. In my opinion it would, sir, for the simple reason that a small-business man has so much more difficulty in going to a financial market to get money to invest in his actual tools.

Chairman PATMAN. And $50,000 becomes a part of his assets, and then if he sells it within 6 months it is a short-term capital gain, and you have got to pay taxes on it just the same, and if it is long term, he pays accordingly.

Mr. SHEEN. You notice that I have suggested that he must schedule that asset, and, if sells it, it is subject to normal or corporate income tax.

Chairman PATMAN. Yes. That is quite an appeal, I think. And the good thing about it, too, is that it will permit producing immediately, and the Government will get the benefit from that production.

Mr. SHEEN. Exactly. You will do more to help that small-business man really stay in business.

Chairman PATMAN. I am very much impressed with it. I want to thank you very much, Mr. Sheen. And I am going to make sure that your proposal gets consideration.

Mr. SHEEN. Thank you very much, sir. I appreciate it.

Chairman PATMAN. Since we have concluded our program for today we will stand in recess until 10 o'clock tomorrow morning.

(Whereupon, at 3:55 p. m., the subcommittee adjourned, to reconvene at 10 a. m. Thursday, December 13, 1956.)

INSTRUMENTATION AND AUTOMATION

THURSDAY, DECEMBER 13, 1956

CONGRESS OF THE UNITED STATES,
SUBCOMMITTEE ON ECONOMIC STABILIZATION
OF THE JOINT ECONOMIC COMMITTEE,
Washington, D. C.

The subcommittee met, pursuant to recess, at 10:10 a. m., in the Old Supreme Court Chamber, United States Capitol Building, Washington, D. C., Hon. Wright Patman (chairman of the subcommittee) presiding.

Present: Representative Patman (presiding).

Also present: John L. Lehman, clerk, and William H. Moore, staff economist.

Chairman PATMAN. The subcommittee will please come to order.

We have as our first witness this morning Mr. Albert F. Sperry, president of Panellit, Inc., manufacturer of data processing, information, and control systems for industry; also president, Panellit Service Corp., systems engineers in instrumentation and data processing; past president and honorary member, Instrument Society of America; past chairman, IRD, of American Society of Mechanical Engineers.

Mr. Sperry, we are glad to have you this morning. I believe you have a prepared statement, and you may proceed in any way that you desire, either from your prepared statement or any way that you wish to.

Anything that you desire to put in the record in connection with your remarks to supplement them, that is germane, we shall be very glad to have it in the record.

STATEMENT OF ALBERT F. SPERRY, PRESIDENT, PANELLIT, INC., SKOKIE, ILL.

Mr. SPERRY. Thank you, Mr. Chairman. I have a prepared statement, but in view of the extremely interesting discussions yesterday, I would like to supplement it with some comments that bear on certain of the questions that have come up.

I have been asked to discuss systems engineering and data processing, their relation to the general problem of automation and their coming role in industry.

I hope that I will be able to convey to you my conviction that these techniques hold out great promise for technological progress, even though many difficulties stand in the way of their complete acceptance today.

Also, that their widespread applications will not require disturbing readjustments on the part of labor, but may require real orientation in management thinking.

Incidentally, yesterday Dr. Moore asked certain of the speakers if they would define the term "automation" again. This has been done so many times——

Mr. MOORE. The question dealt rather more with "instrumentation," which is an even newer word in the common man's language, I believe, than "automation."

Mr. SPERRY. I have been in the instrumentation field for 34 years, and we long time ago came to the conclusion that it was a frustrating task to try to define instrumentation." Both instrumentation and automation are such broad fields that we have had to break them down each time.

But I will in the preliminary to my talk break down the field of automation, so as to delineate the field in which instrumentation plays the most important part. Without trying to define it, I think I can offer some comments that might help.

In order to do this, I intend to consider automation as breaking into two main aspects. This, incidentally, is a little different than the general approach taken at the first hearing by certain speakers, where I heard it broken down into the four aspects, which were, as I recall, mechanization, continuous process, feedback, and rationalization. I think those overlap and confuse the picture a bit.

To me, therefore, the whole field seems to resolve itself into two distinct aspects. The first of these is usually referred to as mechanization and has to do with the replacement of men with machines, with the shifting of the labor population from the line to the staff functions of production. This aspect of the problem occupied most of your attention during the hearings of 1955, and, quite naturally, highlighted those problems which the public associates with technological change and automation.

The second aspect of automation, and the one which we are mainly concerned with in the present hearings, has to do with the control of our technological processes in order to optimize their operation. Mechanization is usually a prerequisite to effective control and, to follow the pattern presented by Mr. Jones yesterday, it can be considered as an extension of our human capabilities to produce motions, force, and work—our muscles, in other words.

Instrumentation and measurement can be said to be extension of the human senses. Systems engineering and data processing which I am covering more particularly, extend our mental capabilities, such as memory, mathematical manipulation, comparison, and decision making.

It is not necessary to have mechanization, instruments, or automation of any type in order to produce a product, if the process is a simple one. A tailormade suit is an example of a completely unmechanized, purely manual operation, and there will always be many activities which will require skilled manual artisanship. As a matter of fact, the increase in leisure due to technological progress in itself creates new demands for such custom-built products, as a byproduct of our ever-increasing standard of living.

Now, if it is a simple process but we wish to produce it in large quantities, we can usually mechanize it in order to produce it economically.

If, however, there is any complexity in either the product or the process, then the end product, while it may be produced cheaply, may not have the desired quality, and the entire operation may break down for lack of control. In such a case, one must apply feedback techniques to effectively control the process and produce the desired result.

To apply these techniques, we usually start out by having the systems engineer analyze the process, lay down the basic rules of operation, and set up the standards and goals. Instruments are utilized to keep us informed as to the status of all the variables in the process. A data-processing system gathers this mass of information, correlates it, compares it with the desired goal, and, finally, makes the necessary decisions so that we can adjust the process and produce the desired result.

In a way, these same principles apply to all human activity—not merely the means of production—and this is why the feedback concept has made such a powerful impact on our thinking during this last generation.

Feedback is the key to successful activity, whether human or machine. It makes a science of acting from present experience, rather than from some preconceived plan. The concept is so powerful that there are many who feel that it is broader than the popular notion of automation, with its emphasis on mechanization and replacing of men with machines.

Norbert Wiener used the word "cybernetics," taken from the Greek word "the helmsman," to describe this science of feedback control and information theory. Unfortunately, the public press has glamorized the word "automation," and expanded its scope so broadly that we really have no alternative but to continue to use it as an American colloquialism for technological progress.

In applying the principles of systems engineering, we may utilize a high degree of mechanization and thus produce considerable laborsaving. Likewise, data-processing equipment is often utilized as a tool for reducing clerical work in offices.

In the early stages of the application of these techniques, we will hear a great deal about this aspect of the problem; that is, the laborsaving aspect. We soon tend to reach a limit of the amount of capital expenditure that one can justify on a pure laborsaving basis.

The concern over laborsavings tends to blind us to the fact that there are many industries and activities in which labor is no longer a significent element of cost. The efficient conversion of raw materials and natural resources into usable and salable products and the effective utilization of our capital facilities are really the major problems that face many industries. As a matter of fact, these are problems even in many industries where labor is a large factor.

Much has been said about the "continuous process" industries and the "flow" concept of production. The chemical and refining industries and electric utilities fall in this class and, as you know, are almost completely mechanized. The paper, steel, textiles, and plastics industries are becoming highly mechanized, but their operation has not yet become as completely continuous as in the processing industries.

Recently, the so-called Detroit-type automation has been developed to introduce continuous material flow to parts manufacture, but the capital costs are usually high and the applications have been largely limited to standardized items produced in very large quantities.

The general rule is that the more continuous the process, the less the percentage of direct labor cost—and in modern refineries the direct labor cost is today only 3 to 4 percent of the product value.

In the more modern and larger chemical and processing plants, the same general picture holds, although there are many small plants which are not continuous and which bring the average labor cost up. As a matter of fact, the average labor cost for the entire industry is not much more than this.

It is also interesting to note that maintenance costs are averaging about twice as high as direct labor, so it hardly seems as though a "second industrial revolution" could result from further savings in manpower, particularly in continuous-process operations.

You probably recall statements made at these hearings that seem to indicate that these plants are operating so effectively that it hardly pays to add more automation. Actually this is not so at all, but the information on this point is very difficult to gather because most of these processes in the chemical industry are rather secretly guarded.

The fact is that most modern chemical processes are operating at conversion efficiencies to a point where recoverable losses are often greater than the entire direct-labor cost, and in the case of some of the newer products, many times greater.

Increases of 10, 20, and 30 percent, and even more, would be attainable by many such plants if truly effective control were possible. I know of many such plants, from my own personal experience, and I have checked this with operating engineers all over the country.

Petroleum refineries do not show such losses, of course, because they are so well standardized, but even there substantial improvement could result if their reactions to short-term changes in supply and demand could be handled more efficiently.

Refineries can usually correct their mistakes by blending and rerunning certain of their products, but this is costly—both in yield and tankage cost. As raw materials get scarcer and more costly, the pressure for better conversions and reduced capital costs will increase.

From the long-range viewpoint, we can expect something like this to happen in industries whose processes are even less continuous in their nature. At first the emphasis will be on the replacement of men with machines, but in a few years the more obvious and sensational opportunities will begin to disappear and it will take more and more effort and greater capital expenditure to produce appreciable labor savings.

Eventually, commerce and industry will find that the cream has been skimmed off, and they will begin to think of automation in its proper perspective—or I should rather say in its other perspective—as a tool for better and tighter control of production.

I feel, therefore, that the greater need today in industry is to find means of reducing waste in raw materials and capital equipment. I think this is true even in many industries where labor cost is a large factor, but in the chemical-processing industries it is our only hope for real progress.

I might add, that I am referring to progress through increased production. I do not want to give the impression that the research work in those industries is not also an important part of the problem.

Now, while there is general agreement that this problem exists, there are some serious misconceptions that raise doubts as to our ability to solve them. One of these arises from the relatively high degree of mechanization and instrumentation that already exists in the petroleum and chemical industries. Many feel that they have gone as far as they can go, and that they have reached a saturation point in automation.

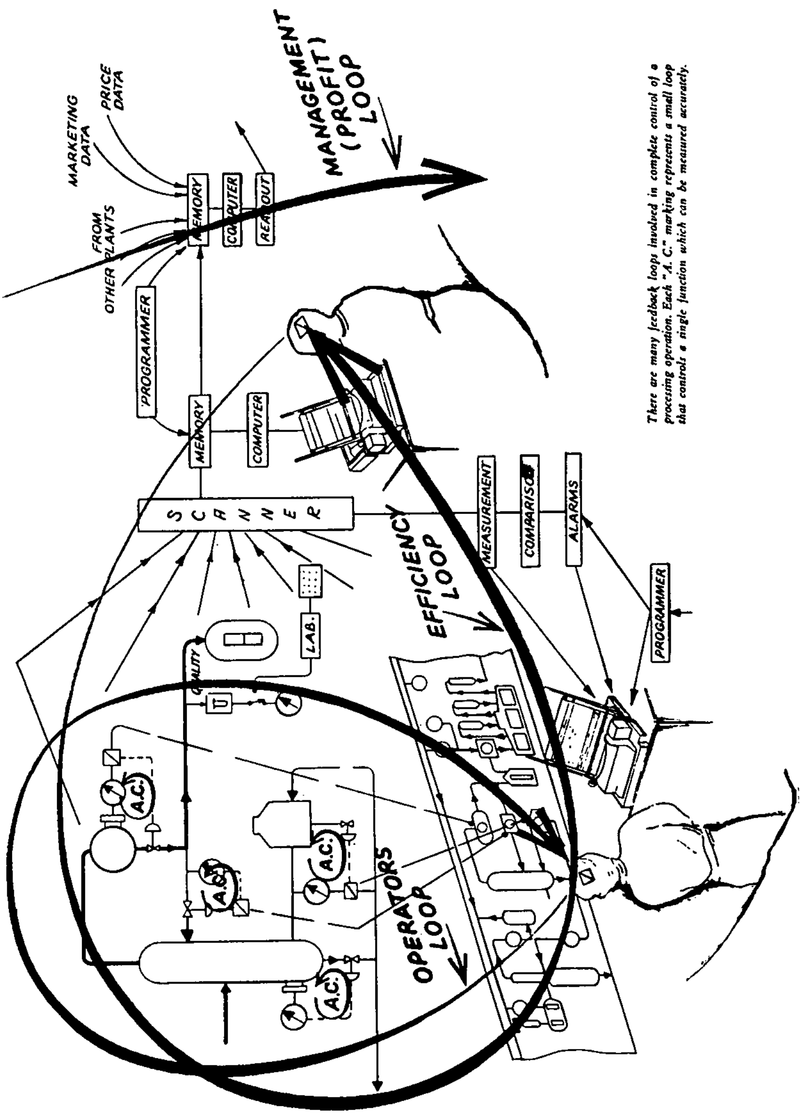
Such a notion is completely erroneous. The fact is that there is very little automatic control in these plants, except at the very lowest levels of operation, and at management levels there seems to be no effective control of operations at all, in the scientific sense of the word.

I would like to describe in a general way the management and operation of a typical industrial plant. I will use a chemical process as an example, but the general principles will apply very largely to any highly organized technical activity.

I have brought figure 1 to show schematically how the individual steps of the process intertwine with each other to form a complex, continuous process.

Each step in the process can be thought of as a closed loop of cause and effect, a feedback control loop in which (*a*) the result of that step in the process is measured, (*b*) fed back and compared with the desired result, and (*c*) if they are not identical, that is, if error exists, then a decision is made as to the action to be taken to eliminate the error and produce the desired result.

(The chart is as follows:)



There are many feedback loops involved in complete control of a processing operation. Each "A. C." marking represents a small loop that controls a single function which can be measured accurately.

This, in essence, is the process of control and for all practical purposes it can be considered as the process of effective management.

In figure 1, I have indicated by the various loops that it can be broken up into four echelons of management, using the word "management" very broadly there.

The largest loop represents the plant manager, next the technical staff, the third the operators and, finally, the laborers or automatic controllers—depending upon the type of process involved.

Let us see how automatic each of these four echelons actually is in a typical up-to-date plant.

The laborers or automatic controllers (the smallest loops), deal with operations that are quite simple and which satisfy the three important conditions for complete automatic operation. These conditions are:

1. They can be measured with sufficient accuracy, reliability, and speed.
2. They are adequately mechanized.
3. The correlations between measurement and correction are definite, simple, and quick. Under these circumstances the machine can make adequate decisions; as a result, these operation are practically always controlled by automatic machines.

One of the most important considerations is the time element that characterizes these functions. Time constants range from seconds in most cases, to minutes for the more difficult (and less highly automatized) functions. The time constant is the measure of the speed with which the process reacts and when it exceeds a few minutes the effectiveness of automatic control is greatly reduced, especially if there are significant disturbances to be coped with. Considerable human attention is usually required to keep such units in operation.

The operator (the next echelon) supervises the complete unit to see that everything is functioning properly and safely. He usually has a centralized control board with instruments, alarms, et cetera, which he reads and compares with the instructions from his technical staff.

He makes the decision to keep the unit onstream and counteracts the disturbances that are constantly cropping up to upset the unit. This is not an automatic operation in any sense, although he uses the automatic devices as mechanized tools to help him get the desired results.

The technical staff and the manager rely largely on the information gathered by hand on log sheets or reports. It usually takes days before they have adequate information on which to base a decision, and management gets its information weeks later, if that soon.

The volume of statistics that management needs is so great that in a typical industrial operation today, it is seldom received in time for effective control.

So we see that automatic control, even in this highly mechanized industry, only exists in the lower echelons of operation. It takes so long for the information to get up to either of the management levels that there is not even a possibility of considering automatic control today. The more complex the operation becomes, the longer the information time cycle grows, and the less chance there is for management to meet the changing conditions with anything like effective control.

Time, as often said, is the essence of this problem. There are plenty of figures and reports available to management in most plants. The instrument industry has made such tremendous strides in the last generation that management is often flooded with statistics that could be of great value if they were available in time and in usable form.

This, of course, is not a problem peculiar to any one industry. It concerns management in every field of endeavor and, therefore, in attacking the problem we can borrow techniques even from such apparently unrelated activities as the biological sciences and the statistical mathematics, and even from the Government.

Table 1 shows in a very general way how these time scales of information gathering have been gradually reduced since feedback techniques were introduced into industrial processing after World War I.

(The table referred to follows:)

TABLE 1.—*Compressing the time scale*

	(1) Automatic Controllers	(2) Operators	(3) Technical Staff	(4) Management
Prewar (1920-1940)	Sec. - Min.	Min. - Hours	Days - Week	Weeks - Months
Postwar (1945-1954)	- - - -	Sec. - Min. Hours	- - - -	- - - -
Today (1955-1960)	- - - -	Sec. - Min.	Hours - Days	Days - Weeks
Future (1960 -)	Split Sec.-	- - - -	Hours	Days

The pre-World War II period brought us the automatic controller and many refinements of instrumentation, which made automatic control of our process variables a practical reality.

The developments of the postwar era made it possible to integrate the operation of complex processes, not automatically, but by extending the capabilities of human operators through centralized control systems.

Remote transmission, miniature instrumentation, alarm systems, graphic panels, and the tremendous strides in product-analysis instrumentation made it possible for one operator to keep the most complex systems on stream.

Today, we are trying to eliminate the "hours" from the operator's time cycle by the development of quality control instruments such as spectrographs, refractometers, and so forth.

At the same time, we are trying to bring the technical staffs their reports within hours and days, and management its reports within days and weeks.

This is where the big push for data processing stands and will be the next few years. The last column labeled "Future" indicates that we soon hope to process all the information needed for control—even by top-level management—within a matter of hours and days.

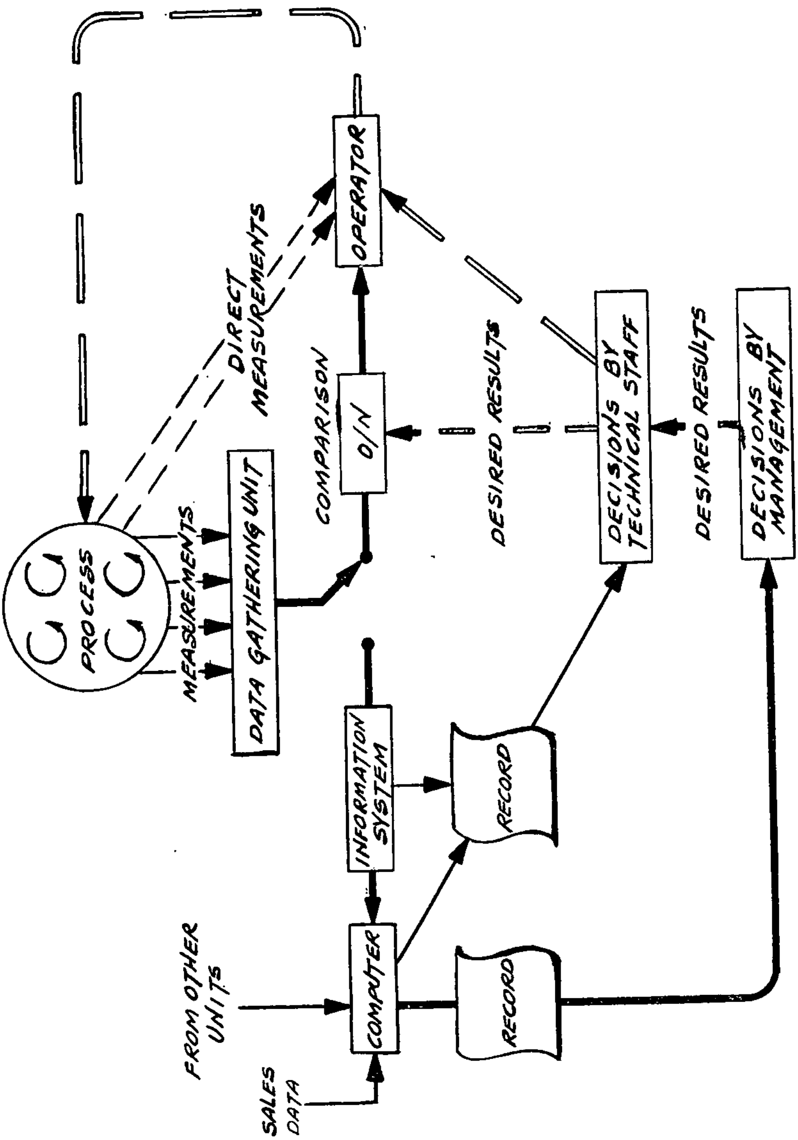
This, I think, is as far as we will want to go. It will furnish management with the information it needs, in usable form and in time, and the basis for effective control will have been accomplished.

At this level, there is very little serious thought of attempting to make decisions automatic. First of all, the cost and the complexity would be such that there would hardly be a possibility of economic return.

But more important, our free, competitive economy requires of management a flexibility of action which would be lost in a completely automatic system with its more rigid goals and its limited adaptability to unpredictable disturbances.

I am attaching figure 2 which shows in a general way, the role of the computer in the industrial data processing system.

(Figure 2 is as follows:)



The computer could be one of the typical electronic office machines, such as IBM, Remington Rand, Burroughs, and so forth, or it could be a special purpose machine designed for a particular type of system.

The big difference between this industrial system and an office system lies in the way data is fed into the computer. In an office the figures are punched onto cards or tape by hand, but in an industrial information system the data must be measured and gathered automatically, 24 hours per day and 365 days per year.

This poses many new problems for the instrument engineers, since the success of the entire system depends on accurate and reliable primary measurements.

What are the problems today? You have been made well aware of the difficulties that faced industry in finding technically trained people who not only can man these new tools of production, but can also conceive, design, build, and maintain them.

This problem is even greater when we are concerned with this more sophisticated aspect of automation—the application of feedback techniques.

The science of automation has become so complex that a new approach has come to the forefront in the last decade—the team approach—as contrasted with the older concept of the expert, the inventor, the designer.

Systems engineering has been developed as a scientific method for producing an optimum result, using any techniques that it finds available.

Today, this involves such a variety of methods that it is becoming almost imposible for one man to understand them all, let alone be an expert in their application to technical problems.

Systems engineering, therefore, gathers together the scientists, mathematicians, engineers, technicians, and welds them into a team capable not only of conceiving an optimum solution to the problem at hand, but also of designing it, building it, putting it into operation, and maintaining it, if necessary.

New organizations have had to develop in order to fill these needs; and a new type of engineer has come to the front, the man who can think beyond the limitations of available hardware, and use every resource on his team to "do what it takes."

Such a man must have understanding and background in order to formulate his goals clearly. He must have enough creative imagination to hurdle the roadblocks of tradition and, yet, have the innate conservatism to draw on the experience of the past.

He must be able to carry out his mission, design, build, buy, erect, and operate his project.

This is a pretty good description of the successful entrepreneur of American industry, and describes quite well the men who pioneered the industrial enterprises that made us the great power of the world.

Now, however, industry has reached the stage of complexity where we must train such men by the thousands to create and build the industrial plant of the future, and we are not making sufficient effort to get them.

True, the military have helped and have encouraged many fine systems projects; and certain of our schools are well aware of the problem.

A few schools like Massachusetts Institute of Technology, have done a good job, and the guided missile projects all have made much progress, but industry has had only a trickle of the benefits so far.

Our schools, while they are aware of the problem, need help not only in maintaining teaching staffs, but in doing the basic research that is so badly needed to keep this dynamic science alive and able to meet its evergrowing problems.

Incidentally, the very nature of the problem has encouraged the growth of many small enterprises, ranging in size from 1 man up to 100 or more, and industry has gone to these men to solve many of their special problems.

My own company grew up in this way, almost through no conscious effort on my part. After 15 years of experience as an instrument designer, followed by several years of plant and process design, the war brought me a problem of information-gathering on a large scale that simply could not be solved by stereotyped methods.

The men who conceived—or rather brought me the idea—were not the least concerned with laborsaving. They were dealing with a process of such complexity and danger that they simply had to devise a means of bringing the thousands of pieces of information needed to control the system before one man. It made no difference if it took more men to operate and maintain it, the important thing was that one man should be in a position to make decisions in time to act and control.

My company has grown, as have many others who have entered this field, but the problems have grown faster than we have. Today, we can only undertake a small fraction of the problems in systems engineering that are put before us, even though we now have a few hundred men involved in designing, building, installing, and maintaining these systems.

We simply cannot find enough men with the ability and training to cope with the problems that are put before us, and other companies are faced with the same dilemma.

Of course, we will find a way but it would be a much healthier situation if we could really utilize our manpower to its fullest capacity.

Another interesting aspect of this situation has been the problem of maintenance. This has created such demands for technically trained personnel, that we have found it necessary to take over the maintenance in the field, not only of our own equipment, but of the entire instrumentation and data processing in certain industrial plants.

If we can solve this technical manpower bottleneck, we can move ahead; and certainly one great service that Government can perform, is to promote the educational activities that have been outlined so well by other speakers at these hearings.

Bringing information to management for continuous control is not a new idea, but the systems themselves are just coming out of the development stage. There are a half-dozen or more companies offering systems of this general type and many more are making vital components.

So far, the few systems that are in operation have been only partial solutions to the problem, and even these have been in industrial plants for only a year or so. As far as I know, the first comprehensive system, involving a complete, large refinery is now being installed, and will be in operation within the next few months.

Because of the technical nature of the problems involved, we have not only had to design and build the system, but install it and take over its complete maintenance for an indefinite period.

This will have to be done quite generally, because users simply do not have the trained personnel to maintain this apparatus by themselves.

This places a strain on the resources of technical staffs of the manufacturers, and the future of this entire development depends on being able to educate and train men capable of engineering and operating these complex electronic systems.

I would like to say a word about the attitude of labor organizations to the introduction of automation and data processing systems. My company is very involved with labor problems, not only in respect to the men who use them, or might be displaced by them, but also to the men who install and maintain them.

We have had to solve many problems, but I can say unequivocally that the labor organizations with whom we have been involved have helped us to solve them as they came up, without raising any roadblocks.

By this, I don't mean to say we have had no difference of opinion. We have had our share of negotiations and discussions, but these have always been part of the normal give and take of industrial relations.

My experience leads me to feel that the responsible labor organizations sincerely want us to enjoy the full benefits of technological progress. There is certainly nothing incompatible with this and their desire to cushion the shock of any local and short-term dislocations that might result from any sudden changes.

I think it is just as important that the public at large understands the change in management attitude during this same period. I think it goes much further than the change from the shrewd entrepreneur to the executive planner and coordination, which I think was discussed quite fully in some of the previous hearings.

I am a relatively small industrialist but I deal mostly with large organizations, and I have been constantly made mindful of their growing awareness of their responsibilities to the public at large.

This is not pure lipservice for the sake of public relations, but a real understanding that organized labor and Government can be helpful and willing partners in this struggle toward technological progress.

I have listened to many discussions of labor problems by management that would have been unheard of 30 years ago, and I am sure they can solve their problems, including those under discussion, without the need of direct legislation bearing on this problem.

Aside from direct legislation on automation, there is much that the Government can do, and must do. Messrs. Sheen and Jones have outlined a number of Government actions which I think are highly essential and which I would highly recommend for your consideration. These have been so clearly stated by them that I do not feel it is necessary for me to repeat them.

In connection with the comments which I enjoyed hearing so much yesterday, I would like to discuss two points which are not part of my prepared testimony.

One of these is the question brought up by Mr. Jones yesterday regarding middle-sized companies. I think you will recall the discussion.

Then there is a scattering of companies doing from 50 to 75 million dollars per year, and finally we have the several very large companies whose annual business is between one-quarter million to half a million.

This presents a slightly different picture from that which you will find in most other industries, and as Mr. Jones has pointed out, there are many middle-sized companies large enough to deal directly with the armed services as prime contractors, and I think a study of their problems might be helpful.

In view of the fact that the record has to be closed by December 20, I realize that it will not be possible to have this study available at this time. However, I understand that we will have another opportunity to put this information into the record at a later date so I should like to be excused at this time, but will submit the study for your consideration at a later date.

The other point that I would like to discuss is the question of the role of the armed services that was brought up yesterday.

As you will recall, a statement was made regarding the number of technicians that the Soviet Union was training, 1,600,000 per year, as conrasted with 50,000 per year that our schools were training.

I find it difficult to believe that Russia is doing 32 times as well as we are in this respect and I have, therefore, made some inquiries from the armed services themselves. This is not because I think we are training a sufficient number of technicians, but rather because it is better to base our conclusions on realistic and factual premises. I learned that the Army itself has trained 66,432 technicians during the last fiscal year. They also estimate that the total number of technicians trained by all the armed services this year, is approximately 150,000 men.

Chairman PATMAN. Are they principally inducted men?

Mr. SPERRY. These are all enlisted men—no officers. All enlisted men. This represents——

Chairman PATMAN. Of course, you have no way of knowing whether they were inductees or enlisted. It does not make any particular difference.

Mr. SPERRY. I did get one impression there I could give you——

Chairman PATMAN. Go ahead.

Mr. SPERRY. A comment, and that is, that the Army is having many discussions about whom they should train, and one of the big questions is: Should they train inducted men or enlisted men?

Chairman PATMAN. That is the point I wanted you to discuss.

Mr. SPERRY. From a realistic point of view it is in their interest to train the men who enlist for a long term, not the inducted men.

Chairman PATMAN. For long-term men?

Mr. SPERRY. Yes. It takes 15 months or more to train men of this type. If he is going to be out in less than 2 years, this is not a very efficient method from the strictly military point of view.

The man that is going to be a professional soldier, or at least going to be in for 3 or 4 years, is going to return dollars and cents value to the Army for his training.

This is a rather understandable viewpoint. The Army, if it has to use its budget in a limited way, I presume wants to get returns from the men it trains.

Unfortunately, this does not help our national situation quite as much as it could.

I should like to illustrate this from my own experience. I am a small industrialist and my company employs probably from 60 to 70 technicians, and we would have been lost in this division of our business if we had not been able to get servicemen who had been trained as electronic technicians. This has been our biggest reservoir of supply, and by far the big majority of our technicians got their training in the armed services.

I would like to make this point very strongly, because while we have heard many suggestions during these hearings, that offer tremendous possibilities for the distant future, all of which I heartedly concur with, here we have a mechanism that is working today although not as an instrument of national policy. It is an instrument of Army policy.

Here is a basic mechanism that is training some 150,000 men every year. Incidentally the men who gave me this information asked me to emphasize the point that these trainees are highly trained technicians. They suspect that in the Russian figure of 1,600,000 there are so many mechanics, armorers, and people who repair rifles and machine guns. The armed services figures do not include those.

This figure of 150,000 are true technicians, the type of men we need in industry.

My estimate of the total number of technicians trained each year, not including those being given on-job training by industry, would be as follows: 150,000 men trained by the armed services, plus 50,000 men trained by our vocational schools, and approximately another 50,000 being trained by the Government for civilian duties. This last group I estimated on the basis of Army Progress Report 4–B on Civilian Personnel. This adds up to a grand total of approximately one-quarter million technicians per year that we are training in this country exclusive of those being trained by private industry.

I think if you take that figure of a quarter million we can still say that Russia is 2 or 3 times as well off as we are in that respect.

Chairman PATMAN. But if you reduce their number by eliminating the mechanics, it is possible we would be closer together.

Mr. SPERRY. We are closer together but they are still ahead—it seems to me that it is a sufficiently startling figure that they are twice as far ahead. To me that is the estimate that I would make after talking with these men.

Chairman PATMAN. That is very shocking itself, that is shocking.

Mr. SPERRY. I think that is more than shocking. I think it is dangerous. When I hear a figure such as 32 times as many, I begin to discount it so much that I wanted to get the real meat out of this. I want to point out that you can discount it all you want and it is still a shocking figure.

I thought it would make the record clearer.

Chairman PATMAN. Yes, sir; we are mighty glad to have that information.

Mr. SPERRY. I think that if there were some mechanism—and this discussion came up too recently for me to try to tell Dr. Moore or you just how this should be done—of making this training program more of an instrument of national policy——

Chairman PATMAN. You mean insofar as the inductees are concerned?

Mr. SPERRY. Insofar as the inductees are concerned. Russia is undoubtedly doing it.

Chairman PATMAN. Of course, they do not have inductees, I do not suppose, except permanent inductees?

Mr. SPERRY. Well, I don't know.

Chairman PATMAN. I do not know what kind of system they have.

Mr. SPERRY. They have some conscription or something of that sort.

Chairman PATMAN. Yes. I assume they use something like that. But, of course, the Army's viewpoint—I can see their viewpoint, they are operating on a limited budget. And they do not want to train people and spend all of the money on them that they have to spend to train them in these trades unless they can keep them and get something out of them and if they are just in for 2 years and the inductees are in for a less period than 2 years, why they cannot see their way clear to do that, to spend all of that money out of their budget.

It occurs to me, though, as a matter of national policy, like you have just mentioned, that Congress should consider encouraging them to do it, although the Army itself might not get its money's worth, the Nation will be helped by it. That is your point; isn't it?

Mr. SPERRY. That is exactly the point. I see this——

Chairman PATMAN. It sounds very reasonable to me.

Mr. SPERRY. It has such an immediate possibility of returns because the mechanism is there. An organization that can train 150,000 men, whereas the whole educational picture only trains 50,000 technicians, certainly can be made into a useful tool. In spite of the Army's dislike for our doing this, we are finding it useful, even to the limited extent that they are available today.

If I were in the Army, and had a limited budget I would feel exactly as they do. Incidentally, the men who talked to me about this yesterday said, they have had months and months of argument as to whether they should go one way or the other and they are not unanimous as to which is the best policy.

There are many people in the Defense Establishment who realize that industry is part of its arsenal. They are not losing these men entirely when they send them back to civilian life as technicians for building essential goods.

For example, in my company over half of our output goes right back to the services. And we are basically suppliers of industrial types of equipment.

I would say that the bulk of our outpost goes back to the defense effort in some way or other.

Chairman PATMAN. Could we separate items like that in the budget and just admit that this is not really military—this part is not. That part should not be charged to military. And in that way, possibly, we could encourage them to do more of this in the armed services.

Mr. SPERRY. It occurred to me that there are already bills before Congress which have to do with our educational program.

Chairman PATMAN. Yes.

Mr. SPERRY. These are not unrelated problems.

Chairman PATMAN. That is right.

Mr. SPERRY. You are spending money, and are proposing to encourage education in engineering. Yesterday you heard a very fine case made for the need for scientific education.

This case has been made so well. But there should be some way of tying in our general educational program with regard to the sciences, with the immediate work of the Army, where there is this existing mechanism. It would seem that it would be possible to convince the Army that the long-range viewpoint of training men for industry is just as much a part, as the training of men to be Signal Corps men, and Air Corps technicians directly.

Chairman Patman. And we should certainly discourage the lack of use of these men, and using them for jobs you know—you know anyone can perform.

People who are qualified to receive training like this—in other words, it is not only helpful to the young men but to the entire Nation.

It occurs to me that we should encourage the armed services to better utilize these inductees, particularly along the lines you have suggested.

Mr. Sperry. There is one other factor that could us back if Government did not implement its declared policy of maintaining free competition, in this instance, among the builders of the tools of automation.

The entire concept of systems engineering and integrated information processing for management would fall down if the components that make up the system were not available to all on an equal basis.

No one company, no matter how large, can corner the know-how in this dynamic field, but it could hold back progress by restricting the free use of one vital element.

I have pointed out, and Mr. Jones pointed out yesterday, that the complications of research and development are such there are going to be many proprietary things developed by large organizations which the smaller companies that you heard talk about are not going to be able to handle, are not going to be able to get into.

The patent structure has become so complicated that small companies frankly just give up in frustration. We have heard a lot about patent-consent decrees that the Government has obtained, and I certainly think that one way in which this committee could be very helpful would be to make sure that, both in regard to the patents and the effects of price discrimination under the Robinson-Patman Act, the companies who entered this field of systems engineering had available to them every possible component.

That is usually true, but it is not always the case in this industry. And as this thing gets more complex and these proprietary components are built up more and more we are actually going to be faced with a problem of getting them on an equal basis.

The Federal Trade Commission is beginning to be conscious of this problem. They have just begun to discuss this with the instrument industry. Perhaps in the next year or two this might well be a phase that you might look into further.

May I say in closing that these hearings, and the excellent report of your committee on last year's hearings, have already done a great deal to clear away much of the confusion and misunderstanding in the public mind with respect to automation. This is feedback working at its best, and it bodes well for the future of our economic system.

Chairman Patman. Thank you very much, sir. We appreciate your testimony. It will be helpful to us.

Mr. Sperry. Thank you.

Chairman Patman. Thank you very kindly, again, sir.

Mr. SPERRY. Thank you, Mr. Patman.

Chairman PATMAN. Dr. Moore, will you introduce Mr. Kirkbride.

Mr. MOORE. Mr. Chalmer Gatlin Kirkbride appearing before the committee is a past president of the American Institute of Chemical Engineers. At the time he was invited to appear he was president of the Houdry Process Corp. but since December 1 has been executive director of research, patent, and engineering department of the Sun Oil Co. Mr. Kirkbride was graduated from the University of Michigan with B. S. and M. S. degrees in chemical engineering. His professional career involves not only industrial but academic experience. He was a distinguished professor at Agricultural and Mechanical College in Texas for 3 years; also he served for 13 years in the accrediting committee of the American Institute of Chemical Engineers. So we will have somebody from Texas.

Chairman PATMAN. When were you in Texas?

Mr. KIRKBRIDE. Well, I lived in Texas for 12 years but I was in Texas at Agricultural and Mechanical from 1944 to 1947.

Chairman PATMAN. If you do not mind, we always ask anyone what part of the State were you from?

Mr. KIRKBRIDE. I lived in three parts of the State. I lived in Galveston for 8 years, and in Dallas for 2 years.

Chairman PATMAN. They are good parts of the State. There are no bad parts, as Dr. Moore reminds me. Sorry you had to leave Texas but we know that you are engaged in a fine work or you would not have done so.

You have a prepared statement, I understand, which we will be glad to hear in any way that you wish to present it.

STATEMENT OF CHALMER G. KIRKBRIDE, EXECUTIVE DIRECTOR, RESEARCH, PATENT, AND ENGINEERING DEPARTMENTS, SUN OIL CO.; PAST PRESIDENT, AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

Mr. KIRKBRIDE. I am appearing before your committee as a past president of the American Institute of Chemical Engineers. At the time I was invited to appear, I was president of Houdry Process Corp.; therefore, I do not necessarily reflect the views of Sun Oil Co.

In the petroleum industry, automation is looked upon as a word recently coined to lend popular appeal to a practice which has actually been a commonplace for many years. It is generally accepted as a logical advancement in the use of automatic controls.

Basically it represents the application of a relatively few mechanical, electrical, chemical, and hydraulic principles, through devices of varying complexity, for the accomplishment of a desired result in a continuous or repetitive process.

The use of industrial instruments generally, and automatic-control instruments particularly, has reached an advanced state of application in the petroleum-refining industry because of factors which are peculiar to that industry.

First, the scale of operations in petroleum refining is necessarily large, and these operations deal almost entirely with the handling of liquids, gases, and fluidized solids.

Second, petroleum refining is made up primarily of continuous processes, and refining units usually are closely interrelated.

The development and use of automatic controls in the petroleum industry form an interesting chapter in the story of the development of the industry itself. The remarkable growth, and the intense competition which has characterized the oil industry, presented many complex problems. The ingenuity of engineers in the petroleum industry has been taxed to the utmost to meet the demands of our modern industrial age for a mobile source of energy, lubricants for every conceivable use, and special products in great numbers—and always at the lowest possible price.

It has been possible to meet these enormous demands only by inventing new processes, by designing larger and more efficient operating units, by combining related processes for increased efficiency, and by integrating operations to balance supply and demand, both in the short and long range.

In doing so, the growing complexity of these processes has spurred engineers to seek constantly for new ways to release plant operators from duties that reduce or restrict their freedom of action and thought. Thus, wherever possible, item after item in plant operation has been subjected to automatic or semiautomatic regulation.

Today's complex refining units combine many operations within one coordinated whole. Most operating units in a modern refinery also are related more or less closely with one or more other operating units.

This is where the centralization of control is of real value. The availability of data from the various operations at one location makes it possible for the operator to reach important conclusions from an evaluation of relative facts.

Through the use of centralized controls, refinery operators today have time to think, to know their plant, to recognize malfunctions, and to make the adjustments necessary to keep the plant "on the line." And they have a new dignity which goes with the responsibility attached to being entrusted with a multimillion dollar installation.

Over the past 30 years, the development of control methods and devices has gone through a continuous evolution, paralleling to some extent an evolution in petroleum refining. In fact, some of these developments have been so rapid as to be considered revolutionary.

Both Sun Oil Co. and Houdry Process Corp. have been especially instrumental in bringing about what might be termed the "catalytic revolution" which unquestionably has changed the nature of the oil industry.

INDIVIDUAL PRODUCTIVITY

One of the most obvious changes in petroleum refining over the past decade has been the increase in crude charging capacity. Daily crude runs to United States refineries have risen from 5,075,000 barrels per day in 1947 to 7,480,000 barrels per day in 1955.

In the same period, total refinery employment has increased from 189,000 to 201,000. It is evident from these figures that productivity has increased.

The great increase in crude runs from 1947 to 1955 has been accomplished primarily through the use of larger, more efficient units. But this increase in crude runs to stills is not the whole picture. It has been accompanied by the development of more complex processes for the manufacture of a variety of new products, such as petrochemicals, which have enabled refiners to increase the value added by manufacture to each barrel of crude oil. The greater use of automatic controls and instrumentation has made possible the precise operation such new processes demand.

This expansion of refining capacity and growing complexity of new processes represents tremendous sums in capital investment by refiners. According to Chase Manhattan Bank estimates, capital expenditures in refining from 1947 to 1955 reached the staggering total of $4,800 million.

Based on Chase Manhattan Bank figures on annual capital expenditures in refining, and Bureau of Labor Statistics employment figures, the gross investment per refinery employee in 1947 was $19,000, compared with $36,000 in 1955. This represents an increase in investment per employee of almost 90 percent.

It is evident from this that the increased productivity per refinery employee is related to the investment per employee. In other words, larger, more efficient processes, operated with the use of automatic controls and instrumentation, have enabled the refinery worker to raise his productivity. These developments have also enabled refinery workers to upgrade their skills through the creation of expanded opportunities for technicians and other skilled specialists. Consequently, as the equipment provided by this capital investment enabled the refinery employee to increase his skill and productivity, his earning power was also increased.

REAL WAGES HAVE INCREASED

The only measure of refinery wages available covers only hourly paid refinery employees. These statistics, published by the Bureau of Labor Statistics, do not include the wages of salaried personnel. There has been a gradual shift of employment to higher-paid salaried classifications, brought about by the need for larger numbers of technicians, specialists, and supervisors. The growing use of instrumentation and process complexity has created this need.

But purely on the basis of statistics covering hourly paid refinery employees, the Bureau's figures show an increase in the average annual money wage from $3,270 in 1947 to $5,200 in 1955—an increase of about 60 percent. In real annual wages, adjusted for the increase that has taken place in the consumers' price index, the gain is from $3,420 to $4,540, or 33 percent, in the same period.

The position of the individual refinery worker, therefore, is much better today than it was in 1947, based on dollars of constant value. But it is significant to consider not only his improvement in wages, but also his position in relation to employees in other industries.

Again based on the Bureau of Labor Statistics, we find the refinery worker among the highest paid in American industry. Whereas the average hourly wage for all manufacturing employees in 1955 was $1.88, the average hourly wage of petroleum refining employees was $2.46, an appreciable difference.

INVESTMENT IN INSTRUMENTS

We have no accurate figures on the investment in instruments in relation to total refinery capital now being employed. However, from a study of available information on a number of refinery units for which we have no data, we can conclude that there has been no discernible trend in the past decade in the percentage of total investment represented by instruments.

While the investment in instruments, in relation to total investment in refinery units, varies considerably in individual cases, we believe that a minmum of 3.2 percent and a maximum of 4.2 percent would be representative of 95 percent of all refinery installations made in the past decade.

In the following table we have attempted to give this committee an idea of the magnitude of investment made each year by the petroleum refining industry in instruments by applying the average percentage of 3.7 to the annual expenditure data of United States refiners.

Financial data for petroleum industry in the United States

[In millions of dollars]

Year	Capital expenditures in refining [1]	Gross fixed assets in refining [1]	New investment in instruments per year
1955	$835	$7,175	$30.9
1954	800	6,400	29.6
1953	675	5,850	25.0
1952	470	5,300	17.4
1951	325	4,750	12.0
1950	275	4,600	10.2
1949	420	4,375	15.5
1948	600	4,150	22.2
1947	400	3,600	14.8

[1] Source: Chase Manhattan Bank.

From this table, it can be seen that annual expenditures for new instruments have increased steadily, but there probably has been no disproportionate increase in investment in instruments as compared with productive facilities as a whole.

The same instruments can control a process whether its capacity is 5,000 barrels per day or 50,000 barrels per day.

Thus, the increase in productivity of the individual refinery worker seems most closely connected with the increased tempo of industry investment in expanded refinery capacity.

EXAMPLES OF PROCESSES TOTALLY DEPENDENT ON INSTRUMENTATION

Since 1925, the petroleum refining industry has gone through a major revolution in which the production of high-quality distillate products from a barrel of crude oil has risen about 30 percent to a possible high today in special situations of 85 percent.

This latter figure, of course, does not represent the current United States average since this is a function of the demand for residual products such as asphalt and Bunker C fuel.

In 1925, refining units were largely manually controlled, supplemented by rudimentary automatic methods which operated to a degree of accuracy entirely adequate for the time.

In 1937, the introduction of catalytic cracking on a large commercial scale at our Marcus Hook refinery created a necessity for automatic control and measuring devices of far greater complexity and precision than had been previously necessary.

Fortunately, instrument manufacturing technology had by then developed to the point where instruments of the required quality—with a few notable exceptions—were available, even though processes for their use had not been generally adopted. The development of instruments in the few excepted categories was accomplished quickly after the need became evident.

For example, our first catalytic cracking installations required programing instruments which were capable of precisely operating some 45 large gate valves according to a very rapid time schedule and with absolute reliability. The success of the process depended upon the precise and reliable operation of these valves.

In addition, the yield and distribution of products from the process was further dependent upon maintaining a very accurate temperature control and flow control of the crude oil vapors and regeneration gases to the catalytic reaction cases.

It is safe to say that without automatic control devices, the catalytic cracking process would have been an impossibility. It is of significance to note that it was this process which supplied the major amount of aviation gasoline blending stock for our Nation in World War II.

The development of other catalytic processes in the years following was also dependent upon precise control of operating variables in the refineries. I believe it is fair to say that virtually no modern refinery could be operated at economically efficient levels today without automatic control instruments.

I say this, not from a consideration of the labor costs which would be involved if one were simply to try to encompass the operation of modern refining units with men rather than machines. Rather, the precision and speed of operation required by today's processes are such that human operators would be incapable of performing the tasks.

Specific examples of processes wherein automatic control is indispensable might include all presently practiced forms of catalytic cracking, precision fractionation, catalytic reforming, high-quality alkylation, lubrication-oil manufacture, and solvent-treating processes.

INDUSTRY TRAINING

The petroleum industry, in cooperation with a number of instrument manufacturers, has had a very effective program of on-the-job training for personnel to handle the servicing, installation, and application of control instruments for at least 25 years.

This program has been entirely adequate for these purposes, and I believe that, even in today's rather competitive market for technical skills, the petroleum industry is holding its own in this regard.

In recent years, the petroleum industry has not been able to man and carry out instrument-development programs aimed at the creation of newer and better instruments to the extent that this would be either possible or desirable. The instrument companies themselves have done a reasonably good job of attempting to supply new instrument ideas to the refining industry, but frequently their success in doing so has been reduced by the difficulty of obtaining proper communication between the refinery technicians and the instrument-development people.

More recently, the Instrument Society of America has served as a common meeting ground for people in manufacturing industries such as the refining industry and technicians in the field of instrument manufacture. It is reasonable to expect that in time a good liaison will be established.

The training by petroleum refiners of scientists and engineers who are capable of understanding and dealing with the problems of automatic control has proceeded quite smoothly over the past 25 years or so. It is apparent that an industry which has utilized instrument control to the degree used by the petroleum-refining industry would have had to develop its own scientific and engineering specialists.

Up until the very recent past, there has been no great shortage of these people because there has been no aggravated shortage of young scientists or engineers in the petroleum industry.

The rapid expansion of our economy from 1945 onwards, coupled with the low volume of scientists and engineers graduated in the years following 1946, has increased the competition for scientifically educated and technically trainable manpower in all fields of endeavor.

Consequently, petroleum refiners have been unable to fill technical manpower rosters, and have been unable to train the desired number of instrumentation engineers.

The solution to this shortage of scièntists and engineers is very complex, and involves things as seemingly remote as the training of secondary-school teachers, and the motivations which impel teen-agers. The problem is only secondarily related to the impact of automation on our economy, and I rather doubt that any quantitative data on the projected need for engineers, or for instrument engineers as a specific subgroup, would be either reliable or significant.

One thing is certain. Instrumentation and automation are rapidly advancing technologies which hold forth the promise of more efficient use of the engineering talents we are producing. There is a very high order of probability that the stridently proclaimed serious shortage of engineering and scientific manpower may be really symptomatic of the birth pangs of a new era of engineering in which automation and high-speed computation will elevate the scientific professions to new levels of prestige and effectiveness.

This latter fact alone will probably attract the best of our young manpower to careers in science.

EDUCATIONAL PROGRAMS

It has been suggested that this committee would be interested in having some expression of opinion from me concerning technical education in instrumentation and automatic control.

A recent survey of some 67 colleges and universities disclosed some 1,014 different courses with content which might be classified as being primarily directed toward instrumentation and control. This would be an average of about 15 courses per institution, so it would seem that the subject is being given adequate, if not excessive, attention.

It is my feeling that the prime requisites for a good instrument engineer or scientist are sound basic training in mathematics, physics, and physical chemistry, plus specialized training in some one branch of engineering or science.

Instruments, as far as the petroleum industry is concerned, are not an end in themselves, but rather an adjunct to processing. This being the case, formal undergraduate training would be best confined to intensive training in the basic disciplines, plus one course on principles of measurement and control.

More than this, I think, would tend to overspecialization and to reduction of the quality of the basic training necessary for effective and versatile performance in the engineering profession.

PROFESSIONAL SOCIETIES

A number of technical societies have given increasing attention to instrumentation and control technology in the past 10 years. The American Society of Mechanical Engineers, through its division on instruments and regulators, has been active in the creation and promulgation of standards, the analysis of educational requirements, and in the development of the theory of instrumentation and control.

The American Institute of Chemical Engineers, which is the engineering society with which I am most familiar, has for many years recognized automatic control as an inseparable element of chemical processing. Although it has not sponsored separate studies of the industrial significance of instrumentation, the institute has maintained representation with the ASME committees in this field.

Additionally, AICE joint programs with the Instrument Society of America in 1954 and this year, 1956, have been particularly effective in serving as a forum for the publication of technical information on the design and application of control systems to petroleum refining and to chemical processing.

The general activities of ISA in this field have been particularly effective, and I believe this committee has already received information in this regard.

SOCIAL AND ECONOMIC IMPLICATIONS

I have already mentioned how the expansion of the industry and the development of more efficient refining processes, made possible to a large extent by the development and use of automatic controls, has benefited refinery workers.

Total refinery employment has increased. From 1947 to 1955, wages have risen 60 percent; and real wages, adjusted for consumer price index variation, have gone up 33 percent. Not only is the refinery worker one of the highest paid in American industry, but he also enjoys higher nonwage benefits than employees of other manufacturing industries.

One measure of his increased earning power is in relation to his ability to purchase the products he helps to produce. In 1935, with 1 hour's earnings the average refinery worker could purchase 4¼ gallons of gasoline; but in 1955, his hourly wage could purchase 8½ gallons of gasoline—exactly twice as much.

What about the consumer of petroleum products? There is no doubt that he has benefited also from the application of more efficient refining processes. Again, I will use for example the product with which we are most familiar—gasoline for the family car.

According to automotive engineers, 1926 gasoline used in a vehicle maintained at a constant road speed of 40 miles per hour gave the equivalent of 26 ton-miles per gallon. The comparable figure for 1956 gasoline is 46 ton-miles per gallon.

Thus, on this basis, it can be said that vehicle fuel economy has been improved to the extent of 77 percent from 1926 to 1956. And yet, except for increased taxes, today's gasoline costs only about a penny more per gallon than it did 30 years ago. Actually, of course, a modern high-compression automobile would not even run on 1926 gasoline.

So it can be demonstrated by example after example that the consumer has benefited from petroleum refining's progressive efficiency. Today, petroleum refineries throughout our country are using techniques and processes that were merely ideas in the minds of research scientists 8 or 10 years ago.

The powerful driving force behind this progress is competition. This competition is evident in every branch of the industry's widespread and diversified operations. Producer competes with producer, refiner with refiner, marketer with marketer, and so on through the whole chain of petroleum operations.

The objective sought in this competition is to be in position to offer better values to the American consumer in the hope of winning his patronage. This intensive competition has spurred the technical improvements necessary to provide customers with a greater variety of new and improved products at the lowest possible cost. Some of these products, like petrochemicals, have given impetus to developments in other industries.

I am sure it is obvious to the members of this committee that the expansion of refinery facilities and the increased efficiency of refining operations are of vital importance to the Nation from the standpoint of national defense.

If you will permit me just one specific example of how the Nation benefits by the advancements in refining technology, we can now wring more than twice as much gasoline from a barrel of crude oil than by old refining methods.

Stated another way, if we were still using the refining methods of the early twenties, it would take twice as much crude oil to supply the same amount of gasoline we produce today. The tremendous amount of crude oil conserved by modern refining methods is obvious.

Now, as far as the future is concerned, instrumentation and automatic control are already so solidly entrenched in the petroleum refining industry that literally no refinery today could run without a high degree of instrumentation. Despite this, today's refinery is far from being a completely automatic plant, and tomorrow's refinery will certainly not be completely automatic. Nor, in the opinion of many refinery engineers, is such an advanced development either practical or desirable.

As a matter of fact, the very nature of petroleum refining renders such a development almost impossible of accomplishment. Sparked by the competitive forces which keep the industry dynamic, changes take place with great rapidity.

Changes in technology, in raw materials, in products, and product quality; changes in operating capacity caused by fluctuation of supply and demand; changes due to the deterioration of physical plants and equipment—all introduce factors in operating control that can be satisfied by the decisions and actions of men, not machines.

On the other hand, there is much evidence to support forecasts that our work force will not increase in proportion to our population. According to estimates prepared by the Department of Commerce and the staff of the Joint Committee on the Economic Report, there will be an increase of 23 million by 1965 in our total population. But these estimates indicate there will be an increase of only 10 million in the labor force.

At the same time, it is estimated that there will be a decrease of about 200 hours per year in the average time worked by men and women in private employment. Therefore, it is anticipated that total man-hours worked in our economy in 1965 will be only about 5 percent greater than at present.

According to a projection prepared for the Joint Committee on the Economic Report, gross national product in the United States will be $535 billion in 1965. This, compared with $391 billion in 1955, is an increase of 37 percent.

In other words, to achieve an increase in our gross national product of 37 percent and to provide for a rapidly growing population, we will have available only about 5 percent more labor time than we have at present. Clearly, this presents a great challenge, and many believe that the answer lies in more efficient methods, with the use of automation to provide the increased productivity necessary.

Assuredly, tomorrow's refinery will need better instruments and instrumentation. It will need faster and more accurate measuring and analytical instruments. It will need inexpensive, reliable, and rugged computer-type instruments which can optimize processes. It will need cheaper instruments that require a minimum of maintenance. It will need instruments specially and peculiarly adapted to refinery operations.

Cooperative efforts between the research and engineering departments of oil companies and instrument manufacturers have already been initiated in these areas. The problems are generally recognized, and I am confident they will be met and solved by that balance of competition and cooperation which our free-enterprise system so uniquely allows.

Chairman PATMAN. Thank you very much, Doctor. Your testimony will be very helpful to the members of this committee, and to the Members of Congress and to the public generally.

Dr. Moore, would you like to ask any questions?

Mr. MOORE. Mr. Kirkbride, I wondered, since you have come from the petroleum industry, whether you would care to comment on a statement which surprised me a bit in Mr. Sperry's statement. I think I understand what he had in mind, but I would still like your comment.

He said, speaking of the relatively high degree of mechanization and instrumentation in the petroleum and chemical industries, and I am quoting:

> Many feel that they have gone as far as they can go, and that they have reached a saturation point in automation. Such a notion is completely erroneous. The fact is that there is very little automatic control in these plants, except at the very lowest levels of operation.

He goes on to say that at management levels they do not have these controls, and that at that level it can still be improved. But this statement, that there is very little automatic control except at the very lowest levels of operation, came as a surprise to me.

Mr. KIRKBRIDE. I would, of course, have to resort to my imagination as to what he was thinking about when he made that statement. But this is what I would conclude that he meant: Back in 1930, when I entered the petroleum industry, we had separate units for each process step. We had a separate unit to fractionate crude oil. We had a separate thermal-cracking unit to crack the heavy oil. We had a separate unit for all other process steps. Each of these units was automatically controlled in itself.

Now, as we have grown in the direction of automatic control, we have tied many of these separate operations together with a single control center. Many manual controls have been replaced with automatic controls. Even so, we could go much further; for example, in the direction of automatic-analyses of product streams. This is in a state of embryonic development, but it will no doubt come to pass.

One of the most important qualities of gasoline is its octane number. There has not been any method of combining the method of determining the octane number of a gasoline in an automatic scheme, but it is conceivable that it could be done so that one could have the octane number of his gasoline instantaneously, as it is being produced.

This general field offers a tremendous breadth of possibilities for development in the field of automatic control.

Mr. MOORE. Well, even in this industry, which is conspicuous for its degree of automation, do you think there is room for even greater automation?

Mr. KIRKBRIDE. It has had to be that way; it is the only way it could have progressed.

Mr. MOORE. Could you estimate at all, or would it be possible to suggest, how fast a pace there may be in rendering present installations obsolete? Any comment at all on that?

Mr. KIRKBRIDE. Well, I would not want to comment offhand, but the danger of obsolescence is really pretty much a direct function of the extent of research and development that is carried on; and in the petroleum industry, most of the processes that were outstanding when I entered in 1930 are obsolete today. It is impossible to compete successfully in the petroleum industry unless the refiner replaces obsolete processes with modern processes. Obsolescence is rapid in the petroleum industry, and consideration of this should be given in our tax laws to permit correspondingly rapid amortization of investments in processes that soon become obsolete.

Mr. MOORE. This final question may appear a little facetious, but how do you know your instruments are always right? I find that my watch is not always right, nor the bathroom scales.

Mr. KIRKBRIDE. Many times I have been in an airplane stacked up over Washington, and hoped that the altimeters were reading properly. Sometimes they aren't, and that is why we have to have people to think and handle the maintenance on instruments. It is a very high type of technician needed for this type of work.

That is why I contend that we can go so far in automation, but we can't go completely automatic. We must always have people to think.

Chairman PATMAN. Doctor, at page 13 of your statement you make a statement that is rather interesting. Of course, they are all interesting, but this one in particular.

What I have reference to: Dr. Seymour Harris, of Harvard, often points out that while we have a 50-cent dollar, we have 4 times as many dollars to use. I notice your statement here corroborates him to the extent, at least, that we have twice as many dollars, when you state this:

In 1935, with 1 hour's earnings the average refinery worker could purchase 4¼ gallons of gasoline; but in 1955, his hourly wage could purchase 8½ gallons of gasoline—exactly twice as much.

So while the refinery worker has a 50-cent dollar, his wages will purchase twice—he has twice as many dollars to make his purchases with.

Mr. KIRKBRIDE. The refinery worker can buy twice as much gasoline even with a 50-cent dollar.

Chairman PATMAN. Yes, sir.

Again I thank you very much for the committee, Doctor, and we appreciate it.

Chairman PATMAN. The subcommittee will stand in recess until 2 p. m., here in this room.

(Whereupon, at 11:45 a. m., the subcommittee recessed, to reconvene at 2 p. m. of the same day.)

AFTERNOON SESSION

Chairman PATMAN. The subcommittee will please come to order.

We have as our first witness this afternoon, Dr. Louis N. Ridenour, director of research, Lockheed Aircraft Corp., missile systems division, Palo Alto, Calif.

Dr. Ridenour, we are delighted to have you appear before our committee. You have a prepared statement, I notice. You may proceed in any way that you desire.

STATEMENT OF LOUIS N. RIDENOUR, DIRECTOR OF RESEARCH, LOCKHEED AIRCRAFT CORP., MISSILE SYSTEMS DIVISION, PALO ALTO, CALIF.

Mr. RIDENOUR. Thank you, sir.

Mr. Chairman, my name is Louis N. Ridenour. I am director of research for the missile systems division of Lockheed Aircraft Corp., and I am appearing here as a representative of the aeronautical industry.

That industry is both a user of and a contributor to what has in these hearings been called automation—the development and use of refined measuring instruments and automatic controls.

In fact, the whole art of guided-missile development, with which I am intimately concerned, is that of replacing the human crew of an aircraft with sophisticated automatic instrumentation.

As the speed and operating altitude of military aircraft have increased, the demands on a human pilot for these advanced flying machines have simply gone beyond the range of human performance.

Lockheed is now building a manned fighter aircraft which can outfly an artillery shell. The demands of this plane on its pilot are almost outside the range of human performance.

Thus, in aircraft applications, as in many other fields where automation is coming to be used, there is in a very real sense no competition between men and automatic control systems. There is no competition because men are outclassed from the start.

Human reaction times are measured in milliseconds—the reaction times of automatic control devices can be, and often are, thousands of times shorter.

Men need air to breathe, and must be kept at a temperature not too far from that of their bodies. Much of the complication of a manned aircraft comes about because it is necessary to provide these amenities in the midst of a violently different environment. Properly designed control instruments are far less demanding in their environmental requrements.

I have dwelt on this point to make it clear that, while your committee and many who have given testimony before it have quite properly been concerned about the social impact of automation on human workers who may be displaced by it, there is a large field of application in which automation is simply taking over tasks which the human being is no longer able to perform—tasks which make demands our nervous systems and musculature cannot meet.

Not only do automatic-control devices take over when the range of human environmental tolerance or control performance is exceeded—they can also be used to replace men in the performance of boresome, unpleasant, or degrading tasks.

We all know that there are jobs in our present society which are of such nature that they seem somewhat incompatible with the dignity of the human individual. A century ago there were relatively more jobs in this category than there are now; a century hence there will be many fewer. Automation is making, and will continue to make, the difference.

Of this view of things, automation, when properly introduced as an important element of human activity, will take over control tasks which men cannot do or do not enjoy doing. The whole level of human activity can thus be raised.

Others who have given testimony before your committee have strongly stressed the requirement of our present society for technically competent men. I concur that this is of the utmost importance.

We are steadily removing the demand of society for the unskilled worker, steadily upgrading the intellectual content of the tasks performed by human workers in our society.

In consequence of this, both the productivity and the pay of workers have steadily been rising. These desirable trends can be continued only if the technical competence of the average worker rises also.

We need fewer men in the shop—where automation is beginning to be applied—and more in the engineering department. The aircraft industry is outstanding in its proportion of scientific and technical workers. In my division of Lockheed, for example, 1 man in 5 is a professional or technical employee.

It does appear that those in charge of the educational system of this country have not yet fully appreciated this growing requirement for technical education, nor taken adequate steps to provide for it. Anything that can be done to improve the scientific content of public education will be immediately helpful in meeting the technical challenge of our times.

Part of the difficulty that the youthful automation industry is experiencing today—and the difficulty that industrial and military users are experiencing with its products—can be ascribed to the fact that the tools of automation are mainly electronic in nature.

The electronics industry, which itself is a lusty infant less than half a century old, is today largely devoted to supplying consumer goods—home radio and television receivers. Let us turn aside to take a brief look at this new industry.

Electronics is one of the major industrial phenomena of our time. At the end of 1955, the industry was producing goods and services at the rate of about $9 billion per year. In the half decade since 1950, this represented an increase of more than 80 percent in output.

Last year, the Electronics Production Resources Agency estimated the total number of manufacturers of electronic and equipment components and other hardware as being 3,600.

One thousand companies produced either end-item equipment or major subassemblies of some type in the entertainment, commercial, or military fields. Components were manufactured by about 2,000 suppliers, while the other 600 companies listed produced miscellaneous related sorts of hardware.

Despite the relatively large number of individual companies in the electronics business, it is still a rather concentrated industry. Only some 50 of the 1,000 end-item producers account for more than 80 percent of the dollar volume of such production. Of the 2,000 components suppliers, about 200, or 10 percent, accounted for 80 percent of the dollar volume in the components business.

Electronics has grown to be a major source of employment for American workers. The industry now provides employment for more than 1.75 millions of people. This figure is especially impressive when we reflect that fewer than one-quarter of these present jobs existed only 10 years ago.

Optimistic forecasters believe that the $9 billion industry of today will attain a level of $15 billion by 1960.

Such growth can be characterized as no less than explosive. It has been caused, it is today sustained, and it will be continued by an equally explosive increase in our understanding of the properties of matter, and in our ability to make engineering application of this new knowledge.

Practically speaking, electronics as we know it today dates from the invention of the thermionic triode, the grandfather of all today's vacuum tubes, by Lee deForest in 1907. Electronics is thus just under a half-century old, and the man who gave it birth is still living.

The development progress of electronics in the early days was slow. It was applied to wireless communication very early; in fact, Marconi sent a distinguishable signal across the Atlantic Ocean in 1903, 4 years before the invention of the vacuum tube. Electronics had almost no other early application.

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World War I was a great spur to electronic development. As a matter of fact, I'd like to tell you a personal anecdote at this point. I had gone to the University of Pennsylvania as a member of the physics department in 1938, and taken leave at the end of 1940 to work on the then breathlessly new microwave radar in the radiation laboratory at MIT.

The radar work was, of course, subject to a high degree of secrecy classification during and immediately after the war.

When I returned to Penn after the war, I had occasion to clean out of my office some correspondence files that had belonged to a Professor Goodspeed, who had been head of the Penn physics department practically since the opening of the 20th century.

Some of this old correspondence was important historical material; all of it was fascinating. Among the more interesting items was an interchange of letters between Professor Goodspeed and Prof. Arthur Gordon Webster, who had been down in Washington during World War I, concerning himself with electronic matters.

Goodspeed had asked Webster to stop off at Penn on his return from Washington to Worcester, Mass. (where Webster was a professor) after the war, to give a physics colloquium on radio telephony, then a brandnew art.

Webster said that he would be willing to do this "subject, of course, to the requirements of military security." Thus, in late 1918 the techniques which underlay radio broadcasting were as secret as the radar techniques—which underlie television—were after the Second World War.

If World War I was an important spur to electronic development, World War II was incomparably more so. Radar—the technique of seeing in the dark by making use of the reflection of radio signals from targets of interest—had been suggested by Marconi as long before as 1922, but it was not really invented until the late 1930's.

It was independently invented, at about the same time, in several countries simultaneously. It became a major weapon of World War II, and enormous technical advances were made.

When I arrived at the MIT Radiation Laboratory just after New Year's Day of 1941, the staff was jubilant at seeing the dome of the Mother Church of Christian Science, 2 miles across the Charles River, on the scope of a primitive radar; when I left 5 years later, radar echoes had been received from the moon, a quarter of a million miles away.

The development of commercial television, which has taken place largely after World War II, owes much to the radar work during the war. Techniques at high radio frequencies had to be developed for radar, and are much used by television; techniques for the visual display of radio signals had to be worked out for radar, and have been taken over by television.

One of the most important electronic developments, particularly in terms of its significance for the future, has been the creation and great improvement of electronic computing machinery.

Beginning in the early 1940's, electronic techniques were used to design machines capable of making the logical decisions fundamental to arithmetic computation and of performing still more elevated logical decision processes.

The resulting high-speed computing machines, as they are now called, have become familiar topics for luncheon speakers. They have begun to take over an increasing share of the routine clerical work which is so prominent a responsibility in modern industrial society, and they have been touted as being able to aid in the decision-making processes of industrial management, and otherwise to assume human burdens.

The fact is that machines of this sort can do all of this. The further fact is that they have not yet been called upon, in any great measure, to do it. We are only just beginning to learn the capabilities and limitations of such information-processing machines, and are only just beginning to learn how to design them so that they will have proper balance for attacking problems other than the scientific and engineering ones whose requirement for solution gave them birth.

In addition, and this is most important, modern electronic automation devices suffer from the occupational disease of modern electronics: they are extremely unreliable.

The unreliability of electronic equipment is perhaps the major factor regulating and guiding the growth of electronic application. The central component of any electronic end item—the vacuum tube—is the least reliable component of all. It has an average lifetime of perhaps 10,000 hours, a little over a year.

However, since this is a statistical lifetime, tubes begin failing as soon as they begin to be turned on. In the entertainment devices which have thus far been the major applications of electronics, this is annoying, but not fatal. This unreliability of electronics has, however, drastically limited the breadth of application of electronic techniques.

Let us explore the reasons for electronic unreliability, and try to indicate its causes. As we have already noticed, the early growth of the electronics industry took place mainly because of its application to the burgeoning amusement industry.

In radio, in electronic musical recording and reproduction, in television, and in the telephone business electronics made it early mark.

Only in the case of the last application, telephony, which was and has always been rather specialized because of the quasi-monopoly situation which obtains, was there any premium on electronic reliability.

In the generalized electronic entertainment business, reliability of the end-item equipment was about the last thing desired or sought by the manufacturer. There being only some 8,000 hours per year, even the most avid radio or television fan was unlikely to use his set more than a few hundreds of hours per year, and a mean life of a few thousands of hours was plenty to make the equipment seem well designed and built.

At the same time, the price battle in the discount houses was vigorous and influential.

The overall result has been that the principal controlling factor in electronic development has been price. Engineering departments of radio and television manufacturers have existed principally for the purpose of engineering cost out of the company's product. The prototype of all black-and-white television receivers has been the RCA-type 630 chassis of the late 1940's; engineering progress in television since that time has consisted very largely of finding out which complicated circuits, which expensive components, can be successfully engineered out of that design without unduly affecting performance.

The sole exception to this trend of cheapening electronic equipment at the cost of performance has been the work done by the telephone companies. Here there is a premium on reliability of equipment which does not exist in the case of consumer electronics.

There are now situated at the bottom of the Atlantic Ocean vacuum-tube cable repeaters which have been designed with the utmost care by Bell Telephone Laboratories. A mean life of 350,000 hours is expected for the most perishable part of these repeaters, the vacuum tubes; this lifetime is many times that anticipated for the tubes of any existing radio or television set. Such long life has only been obtained by the greatest care, attention to detail, and willingness to spend money to achieve it.

It is a major paradox of the electronic business that the vacuum tube, which is absolutely essential to the equipment of modern electronics, is the least reliable component of electronic equipment.

I made the remark 5 years ago that there was nothing wrong with electronics that elimination of the vacuum tube would not cure, and that remark is still pertinent today.

However, it is only very recently that we have been able to consider seriously the likelihood that we might eliminate vacuum tubes from electronic equipment. The major line of electronic development is now that which centers around doing this.

As of today, the thermionic vacuum tube is just under 50 years old. The solid-state device called the transistors, which bids fair to replace this vacuum tube, is about 8 years old.

This difference in ages is also a fair measure of the difference in the technical effort which has been expended in behalf of the two devices: the International Radio Tube Encyclopedia, which lists all the type numbers of the vacuum tubes produced at any time anywhere in the world, reaches a total of 18,500 type numbers for vacuum tubes.

Comparable figures for transistors are not so easily accessible, but the latest compilation of type numbers produced in the United States totals approximately 235 transistor types and, even adding foreign contributions, the list does not exceed 300.

Production is another index, and a most important one, to what is going on. The total production of transistors in the 8 years of their existence is not over 5 millions of units.

This number of vacuum tubes is currently made in any 2 working days in this country alone; over 40 millions of tubes are made every month; half a billion tubes every year.

At a conservative estimate, the cumulative worldwide production of vacuum tubes today exceeds 7 billions—3 tubes per generation for every man, woman, and child in the world.

Thus we are now in the period of transition from consumer electronics centered around the vacuum tube to industrial and military electronics based on the far more reliable transistor.

Until this transition is complete, the tools of automation will suffer from the law reliability that characterizes current electronic equipment. This unreliability has two major causes: the deficiencies of vacuum tubes, and the price-centered nature of the consumer electronics industry.

The cure for this unreliability is inherent in the new solid-state devices, like the transistor, that can and will replace the vacuum tube. At the same time, designers must put far more emphasis than is now customary on the problem of attaining the greatest possible reliability.

To sum up, I feel that the following points are important:

1. Far from competing for desirable jobs now done by men, the devices of automation will relieve human beings of tasks which are either beyond the scope of human performance or beneath human dignity.

2. The growth of automation is putting unprecedented demands on the educational system of the country; a far greater output of technically trained individuals is required.

3. Automation requires of electronic equipment far greater reliability than has yet been attained in the price-centered consumer electronics industry.

4. The tools for achieving this improved electronic reliability are being developed; notable among them is the transistor.

Industry and government, hand in hand, must encourage the trends that the growth of automation foreshadows. Anything that can be done to encourage the availability and quality of technical education, to speed up the transition from unreliable consumer electronics to the ultra-reliable military and industrial electronics of the future, should and must be done. Since the end result of increased automation is to enhance the dignity and effectiveness of human life, this is in the general interest.

Chairman PATMAN. That is a very fine statement, Dr. Ridenour. We appreciate it.

I just want to emphasize some of your points, and ask you a very few questions, if you please.

Your testimony corroborates testimony that has already been introduced about the educational system.

I notice you state what other witnesses have stated, that anything that can be done to improve the scientific content of public education will be immediately helpful in meeting the technical challenge of our times.

I am personally very much impressed that that is an urgent matter. I think we should do something about it.

Many different plans have been proposed before our committee which will be followed through for a discussion and I hope action.

On page 7 you mention about television. I just wonder if you have any ideas about the $64,000 question on color television, about when you expect it to be in general use.

Mr. RIDENOUR. Yes, sir, I have. I do not know whether you want me to tell you about them.

Chairman PATMAN. We would like for you to.

Mr. RIDENOUR. My views are rather unconventional.

Chairman PATMAN. We just want it for information. It does not make any difference to us how conventional it is.

Mr. RIDENOUR. I spent nearly 4 years of my life working in the television field and I formed very strong opinions about certain matters there.

I feel that the problem of how to develop the ultra-high frequency channels which is bothering the FCC——

Chairman PATMAN. Very much so.

Mr. RIDENOUR. And how to bring about practical color television and how to bring about practical paid television are all tied up together.

If you will allow me to say a word about that.

Chairman PATMAN. We would like for you to comment fully, if you please.

Mr. RIDENOUR. Well, first then, with regard to why talk about paid television:

We are experiencing a transition to a wholly new financial structure of the entertainment industry.

The motion picture theaters have made it possible for the producers in Hollywood to put millions of dollars into a single production, and to produce thereby, I think it is fair to say, pictures which are considerably better than the half-hour soap operas one sees on television with a commercial at the beginning, the middle and the end.

Now, the whole purpose of pay-as-you-see television is to make it possible by another method to channel money from the people who want superior entertainment, and are willing to pay for it, to the producers who need money to create this entertainment.

It is a bit like erecting an electronic theater that covers the whole United States.

The people who have opposed the development of paid television have made a great point of the fact that the individual American citizen, having bought a television receiver, ought to get free programs. This is rather like saying: if you go to the hardware store and buy a frying pan you ought to get free pork chops.

I am not sure that either statement is quite true.

Chairman PATMAN. Or an automobile, get free gasoline.

Mr. RIDENOUR. For example, yes, sir.

Be that as it may, it is clear that we cannot let paid television, if it should come about, take free television out of the American home. We must not interfere with what exists now.

This suggests very strongly that paid television ought to be cultivated in the part of the radio spectrum which is today hardly at all in use· namely, the ultra-high frequency, UHF part of the spectrum.

I am of the opinion that paid television, also, ought to offer something that is scarcely available today, although it is marginally available, namely, color.

If one looks at the technique of color television as it now exists, and as it is being developed and made available to the public, it turns out that the whole basic idea behind the thing is a very clever attempt to squeeze about 6 megacycles worth of picture information into 4½ megacycles of channel space, the result of which is that they ought to sell a little technician with every color television set.

There are a great many handles that need to be turned to make it work right. It would be rather simple to do a job of color television if a wider band in the frequency spectrum were made available, wider than the 6 megacycles which is the presently defined channel used by television stations.

In the ultra-frequency spectrum there are over 400 megacycles available. So that there is, in my opinion, plenty of room to do a more simple-minded job of transmitting color over the air, through the use of a wider channel for the job.

This would have an immediate benefit to the consumer because it would make it posisble to design a far simpler and cheaper and more reliable color receiver.

Now, this has been a rather rambling reply to your very challenging question, Mr. Chairman.

Chairman PATMAN. I am very much interested in your reply and I know that the people all over the country will be interested in it, the Members of Congress in particular. And if you want to elaborate on it further, it will be appreciated. We do not want to cut you off.

Mr. MOORE. Is widespread use of color being held back today deliberately or scientifically awaiting further development in the ultrahigh frequency sector?

Mr. RIDENOUR. In my opinion, sir, it is not. I think that the Radio Corporation of America, which is the main backer of color television development, is doing everything in their power to advance the art, and to bring it forward.

Mr. MOORE. You don't feel that the prospect of paid television is delaying this development in the other sphere?

Mr. RIDENOUR. No, sir. I do not. What I do feel is that the technical scheme which is now the one on which color television must rest, is so complicated and difficult that that in itself is holding the art back.

And I feel that the relaxation of these technical requirements, which can only come by a widening of the channel width that is made available for color television, will be possible only through the opening up of new and wider channels in the UHF spectrum. This would, so far as I can see, solve the problem of UHF television, because it would provide a new service there that people want, and that they would buy sets or converters to get.

Second, this would solve the color television problem through the simplification of schemes for transmission and reception.

Third, it could open the way to pay television if this is wanted.

Chairman PATMAN. I want to thank you for that comment.

You mention about the life of a vacuum tube, I believe, of the Bell Telephone Co., that is in the Atlantic Ocean, being 350,000 hours.

Isn't that about 40 years?

Mr. RIDENOUR. It is about 4½ years.

Chairman PATMAN. About 40?

Mr. RIDENOUR. Four and one-half.

Chairman PATMAN. Four and one-half?

Mr. RIDENOUR. Wait a minute. Yes; you are absolutely right. Forgive me. It is 40.

Chairman PATMAN. About 40 years?

Mr. RIDENOUR. Yes.

Chairman PATMAN. That is the way I just figured it roughly.

Mr. RIDENOUR. Yes.

Chairman PATMAN. That is quite unusual, isn't it, for a vacuum tube to last that long?

Mr. RIDENOUR. It is entirely unprecedented. This tube is the culmination of a long program of design and development and extremely careful kid-glove manufacture.

Mr. MOORE. Does it follow the tube or the transistor approach.

Mr. RIDENOUR. These repeaters came under design at a time many years ago when the transistor was not yet dreamed of. So that we now have vacuum-tube telephone repeaters under the ocean.

If the Bell System had it to do over—and they will have it to do over in a generation, as the chairman has pointed out—they will undoubtedly have transistor amplifiers next time.

Chairman PATMAN. In your concluding statement, indicating some points there that are important, the first one is—

far from competing for desirable jobs now done by men, the devices of automation will relieve human beings of tasks which are either beyond the scope of human performance or beneath human dignity.

I have always heard that the four greatest evils are poverty, ignorance, disease, and crime.

So I assume from your statement there that one of the goals will be in the use of automation relieving drudgery which is not in one of these four that I named, but I believe it logically would belong there and a great evil and so automation should go a long way towards relieving drudgery.

Mr. RIDENOUR. Yes, sir. I cannot emphasize that too much. People are worried about these automatic devices reducing the number of jobs available. What one has to do, I think, is to look at the other side of the coin, which is that these automatic devices are giving more job satisfaction to people in what they have to do.

As a Member of the Congress, I know that you take great pride and satisfaction in what you do. Very few of us have as rewarding a task to do as you have.

The devices of automation are making it more and more nearly possible for each of us to have a task as challenging and rewarding as yours, sir.

Chairman PATMAN. Well, I just feel like that we mean so little, I mean Members of Congress, in comparison to scientifically trained people, engineers, like yourself, and other people who have appeared before this committee.

In time of war, for instance, World War II, I realized the importance more than I ever realized before of trained people, skilled people, scientists, engineers—we just could not have gotten along without them.

And although I am chairman of the Small Business Committee and have been since it was created, and I offered the resolution that caused its creation in 1941 just a week before Pearl Harbor, and I have been the chairman except when the Republicans put us out a couple of terms, I am not opposed to big business at all.

I feel like there is a place in our economy for big concerns and little concerns, too. We just want to make sure that the rules of the game are written properly so that the Golden Rule will prevail and everyone will have an equal opportunity, an equal chance.

And big business, certainly, performed a great service during World War II. I don't suppose we could have gotten along without the big concerns that we had. And we certainly are indebted to them.

The one reason is because they were in a position to employ, by going together, the finest people for the jobs that we had to do, the people who had the know-how, the professional know-how, the knowledge, the ability, to do the job.

I notice you state here, point 2—

the growth of automation is putting unprecedented demands on the educational system of the country; a far greater output of technically trained individuals is required.

That is, of course, along the lines of other testimony that we received. And I think Members of Congress who keep up with these hearings are convinced that that is certainly a point that should receive early consideration that is urgent.

I do not know what the answer is. I know that college professors are human beings like ourselves, must take care of themselves. They have families like we do. And they are entitled to compensation that will reward them adequately for the services they perform, to enable them not only to have the comforts and conveniences and some of the luxuries of life, but also sufficient to educate their children in the best schools and colleges of the country.

And I am afraid that the salary range has been rather low from the testimony we have received. In fact, too low in some States.

Mr. RIDENOUR. Mr. Chairman, I paid last year Federal income tax in an amount slightly greater than my total salary as dean of the Graduate College at the University of Illinois, 5 years before.

Chairman PATMAN. Quite a difference. It just goes to emphasize the point that you were receiving such a low salary at that time.

And I know that has got to be corrected. I do not know how it should be done, but something has to be done about it. We cannot afford to have these professors taken out of their positions in the colleges and put into private work when we need them so badly in the colleges, to train other people.

At the same time they have to decide and we have to answer it some way. We have to answer it satisfactorily. And I assume that adequate salary would be about the first consideration that should be given, for the purpose of trying to solve the problem.

> Automation requires—

so you state in point 3—

> of electronic equipment far greater reliability than has yet been attained in the price centered consumer electronics industry.
>
> Four, the tools for achieving this improved electronic reliability are being developed; notable among them is the transistor.

Mr. RIDENOUR. There is a point there which is not in my prepared testimony but might be of interest to you.

Chairman PATMAN. Feel free to develop it, please.

Mr. RIDENOUR. The transistor was invented at the Bell Telephone laboratories in the year 1948, and the three men who are most responsible have just received the Nobel Prize in physics, from the King of Sweden.

There was considerable discussion at the time of this discovery as to whether it should be subject to secrecy classification or whether it should be published. After all of the returns were in, it was decided that this discovery was sufficiently important, sufficiently significant outside of the military, so that its classification would be a mistake.

It was made freely available to all of the people of this country.

I think this is an example of how we can help ourselves by telling ourselves what we know. I think that we should all congratulate ourselves that we still live in such an atmosphere that a discovery as important as this one, which could have been kept under wraps, was still published for the good of the national economy.

Chairman PATMAN. Dr. Moore wants to ask you a question.

Mr. MOORE. I take it from page 9 that this transition to transistors is not being delayed by anything other than cost considerations and the time it takes for an evolutionary change; is that correct?

Mr. RIDENOUR. That is correct. It has been proceeding very rapidly. In the hearing aid business, for example, there is not a single hearing aid presently under manufacture that uses any vacuum tubes at all.

Mr. MOORE. In due course it will substantially take over the field?

Mr. RIDENOUR. That is my expectation, yes.

Mr. MOORE. One final question, and this may be a little visionary in a sense, but what do you foresee as the next big frontier for commercial development in the field of electronics?

Mr. RIDENOUR. Well, I am probably a little old and stodgy, but at the moment my prediction would be confined to faster and faster progress along the lines that are presently in work.

I think that the business of interpersonal communication is going to be managed by radio, and by very compact radio sets. And we shall presently have in our pockets personal telephone sets that are about this size [Referring to a watch].

I think that we shall experience a totally new level of reliability in all of the new electronic equipment. I think that the tools of automation which are under discussion in this committee will become ever more potent and effective.

And I cannot imagine the next great breakthrough, which is kind of the definition of a breakthrough.

Chairman PATMAN. Thank you very much, Dr. Ridenour, and if you have anything that you would like to add to your testimony when you review it, you may be privileged to do so.

Mr. RIDENOUR. Thank you, sir.

Chairman PATMAN. Dr. Bronk, I believe, is our next witness.

Dr. Detlev Bronk, president of the National Academy of Sciences, National Research Council, Washington, D. C.

Dr. Bronk, we certainly appreciate the fact that you agreed to appear as a witness. We shall look forward to your testimony.

Would you like to present your testimony in writing and read it or would you like to speak extemporaneously?

Dr. BRONK. I prefer to speak extemporaneously and give you an opportunity to ask any questions that you may wish to ask.

Chairman PATMAN. That is very fine. And we have in mind your time limit, too—that you want to get away from here at a certain time. We want you to feel free to work to that end.

STATEMENT OF DR. DETLEV BRONK, PRESIDENT, NATIONAL ACADEMY OF SCIENCES, NATIONAL RESEARCH COUNCIL, WASHINGTON, D. C.

Dr. BRONK. Thank you very much. I have plenty of time, I think.

Mr. Chairman, I am here as president of the National Academy of Sciences and its Research Council, although as Chairman of the National Science Board of the National Science Foundation. I am also very much interested in the generous support given to science by the Government through the National Science Foundation.

I assume we are concerned with the usefulness of the new developments known as automation for the furtherance of human welfare and the building of our national security and economy.

The title that has been given to me is, "The Need for Trained Scientists and Research Workers in the Field of Automation." With your permission I would like to modify that somewhat and speak of the need for automation in the field of research and the way in which the development of automation affects the national scientific manpower problem.

Our country has attained its high position in part because of the great natural resources which have been available to us, but more especially because of the qualities of American manpower, courage, imagination, ingenuity, devotion to human freedom, and willingness to work hard. These qualities have brought us to our present high position at a time of great destiny.

During these recent months when there has been so much attention focused on the Middle East, I have kept remembering the first time I saw the pyramids when I was serving with the United States Air Force during this last war. It emphasized in a spectacular way some of the things we are concerned with this afternoon.

As we came into Cairo that early morning, I saw the shadows of the pyramids spread across the desert sands, I could not help but be reminded of the tremendous amount of human effort that had gone into the building of those structures by what was essentially slave labor. In a space of less than 2 days, I, on the other hand, had come from Mitchel Field in relative ease and comfort. The reason that was possible was because of the creation of machines, in part by our industry but essentially as the achievements of the human mind.

It is the function of machines to extend the range of human powers.

The airplane has made it possible for our muscles to act in such a way that we are able to fly as birds have never flown—we are able to travel as the human unaided muscles could never enable one to move.

We are able to hear around the world not because of what our unaided ears can do, but because of the instruments which we have developed as aids and extensions to our human senses.

We are able to see distant objects by television that men unaided could not see.

And by the electron miscroscope we are able to explore the very nature of the living cell.

Last evening I was speaking at a dinner held in the Chicago Museum of Science and Technology on the occasion of the receipt of a spectacular exhibit given by the International Business Machine Corp. to that museum.

That was a reminder that now, by new devices, the capacity of the human has been extended. I refer to the new electronic devices which have made it possible for the human mind to think as the human mind has never before been able to do.

I think we should not lose sight of the fact that these new devices have been conceived of and developed by the human mind as an aid to the human mind itself. I do not want to get into deep philosophical water but I do think it is important, as we go forward in this tremendously significant developments as a new chapter in science, technology, and industry, to remember that all of these devices are merely means for extending the powers of man himself; in this case, his intellectual powers.

This relates to the general theme assigned me, because when we talk about the shortage of scientific manpower, when we talk about the shortage of all types of trained manpower for the accomplishment of the task which confronts us in society and for the development of new means for extending our physical and spiritual developments, we must continually bear in mind the fact that we will be able to meet these new needs, not merely by the unaided powers of man, but by the continual development of new aids to man.

And so I see in automation the means whereby man can supplement an inadequate reservoir of manpower competent to deal with the increasingly complex modern society.

And so I disagree with those who say that by automation we may create a less satisfying way of life because the need for man will be displaced.

I believe that through automation we are going to free men from dull, uninteresting tasks, so that he can do more significant things that will enable him to achieve his higher destiny.

I believe that as we have greater and greater need for trained manpower, we shall through automation find the means for satisfying this inadequate supply of manpower by extending the capacities of the available manpower.

This brings me, however, to what I think is a very significant problem of great national concern. If we are to make unnecessary much of the dull, uninteresting labor, what are we going to do with those people who are now performing that type of labor?

I am one who believes that the potentialities of people for doing more significant things is practically unlimited.

And so when I hear some of my colleagues say that we should have fewer people going into higher education I object.

I believe that as we are able to free men from the necessity of doing dull, grinding, work, we will enable them to develop more fully their intellectual capacities, provided through education we give them the opportunity to develop their potentialities.

I am one who believes that we should have more and more opportunity for higher education, so that more and more people will be able to carry out their higher activities.

I believe it will require a greater diversity of educational institutions, so that people will be able to fit themselves for those things for which they are especially qualified. I do not believe if we are to continue to have a satisfying democracy that we should lay stress upon encouraging fewer and fewer people to go into higher education.

Unless our country is to be torn between those who know and those who do not know, we must give more and more people an opportunity to know more and more about the laws of nature, the laws of human relationships, the spiritual qualities which make for satisfying rights so we can have a more wholesome society.

I believe one of our most powerful weapons in this grave conflict of ideologies is a more desirable way of life. The more we can do to enable people to create the physical means for a more satisfying life, the better guaranty will we have that democracies will survive.

From a more practical standpoint, it is perhaps unnecessary to add to what has already been said with regard to the need for more and better scientific education. This has been said over and over again by countless committees, boards, and commissions.

But it is desirable repetition to say that we should do everything we can to raise the quality of scientific education.

This affects Congress in this way: If we are to have more people better educated, it is obviously necessary that we have more well-qualified, inspiring teachers. If the opportunities for a satisfying life as a teacher becomes less and less, we will have fewer and fewer inspiring teachers.

In the field of science it is important that there be better facilities and more support for research as a way of learning. It is a way of keeping one's mind alert and better fitted for the teaching and inspiring of the young.

In our various governmental agencies and especially in the National Science Foundation we are deeply concerned with supporting fundamental science more adequately so that our teachers in the colleges and universities will be less tempted to go out into other forms of activity.

When it comes to the matter of secondary school education, from which we derive our future scientists, the problem is somewhat different, because it may be impossible to provide adequate opportunities for research.

But if we had a higher regard for education and for the educated man in our local communities, people would be less tempted to leave secondary schools and primary schools and go into other walks of life.

How this can be accomplished, I have no easy answer.

We must, by all devices, try to improve the regard for the teacher, so that those young people who are entrusted to the teacher will be encouraged to go into an educated way of life.

Also, I feel that one of our great national responsibilities is to recreate a regard for the satisfaction of hard work. This is not in conflict with what I have been saying about significance of automation as a means of freeing man from the necessity for hard physical work.

Automation frees man from the necessity for doing hard, dull, grinding physical labor. But now that we have passed our geographical frontiers, and have our Nation's future dependent upon our intellectual frontiers, we must develop in our young people a realization that hard intellectual work is not only a necessity but a great satisfaction.

And so when we hear that there are fewer and fewer people studying science and mathematics, it reflects the desire of so many to have an easy way of life.

Our country did not become great by the choice of the easy way. It was made great by hard work and courage. Now we need that same hard work and courage.

What I have tried to say is this: I see in automation great opportunities for extending the range of man's ability to think, and to do things of greater significance so that man can have a more satisfying way of life.

I see in automation the means whereby man can understand better the laws of nature, and of life itself, so that man may be in a better position to develop industry, learning, the control of man's own body, and of man's own thoughts.

Chairman Patman. We have heard several witnesses, as you indicated, about our lack in education, particularly along the lines that you have suggested.

I wonder if you have any suggestion to make as to what Congress should probably do, that would be helpful in solving those problems or should it be done entirely on the State level, or should we encourage the military to better utilize the young men, inductees as well as enlisted men.

Dr. Bronk. I think that Congress can do a great deal in this regard by increasing the support for fundamental research because as I have just said, this enables people to keep themselves intellectually alive and thereby better to fulfill their responsibilities as teachers.

The way in which this can be done is by support of the National Science Foundation and those fundamental aspects of the research programs of all the various Governmental agencies—the Department of Commerce, the Department of Defense, the Department of the Interior, and related organizations.

I feel that in the field of education there should be more widespread support of our private educational institutions which have played such a tremendous role in the development of our country.

If education is furthered in these private and State institutions there is a greater sense of participation on the part of individuals, because they are more intimately related to these colleges and universities.

In this regard, I think that we should all pay high tribute to the tremendous loyalty of individuals and of private industry.

Several years ago, over a period of years, I served on the Commission for the Financing of Higher Education under the Association of American Universities. In the late forties and early fifties, we were gravely concerned with what was to be the future of higher education because of the great shortage of funds.

Since that time there has been a tremendously satisfying response on the part of the American industry in the support of our institutions of learning. The alumni and the friends of these institutions have contributed in increasing numbers.

With regard to the role of the Department of Defense, in the manpower shortage as it is affected by the necessary draft of our young people, I believe that there is much that can be done in order to utilize those who are drafted better in accordance with their special aptitudes.

It has been my experience in the military services that we can, by careful thought, train the people more quickly for the basic military responsibilities and use the time saved for their education on specialized scientific and technical problems with which they will deal in modern warfare.

Chairman PATMAN. It has been brought to our attention, Dr. Bronk, that Russia is ahead of us in graduating scientists and engineers and technicians.

For instance, a year ago, to be exact in November of 1955, this committee conducted the first hearing, I believe, that has ever been conducted in Congress or by a congressional committee, on automation.

Testimony before our committee at that time disclosed that the Russians were graduating twice as many engineers this year, 1956, as the United States.

Furthermore, the alarming, shocking information was brought to our attention that Russia is graduating 32 times the number of technicians that we are graduating. And that was such a shocking figure that many people have looked into it more carefully since that time.

And Dr. Sperry enlightened us some this morning as to what is being done in this country that has been overlooked in that respect, particularly concerning technicians. And he invited our attention to the fact, too, that possibly Russia is including a lot of mechanics in their 1,600,000 and that they are graduating this year as technicians.

Do you have any information that you would like to bring to our attention along that line as to how we stand with Russia?

Dr. BRONK. I do not have any available with me at the moment, Mr. Chairman, but there have been studies of this sort made under the auspices of the National Science Foundation and the National Research Council. These are available. In general they bear out what you have just said.

I would hope that we have enough faith in our future and enough ability to define our own objectives, so that we do not have to depend upon the stimulus of Russia to decide what we should do.

Some of us who have been arguing for the better education of our young people for many years, are somewhat gratified to see us more alert to this need at the present time, but we wish we had not had to wait for comparison with Russia in order to come to these conclusions.

Chairman PATMAN. I thoroughly agree with you.

Is there not a place where television can be used for education? And, if so, which level would it be, the elementary grades, high school, or in the arts and sciences?

Dr. BRONK. I think this is one of the challenging opportunities that lies before us in all levels of education, from the very elementary levels on up through adult education. It is heartening to see that after years of failure to recognize that one can do new things in education we are beginning to do some of the things that are now possible by modern science and technology.

Television is being extensively experimented with, to see how we can better use it for general education. Beyond that, there have been studies made as to the utilization of television in the classroom so that the shortage of teachers can be met by using one brilliant teacher to reach hundreds of thousands of students.

There have been tests made as to whether or not students suffer from a lack of intimate contact with the professor under these conditions. It is significant that in at least one test it was found that the students felt they were just as close if not closer to the figure on the television screen than they did if they sat at the far end of a large classroom.

There are a number of experiments being carried out in the development of sound films for instructional purposes, which again will be used not to replace the teacher, but to supplement the teacher, so that a brilliant physicist or biologist or chemist will be able to talk to classes of high school students and college students.

In this way, we can bring more inspiring presentations to the students, and we can also help solve the shortage of good teachers.

Chairman PATMAN. Well, we certainly have appreciated your testimony, doctor. You have enlightened us on so many questions.

Tomorrow morning we have as our witnesses, Friday, December 14, Mr. Rocco C. Siciliano, Assistant Secretary for Employment and Manpower, Department of Labor, and also tomorrow morning Mr. George Meany, president of the American Federation of Labor-Congress of Industrial Organizations.

The subcommittee will stand at recess until tomorrow morning at 10 o'clock.

(Whereupon, at 3:20 p. m., the subcommittee recessed, to reconvene at 10 a. m., Friday, December 14, 1956.)

INSTRUMENTATION AND AUTOMATION

FRIDAY, DECEMBER 14, 1956

CONGRESS OF THE UNITED STATES,
SUBCOMMITTEE ON ECONOMIC STABILIZATION
OF THE JOINT ECONOMIC COMMITTEE,
Washington, D. C.

The subcommittee met, pursuant to recess, at 10:05 a. m., in the Old Supreme Court Chamber, United States Capitol Building, Washington, D. C., Hon. Wright Patman (chairman) presiding.

Present: Representative Patman (presiding).

Also present: John W. Lehman, clerk; Grover W. Ensley, executive director; and William H. Moore, staff economist.

Chairman PATMAN. The subcommittee will please come to order.

We have with us this morning Mr. Siciliano, Assistant Secretary for Employment and Manpower, United States Department of Labor, Washington, D. C., accompanied by Mr. Clague, Commissioner of Labor Statistics.

We are mighty glad to have both of you gentlemen. You may proceed any way you desire, sir.

STATEMENT OF ROCCO C. SICILIANO, ASSISTANT SECRETARY OF LABOR FOR EMPLOYMENT AND MANPOWER; ACCOMPANIED BY EWAN CLAGUE, COMMISSIONER, BUREAU OF LABOR STATISTICS; AND LEON GREENBERG, CHIEF, DIVISION OF PRODUCTIVITY AND TECHNOLOGICAL DEVELOPMENTS, BUREAU OF LABOR STATISTICS

Mr. SICILIANO. Thank you, Mr. Chairman.

I would first like to thank you for this opportunity to discuss the Department of Labor's work in the field of automation and technological change.

The hearings before your committee last October were most constructive in clarifying the meaning and some implications of technical developments for the economy. The Department's staff has used the hearings as a convenient reference and a ready source of useful ideas.

We noted with interest, in your committee report of last year, your recommendation for continued research on automation and occupational change.

This morning I would like to discuss and review the program of the Department of Labor in this field during the past year, to discuss briefly some of our research findings, and to indicate the outook for future work. Before taking up these matters, I would like first to summarize some more general views.

A reasonable view of automation and other laborsaving innovations must take account of two important aspects. In an economy of full employment we must look with approval at efforts to increase output per man-hour. Automation affords us a means of enlarging both our per capita material abundance and leisure at the same time as our population continues to grow. Moreover, the margin of our productivity level over that of competitive nations is an important element of our national security.

We must be mindful, however, of potential human costs. Dramatic changes in production techniques may often have important consequences for the people who work in factories, plants, and offices. The past history of our economy saw examples of job displacement and obsolescence of skill that often imposed harsh readjustments on individual workers.

Today, there seems to be general or universal agreement about the need for adequate worker training, guidance and education, protection against arbitrary discharge, and social provision for income security in the event of unemployment.

Modern management is, more and more, coming to recognize the importance of considering the problems of the individual worker in making changes. This personnel planning is as essential to the progress of technology as is the careful planning that precedes an investment in new machinery.

Because of its responsibilities in the training, placement, security, and general welfare of workers, the Department of Labor is keenly interested in the progress of new industrial technology.

Sound administration of manpower programs necessarily requires some understanding of the implications of these changes for employment, occupational and skill requirements, industrial relations, and for special groups such as the older workers.

Accordingly, we have given special attention during the past year, and I might say during the past 2 or 3 years, to programs concerned with the human impact of changing technology. These activities cover various areas of study and action, including automation and productivity research, the skills of the work-force program, and the older worker studies.

AUTOMATION AND PRODUCTIVITY RESEARCH

First, we have broadened the Bureau of Labor Statistics' research work during the past year in the measurement of productivity growth and study of technological developments.

To obtain factual information on actual experience of management and labor in introducing technological innovations, the BLS initiated a series of case studies of individual plants. The first two case studies—one on a radio plant, using printed circuitry; the other, on an insurance company adopting a computer—were submitted to this committee during the October 1955 hearings, at which time Secretary Mitchell appeared and testified.

This year, we published a study of a bakery that had undergone extensive mechanization. We are now preparing a study of technological change at a petroleum refinery, and the introduction of an automatic system of handling reservations at an airline.

We plan to make additional studies in the coming year in plants adopting automatic techniques in the metalworking, wholesale distribution, and chemical industries.

In making these studies, our staff interviews management and labor officials concerning changes in productivity, employment, occupational needs, wages, industrial relations, and related subjects pertinent to presenting a record of human adjustment at a single plan. This case-history technique, as you may recall, was recommended by several witnesses before your committee in October 1955.

These case studies are filling a gap in our knowledge of the effects of current changes. While trade and technical journals report fully on examples of the latest automatic control or computer developments, concrete information about the human adjustments required is too often only fragmentary.

Consequently, these studies have proved useful in discussing ways of adjusting to technological change, and have been widely circulated and reprinted.

In addition to these on-the-spot studies, the Bureau of Labor Statistics has published an extensive bibliography on Automatic Technology and Its Implications, which is designed to assist other research workers in studying this important aspect of the economy.

Also, the Monthly Labor Review from time to time publishes significant articles on the subject of automation, including a summary of this committee's hearings. And we are now also engaged in preparing a broad review of changing technology, which will be the Department of Labor's yearbook in 1958. It will cover the origin, development, and implications of the new technology.

Because of their great importance in evaluating and gaging the rate of technological change generally—and thus the dimensions of the social problems that may be implied—considerable attention is directed to the BLS statistical program on trends in output per man-hour. Indexes for the trend of the manufacturing sector, from prewar up to 1953, were released last year by the Secretary at this committee's hearings.

Our current work is concerned with the improvement of this important series, and the development of indexes for the economy as a whole and its important sectors. This fall, indexes of output per man-hour for the basic steel industry were published, covering the period since 1939.

Finally, mention should be made of the growing interest abroad in the human aspects of automation, which should be noted. Within the past year, private citizens as well as Government officials from Sweden, England, France, Germany, and Australia have come to the Bureau of Labor Statistics and other bureaus in the Department, seeking information and advice in studying the American approach to the social problems of automation.

SKILLS OF THE WORK-FORCE PROGRAM

The progress of automation, along with the development of peacetime atomic energy, the increasingly complex technical defense program, and the extension of industrial research, is certainly going to contribute to today's widely discussed shortage of qualified personnel.

Persons with creative talent are needed not only in the ranks of the scientists and engineers of automated factories, but also among the teachers of technicians, the skilled workers supporting them, and the managers and executives responsible for the plant's performance.

The problem of shortage of skills has many ramifications for our educational system, for our industries, and, indeed, for our whole system of incentives and attitudes toward work and study.

The Department of Labor is seeking to make a contribution to this important problem through its skills of the work force program. This program is intended to stimulate an increase in the number of qualified workers in the skilled occupations and professions, and to assist in broadening the skills of the whole labor force.

One line of activity concerns the improvement of our statistical and research program on current occupational trends and opportunities.

As part of this program, the Bureau of Labor Statistics in its occupational research studies is bringing together a vast amount of information about various fields of work. The new Occupational Outlook Handbook, to be published early in 1957, will cover the outlook, nature of the work, training requirements, earnings and working conditions for about 500 occupations and industries.

Through the Bureau of Employment Security, the Department of Labor is providing leadership and technical assistance in improving and expanding counseling, testing, and selective placement services throughout the State employment services, particularly in relation to skilled and professional workers.

The Women's Bureau, in cooperation with the Bureau of Labor Statistics, is conducting a survey of wages and working conditions of nurses and other personnel in hospitals in 16 large cities. This effort is directed toward alleviating the shortage of trained nurses which has been a serious problem for many years. The Women's Bureau is also making other analyses of the demand and supply of women workers.

We are also promoting more adequate training programs in industry by stimulating employers and labor groups to improve on-the-job training, by encouraging the extension of educational activities in support of industrial training, and by creating in the general public an atmosphere of general and greater acceptance and interest in training.

During this current year, several community studies, directed by groups of local representatives of education, business, and labor, under the technical guidance of the respective State employment services and the Bureau of Employment Security, are being made to evaluate their community skill requirements and to provide a basis for developing necessary training facilities.

These initial pilot studies, each slightly different in approach, will in addition provide important experience in assisting many other communities as they undertake a systematic appraisal of their own present and future manpower requirements.

These communities, by the way, Mr. Chairman, are St. Louis, Phoenix-Tucson, which is one, Bridgeport, and Indianapolis.

OLDER WORKER STUDIES

When an older worker is displaced, he generally experiences more difficulty in finding a new job than a younger worker. Special attention to his particular problems of readjustment seems essential in an age of changing technology. In this room, last year, a number of witnesses mentioned the special difficulties of the older worker under automation.

The Department of Labor has been engaged in a comprehensive program of study and demonstration projects designed to overcome age barriers and discriminatory hiring practices, and to increase job opportunities for older workers. These particular programs cover a number of things: (*a*) Job performance and age; (*b*) status under collective bargaining and private welfare plans; (*c*) pension costs; (*d*) forums on earning opportunities; (*e*) adjustments to labor-market practices; (*f*) counseling and placement; and (*g*) changing patterns of labor-force participation.

The Bureau of Labor Statistics undertook two fact-finding projects. One consisted of a pilot study of the age and on-the-job performance of production workers in selected manufacturing establishments.

The main emphasis of this study was to develop suitable statistical tools for measuring the relationship between age and job performance in terms of output per man-hour, attendance, and other performance criteria.

However, the preliminary findings from this study are being tested in a more extensive survey this year. Even the preliminary figures from this pilot study have important implications for employment policy. Output per man-hour of both men and women pieceworkers showed only slight variation up to age 54, and in no group did the average performance of workers 55 through 64 fall below 90 percent of the group aged 35 to 44.

Measurement of the output per man-hour of individuals showed that variations in the output of persons in the same age group were very large. Actually, variations in output within age groups were generally larger than between age groups.

This means that workers displaced by technological developments should be selected for retraining projects on the basis of individual ability and not simply on the basis of chronological age.

In addition, the Bureau of Labor Statistics issued a report on the status of older workers under collective-bargaining agreements. One significant finding is that older workers generally do not find age a barrier to coverage under health-insurance plans, but pension plans frequently have provisions barring new employees for the older age groups from ever receiving benefits.

Finally, the Department of Labor is trying to improve operating services and educational activities—for the older workers—of the 1,700 employment offices of the United States Employment Service.

About one-half million dollars have been allocated during this current fiscal year to State employment security agencies, to strengthen and extend direct counseling, placement, job development, and employer visiting services in behalf of older workers in the local employment offices.

As a result, specialists in older workers' matters have already been appointed in 44 States and in approximately 70 of the largest communities. Much of the guidance for this program was developed during the past year by the Bureau of Employment Security in cooperation with the States—this is a Federal-State program—in a study of the nature and extent of the problems of older workers in the labor market in seven major areas.

SOME RESEARCH RESULTS

We have no direct answer to the question "How rapidly is automation growing?" From our constant survey of published information in trade and scientific journals, industry periodicals, and a host of similar sources, as well as our own studies, we have the impression that the growth of automation, so far, has been generally characterized by extensive planning and learning periods.

However, where automation has been adopted in only a small segment of an industry or an establishment, it may be the forerunner of more extensive application later. For example, the large insurance company described in the case study presented in evidence at your hearings last year, has recently installed two additional large computers.

Its experience with the first computer—discussed in our case study—prompted its decision to expand the number of computer installations. The company will consider even further installations if its recent additions fulfill expectations.

Thus, it would appear that, as learning periods are successfully completed in small sections of many American plants, a new and significantly larger growth in the rate of introduction of automation may yet be ahead of us.

One of the significant statistical indicators of the results of technological change is the measure of productivity. According to estimates of the staff of the Joint Economic Committee, the rate of productivity growth for the total private economy has been significantly higher than prewar; but these figures are affected by many economic factors in addition to technology.

In the manufacturing sector, our estimates—and I am referring to the department's estimates—show an average annual increase of about 3½ percent in output per man-hour of production workers since World War II, compared with a rate of 3.3 percent for the 30-year period prior to the war.

So the total effect of automation on productivity in the economy is not clear-cut.

At the same time, economic activity has expanded sufficiently to maintain nearly full employment. Total civilian labor force and employment, in fact, reached record highs during 1956.

Average monthly employment increased by nearly 2 million for the first 11 months of 1956, compared with the corresponding period in 1955; while unemployment remained about the same.

While the overall extent of labor displacement appears to be small, as measured by unemployment statistics, it should be recognized that its concentration in a particular industry or area may constitute serious economic and social problems.

I think Secretary Mitchell touched on the isolated areas of serious or persistent unemployment last year. I think the same thing is true today.

So far, the available fragmentary evidence about plants introducing automation does not reveal large-scale layoffs of workers. The three plants we have studied, and many others that have been reported, are generally ones where management sought to expand and diversify output rather than displace labor.

Workers whose jobs were eliminated were, for the most part, absorbed in other activities of the plant. In the case of our most recently published study of a bakery, there was a slight layoff at the outset, despite a considerable absorption of the people affected; but within 2 years, expanding business required the hiring of slightly more persons than those previously laid off.

As is obvious, the key word here is "expanding." The establishments we have studied could absorb all—or nearly all—of the people who were displaced by automation, because of an increasing volume of business. This underlines one of the recommendations of the subcommittee last year, concerning the maintenance of a dynamic and prospering economy.

From an industrial-relations viewpoint, it is gratifying to see, from our bakery study, how management and labor can often plan to alleviate the effects of change on the workers. Union representatives were called in at an early stage of the planning, to work out with management the assignment of workers, their duties, and wages.

Through collective bargaining, the work schedule of the plant was adjusted to keep layoffs to a minimum. Workers shifted to lower rated jobs were able to keep the higher wage rate paid on their previous jobs.

In most of our case studies, including those still in preparation, there is evidence of advance notification of workers by management, and in some cases actual advance consultation with worker representatives.

Benefits, in a plant introducing automation, are not equally spread among all workers. From our studies we found that there was a difference between automation's effect upon people on the one hand, and job structure on the other.

Most of the people who were directly displaced were transferred laterally within their skill levels, and in some cases were actually downgraded. No one, however, suffered a cut in wages as a result of these transfers. The job structure, or staffing pattern, was nevertheless generally upgraded by the change to automation; that is, the ratio of skilled or better paying to less skilled or lower paying jobs increased.

A few of the more skilled jobs were filled from the ranks of those on hand at the spot of the change, but generally the small number of highly skilled jobs created by automation were filled by more talented people selected elsewhere within the establishments or by hiring them from the outside.

The important point to note here is that the number of skilled jobs has increased relative to those of lesser skills.

Anticipating the rising importance of groups requiring intensive training and skills, we in the Department have tried to look ahead at the composition of our future work force. Based on what has already been happening, and of course based on people who are already born, projections of probable changes in occupational employment to 1965 and 1975 have been made in connection with the Bureau of Labor Statistics' occupational outlook project.

These show that by 1975, professional personnel may account for 1 out of every 8 workers, a third higher than the proportion today. The white-collar group, which includes clerks, salespeople, managers and owners, as well as the professionals, are expected to be the dominant occupational group, with 44 percent of the labor force.

This year, 1956, we were able to make the determination, for the first time in history, the white-collar group exceeded the blue-collar.

Among blue-collar workers, we may expect some increase in the proportion represented by craftsmen and operators, and an actual decline in the number of laborers. Owners, managers, and laborers on the farm are also expected to continue to decline in number.

I am submitting, attached to this statement, a table showing a projection of the labor force to the year 1965.

Summing up these studies of our changing occupational structure, we foresee the need for a very considerable increase in the amount and quality of training and retraining throughout the labor force.

Fitting today's workers into the jobs of tomorrow's technology will require vigorous action which must be planned now by industry, Government, unions and local communities. Earlier in this statement some of the Department of Labor's work in connection with helping to improve the skills of the Nation's work force was described.

FUTURE RESEARCH PLANS

In view of the many economic and social implications of automation and other technological changes, it seems essential that research work in this area be continued.

The Department of Labor hopes to conduct broader studies of the implications of automation for employment, productivity, occupations, and displacement.

For example, we hope in fiscal year 1958 to make a broad study of the effects of the electronic computer, its rate of adaptation, the accompanying gains in productivity, and effects on jobs and occupations. To attain a broad view, both makers and users of this equipment would be queried.

As I noted above, the Bureau of Labor Statistics' study of job performance and age is being extended this year to a larger number of representative establishments. Also, we plan to extend our program of case studies of plants introducing technological change to cover the special problems of older workers.

Next and of great importance, the Department hopes to develop more accurate information on the supply and demand for workers in many occupational fields, especially technical and professional.

We hope, also, to improve our methods of estimating future occupational requirements through study of industrial employment trends and the changing occupational composition of each industry.

These types of investigation represent forward steps, but still will not yield sufficient information concerning the effects of new technology upon the rate of productivity growth in our economy or its major sectors.

To make a realistic determination of automation's impact upon changes in productivity, employment, and other factors in a major sector such as manufacturing, we must study the details of the important individual industries within the sector.

This means comprehensive productivity studies of the individual major industries, coupled with equally comprehensive studies of the developing technology at work in these industries—in other words, a study both of the plant itself and of the entire industry, and then a study of the machine itself and its effect upon workers.

Such information, analyzed in the light of employment changes and occupational shifts in the industries, could permit the type of assessment your subcommittee called for a year ago—one which could be used "for policymaking in business as well as in Government."

The objective of technological progress should be, to cite the words of the President's Council of Economic Advisers, "better living in all of its aspects, not merely indefinite increase in per capita income and possessions."

With better understanding of the implications of the changes for the workers, employer and the community, we can surely attain this goal for all Americans.

(The table submitted by Mr. Siciliano is as follows:)

Employment in the major occupations of the United States, 1910, 1955, 1965

	1910		1955		1965 estimated	
	Number (in millions)	Percent	Number (in millions)	Percent	Number (in millions)	Percent
Total	35.5	100.0	61.7	100.0	73.1	100.0
White collar	7.9	22.3	23.8	38.7	30.5	41.6
Professional	1.6	4.6	5.7	9.2	7.8	10.6
Proprietors and managers	2.6	7.6	6.0	9.8	7.3	9.9
Clerical and sales	3.7	10.4	12.1	19.7	15.4	21.1
Blue collar	13.3	37.4	24.7	40.2	29.4	40.3
Craftsmen	4.2	11.8	8.2	13.4	10.2	14.0
Operatives	5.0	14.1	12.8	20.8	15.6	21.3
Laborers	4.1	11.5	3.7	6.0	3.6	5.0
Service	3.4	9.6	7.2	11.3	8.1	11.1
Farmers and farm workers	10.9	30.7	6.0	9.8	5.1	7.0

Source: 1910 and 1955: U.S. Census Bureau; 1965: U.S. Department of Labor, Bureau of Labor Statistics estimates.

Mr. SICILIANO. I would like to mention, Mr. Chairman, that, as you know, Mr. Clague, the Commissioner of the Bureau of Labor Statistics, is here this morning.

Chairman PATMAN. Yes. I expected to ask him if he had additional comments he would like to add.

Mr. CLAGUE. No, Mr. Chairman, I think not. We have covered pretty well the work that we are doing in the Bureau of Labor Statistics in Assistant Secretary Siciliano's statement.

Chairman PATMAN. Thank you, sir.

I would like to have you comment just a little bit more on the aged people. This problem is becoming an increasingly bad problem, I think. I do not think we can afford to lower the age on social security below 65 at this time, but the workers between 45 and 65 are finding it very difficult to get a job when they have to be readjusted; when they lose a job one place, for any reason on earth, and must seek another job, they just cannot find it.

Have you come up with anything in the way of a concrete recommendation to the Congress on that?

Mr. SICILIANO. Mr. Chairman, we have actually come up with a number of results from the various studies that we are making. As a matter of fact, I identified earlier some of the problems affecting older workers that we are trying to overcome.

Take one of them which is this pension cost handicap. It is often cited by employers as the reason they are reluctant to hire ——

Chairman PATMAN. I think that is a No. 1 item; I think it is.

Mr. SICILIANO. Yes, sir. They have often felt it is the obstacle to the hiring of workers, we will say, over 45.

We have met during this past year with quite an impressive group of consultants in the form of a committee to the Secretary of Labor. These people represent insurance companies, institutions, that is, private institutions, foundations, others who have a vital interest in the greater use of the older worker.

We have tried to analyze whether these pension costs are really a bona fide obstacle; and, if so, whether they can be overcome by some type of adjustment, either with the insurance company involved or in the companies themselves.

This is not an easy area for progress. Attitudes will have to be changed by explanation, and facts will have to be presented. The facts of ——

Chairman PATMAN. I know. But you are just a little bit beyond what you first said. You said you were making studies. Well, that has been going on for quite a long time, has it not?

Mr. SICILIANO. Well, actually in this pension field area, we have been doing this just during this past year.

Chairman PATMAN. Well, I heard some 2 or 3 years ago that one suggestion was that where there is increased cost, that the Government should pay that increased cost, so as to cause no discrimination against the aged worker.

Have you considered that?

Mr. SICILIANO. We haven't gotten to the point of recommending that the Government pay the differential in cost for pension plans in private industry. Is that the suggestion, Mr. Chairman?

Chairman PATMAN. Yes, sir.

Well, have you really come up with anything which is definite and positive and concrete; that is, a suggestion which would be helpful to these workers?

Of course, the study has been going on for a long time, but you know it is becoming a desperate situation with a lot of people.

Mr. SICILIANO. Well, Mr. Clague also wants to add something here, but we recognize the situation as desperate; in fact, we think it is going to be even more serious in the next 10 years, because the composition of our labor force is going to change materially in the next 10 years. By 1965, we will have a net increase of some 10 million people to our labor force. But of that net increase of some 10 million, about a half of it will be in this age group.

Actually—I have the figures here—5 millions will be 45 years of age and over. We will have, in 1965, some 900,000 less people than we have today in the age group of 24 to 35, this so-called middle management group.

So that the conclusions are obvious that industry is going to have to use older workers to a greater extent. They are going to have to use women, because half of this 10 million increase will be made up of women; and they are going, of course, to have to concentrate in retraining or new training for these older workers.

Mr. Clague, do you want to add a comment?

Mr. CLAGUE. I wanted to add a word, Mr. Chairman, on this matter of pension costs.

It depends on the kind of pension contract that is written, and that is one of the findings that came out of this group: That, if you write the pension contract in such a way that the benefits are related to the length of service the older worker has, then it does not operate as a cost against him.

But if you write the contract in such a way that the benefits are much higher in relation to his contributions, then, of course, the employer is up against the fact that it will cost him money to hire this older worker, age 50 or above.

So one of the recommendations that we were able to make was that management and labor and the insurance companies might well take into account the kind of pension contracts they are writing.

Then, Mr. Chairman, since social security has been extended so widely, we now have an additional advantage: That this industrial pension that is paid privately comes on top of, let us say, a reasonable social-security benefit.

Therefore, again it will be easier to write the kind of contract that will help in the employment of the older worker by another concern.

Chairman PATMAN. Well, the impact is terrific in areas where these defense plants were located. Take, for instance, an ordnance plant employing several thousand people from, say, 1940 to 1955, 15 years. During that time, thousands of people were induced, by reason of the fact that they had good employment at good wages, to give up their farms and their businesses, and depend entirely on that work.

Mr. CLAGUE. Yes.

Chairman PATMAN. Well, at the end of the 15 years, maybe they are only 45 years of age or 50 years of age. They lose the job, and there is no place for them to go. They cannot go back to the farm because since under the farm program you have to have some sort of an allotment in order to grow crops that are sufficiently profitable to enable a person to earn a living for himself and his family, and he is unable to get that kind of an allotment.

There is no place for him to turn. It is a pitiful situation.

Have you actually gotten anything done in the last few years for these older workers, that you could point to?

Mr. SICILIANO. I think you cannot point to any one single thing and say, "This is what we have done." We have actually tried to do things in several areas.

For example, I mentioned in my prepared remarks that we have attempted to identify people in the various major employment offices throughout the United States who are charged with the responsibility for the counseling, the testing, and the placement of older workers.

Now, this is one step. It is an important step.

Chairman PATMAN. Have they reported to you any results? Have they reported to you results?

Mr. SICILIANO. Oh, yes. The placement figures for this older worker category are definitely on the upgrade. There is a very definite improvement and a very definite result in this area.

Chairman PATMAN. Of course, part of that is due to the fact they cannot get anybody else to do the job. You see old people working as elevator operators, you know, and jobs like that, where they cannot get anybody else to do the job.

Mr. SICILIANO. I am sure that is a factor. And, of course, the expanding economy, the employment picture, is a definite factor. Yes, sir; that is right.

Mr. CLAGUE. Mr. Chairman, I might add another point there. Many of these older workers are highly skilled, although generally speaking a high skill is so much in demand that a skilled man can get a job.

But among the semiskilled, there are many older workers. One of the complications is that the older worker is pretty much settled in the community where he is. You spoke about the 15 years. He has a home, he has bought property, he has a family. If the job is somewhere else, it is quite a problem to get him to move off a thousand miles away.

And we find that among the older workers, particularly, this problem is serious. Younger workers are glad, sometimes, to move to another part of the country. They want to see the world, the West or Texas or someplace else.

But these older workers are settled. They stay in these distressed communities, and you really have to bring the work to them.

One of the programs of the Department has been to try to get industry put into those communities.

Mr. SICILIANO. In other works, part of the job is not only with industry, but also with the individual himself, to condition his own attitudes to such a point that he might either seek to transfer his skill or learn a new skill.

But these habits do become fixed, and of older workers very often wish to stay in the exact locality they are in, and do exactly what they have been doing.

Chairman PATMAN. Yes, sir.

I think it is really to their credit. It is just one of the problems we cannot solve.

Mr. SICILIANO. It is a very serious problem, and we have to move in a number of ways.

Chairman PATMAN. Dr. Moore, do you wish to ask any questions?

Mr. MOORE. Mr. Siciliano, a strike at the Standard Motors in England—so bitter as to attract widespread attention in this country—was attributed to company plans for the installation of automatic machinery.

Are you aware of any important labor disputes or strikes in this country that have developed over the issue of advancing automation in plants?

Mr. SICILIANO. I am aware of no such strikes. I don't know of disputes that may not have reached the strike stage, although I would assume some of these adjustments might cause an occasional difference of opinion.

I would like to ask Mr. Greenberg, who is the Chief of the Productivity and Technological Development Division, if he knows of any.

Mr. GREENBERG. I don't know of any; certainly of no large-scale disputes such as that which occurred in England.

Of course, I am sure that as a general, day-by-day affair, there must be differences of opinion in plants when technological changes are introduced, but this has not been terribly serious. There has been something in the newspapers about a dispute over speedup, but I am not sure that this is really a technological change problem. That is more in the nature of any day-by-day dispute which may occur within a firm.

Mr. MOORE. Well, apparently our labor in this country is rather more willing to accept these radical changes, or labor-management relations are better able to adapt to them than were Standard Motors and its employees.

Mr. SICILIANO. I would like to say that there is a complete willingness, so far as we have been able to see, of acceptance of technological change on the part of both labor and management.

The only emphasis we would make in the Department of Labor is that the human values must not be overlooked or underestimated, and that there should be consultation with workers.

Mr. MOORE. I have nothing further.

Chairman PATMAN. Dr. Ensley?

Mr. ENSLEY. Mr. Secretary, if you don't mind, I might address this question to Mr. Clague or Mr. Greenberg.

Mr. SICILIANO. I would be very happy for you to do so.

Mr. ENSLEY. If you look at current aggregate data, and make comparisons with a year or two ago, it seems to us that you come up with a tentative conclusion, at any rate, that output per man-hour in recent months or in the last year has been falling.

Would your information confirm this, or not? I would first of all like to get your reactions to that very tentative conclusion; and second, if there is something to it, your views as to why you have this below-normal increase in output per man-hour in recent months.

Mr. CLAGUE. I think I will have to answer that question in several parts.

In the first place, such figures as we have currently are very limited in character. We have the Federal Reserve Board index of production; we have our employment data in the Bureau of Labor Statistics. And the conclusions that you mention are those drawn by people who are putting these two sets of figures together.

Now, when more accurate data are available, when we have had time to gather the full picture of production in the United States in 1956, the results may be somewhat different than what they now show. Let me stress that first.

However, the general picture that you sketch is not an unusual one, and we find it in our productivity figures as we go back through the years.

You have to be very careful about drawing any conclusions on productivity from any short-time period, even 1 year; and of course for a quarter of a year or for a month, it sometimes becomes quite ridiculous to draw conclusions from what one finds in the figures.

Productivity is really an underlying relationship between output on the one hand, and people on the other, and it is most significant as a long-time trend.

Bearing that in mind, however, we do know this: In times of a business downturn, the volume of production falls off. Plants don't operate at capacity. Sometimes output falls more than they can cut the labor being used.

It is quite natural that the firm should hang onto its people. It doesn't want to let them go. So you sometimes get an adverse effect in a business downturn; I mean, what looks like a temporary adverse effect on productivity.

Conversely, when business turns up, like in the year 1955, the plant has its workers on the job. The plant gets new orders. Output expands. Then you can get a rather spectacular increase in productivity. The figures, in other words, look very good—output is high, with very little additional labor.

I did call attention to this last year when those 1955 tentative figures were issued. I expressed the opinion that those were due to the fact that it was a recovery year after a business downturn.

Now, when we reach a full employment year like 1956, when most all businesses are employed to capacity, they cannot ignore any longer the necessary repair labor, the servicing labor, and so forth. The firm has to take on more people, but the output does not expand proportionately.

So I would say, Mr. Ensley, the figures probably do picture the kind of thing we get in a business downturn, a recovery, and then a leveling off at the top, as we have had in 1956. So I suppose it is true that more labor has been employed this year per unit of output; that is to say, the increase has not been up to the normal rate of growth.

Mr. Ensley. Remembering this tremendous rate of capital investment of the last year——

Mr. Clague. Yes.

Mr. Ensley (continuing). And that is currently going on, and current high levels of employment, would you venture or hazard a guess as to what, assuming this boom continues, the output per man-hour figures will look like for the next 6 months or so; in other words, extending your analysis of what has happened as we went into the slump in 1953 and 1954, the boom year coming out of the slump in 1955, and then leveling off with the result of a decline, perhaps, in the rate of output per man-hour in 1956, where would this type of analysis carry us into 1957, on the assumption that we are bringing in this new capacity that we have just built this year and currently putting into operation, and a continued reasonably full employment?

Mr. Clague. Well, the two factors you mentioned are as follows:

First of all, we are at the peak, operating at almost full capacity; labor is scarce generally, in many areas and industries, and consequently we have the normal difficulties in attaining high productivity in a full employment economy.

Sometimes it is hard for the employer to get labor. Sometimes output is held up because of shortages of labor or of supplies.

Now, that kind of situation is still existing, and would, I think, continue into 1957.

The other side of it, as you mention, is the high capital investment of recent years, the enormous amount of new machinery and equipment being put in.

Our studies so far indicate that this is still in its early stages, as far as extensive labor displacement is concerned. You will notice that the overall productivity increases for the economy are not spectacular. They are not even as spectacular in manufacturing as they were in the 1920's.

This doesn't mean, however, that capital investment and automation is not taking hold. I, myself, feel that the enormous amount of capital investment that has taken place in recent years is bound to have some effect on productivity in the long run. Businessmen are foolish to put in this equipment if it is not going to save labor; and as it spreads, I think it will take effect.

You will recall that our study of an insurance company was based on the introduction of a new electronic computer. Already the company has added two more. This shows how mechanization moves faster as it develops. However, for industry as a whole I would not expect anything spectacular in the early part of 1957 or even in 1958.

Mr. ENSLEY. To what extent has the change in product mix, so to speak, during 1955 and 1956 and in, say, the outlook for 1957, affected the output per man-hour? You would say 1955, being a year notable for its consumer durable goods and automobiles and other items of high output per man-hour type, as against 1956, where automobiles were down and services and nondurables moved ahead—does that have or does that constitute a factor?

Mr. CLAGUE. Yes; that certainly does have an effect.

When there is an expansion of a high-productivity industry, let's call it, an industry where there is large capital investment per man and large output per man, like automobiles, there is no doubt about the fact when such an industry declines during a year, as compared with another industry like textiles, which has less capital per man and less output in dollars per man, there is a depressing effect on overall productivity figures. But this will be modified again when automobiles expand.

This factor is present, but I don't know that I could say what fraction of the change was due to this one as distinct from technical improvements within individual industries. I don't know whether Mr. Greenberg wants to add anything to that, or not.

Mr. GREENBERG. Mr. Ensley, we haven't looked specifically at the years 1955 and 1956 with regard to your question; but, based on our analysis of what has happened since the war in manufacturing and in the total economy, I would guess that industry shifts have not had a major influence on the productivity trend.

Generally speaking, even though significant changes may occur in the importance of industries, it takes a rather big change to affect the productivity trend.

Mr. ENSLEY. That is all, Mr. Chairman.

I am very interested in these productivity figures, these statistics of output per man-hour, which I think we have got to improve on in the years to come.

Chairman PATMAN. Mr. Siciliano, I would like to ask you a question or two, please, sir.

Mr. SICILIANO. Yes, sir.

Chairman PATMAN. You consider the economy is going along now on what you might consider an even keel, or going along evenly, or is it up or down?

Mr. SICILIANO. Well, I am not going to be able to give you an answer on that, Mr. Chairman. My own experience, though I am not an economist, would indicate that it is hard to ever say that anything is ever moving along on an even basis.

I don't think that, even when we are optimistic about the upward movement of the economy, we can be sure that it will continue on that basis.

So that all I can say is, I don't think the movement could be ever considered even; but it is perhaps a good movement.

Now, I don't know if Mr. Clague wants to add anything to that.

Chairman PATMAN. Would you call it good up or down?

Mr. SICILIANO. Normally, progress is up.

Chairman PATMAN. You would say it was moving up or down?

Mr. SICILIANO. I would say it is moving up.

Chairman PATMAN. Up.

Do you see anything in the high interest policy of the Federal Reserve System which is causing any unfavorable signs to appear?

Mr. SICILIANO. The Federal Reserve moving upward the interest rate, for example?

Chairman PATMAN. That is right.

Mr. SICILIANO. Well, obviously that has an effect on many of the small borrowers of money, and that would have a deterrent effect, I would assume, although I am not too sure that it would make borrowing any more difficult for them than it has been already.

Chairman PATMAN. Do you see any unfavorable signs by reason of this policy?

Mr. SICILIANO. Unfavorable signs to the borrower, for example?

Chairman PATMAN. Unfavorable signs in the economy, like small fellows closing up and putting people out of work.

Mr. SICILIANO. No, sir, I don't see——

Chairman PATMAN. You do not see any signs like that?

Mr. SICILIANO. I do not see any. There may be some, of course, some effect.

Chairman PATMAN. What about the home construction, the housing construction? It is down very low.

Mr. SICILIANO. Housing starts are down, although I understand that actually this current year will show that the total or the aggregate in volume of dollars will be the second greatest year on record, although the housing starts themselves are down.

That is possibly accounted for because of the——

Chairman PATMAN. Inflated price of material?

Mr. SICILIANO. Inflated prices, and the higher priced homes.

Chairman PATMAN. And other costs?

Mr. SICILIANO. Yes, and other costs.

Chairman PATMAN. Yes.

Let's see, do you see any effect on the disposable income of workers by reason of the high interest policy?

I refer particularly to this: As interest rates go up—it is possibly too early to see much difference now—you know, somebody must pay that increased cost. If interest goes up 1 percent, our total debts of the Nation are $700 billion, a few billion more than that, including the national debt—now, we will always have those debts, and more, because our system cannot operate without debt.

When that interest charge goes up 1 percent, that means $7 billion a year. Somebody must pay it. If you divide that $7 billion by the 165 million-plus people, you will find that that is about $40 per capita for every man, woman, and child, just that 1 percent increase on the debts of the country.

A family of 5—that is $200 per year.

Now, whether they know it or not, they are paying that, they are doing it either through higher rents—because the landlord must pay the higher taxes and higher charges because of higher interest rates—or, if he is buying a home, he must pay it in the form of higher interest; or if he lives in the city he must pay higher taxes, and pay higher taxes to the State; because all the States, counties, cities, and political subdivisions have to pay higher taxes, too, and that goes right down to the person paying the taxes. He has got to pay more.

And the automobile manufacturer must charge more, because interest is a part of the cost of doing business, and that is passed right on down to the consumer.

So, whether we know it or not, we have a hidden tax there of about $7 billion a year additional with every 1 percent increase.

I don't suppose you have been able to detect any difference in that so far, to this extent, that the average person has so much less to spend by reason of that hidden tax or that extra interest that it is affecting his purchases of other goods, durable goods, for instance. You do not see any change in it so far, I don't suppose.

Mr. SICILIANO. I don't think I do. I would assume that there could be an effect here in terms of the purchase of consumer goods, but thus far it seems to be not deterred too much.

Chairman PATMAN. It is a little bit—it has not been going on long enough, probably, to just be able to see the difference. But, naturally, it is coming, because we cannot escape it.

Are you dealing satisfactorily, in your judgment, with the critical areas, the critical-unemployment areas, in the country? Or do you need new legislation or additional legislation?

Mr. SICILIANO. Mr. Chairman, I think that the administration is prepared to submit to this forthcoming Congress legislation which is designed to alleviate some of these persistent problems that have plagued these so-called critical areas of unemployment.

Chairman PATMAN. Chronic unemployment.

Mr. SICILIANO. Chronic, persistent areas of unemployed; yes, sir.

Chairman PATMAN. Do you feel that you have the weapons to deal with it now, the tools, or that you need additional power and authority and money?

Mr. SICILIANO. Yes, sir; that is right.

Chairman PATMAN. All right. Well, thank you, gentlemen, very much.

Mr. SICILIANO. Thank you.

Chairman PATMAN. Mr. Ruttenberg?

Mr. George Meany was to be the next witness this morning—president of the AFL–CIO—but Mr. Meany is unable to be here, and we have with us in his place, Mr. Stanley Ruttenberg, who is the economist for this group.

And I want to say, personally, Mr. Ruttenberg, that we shall look forward to your testimony. I know that you will give us some good ideas and suggestions.

STATEMENT OF GEORGE MEANY, PRESIDENT, AFL–CIO, PRESENTED BY STANLEY H. RUTTENBERG, ECONOMIST, AFL–CIO

Mr. RUTTENBERG. Thank you very much, Congressman Patman.

Might I just say at the outset that Mr. Meany is terribly sorry he could not be here this morning. He has asked me to read excerpts from his statement, which is to be submitted in his name.

What I have are really just excerpts from a longer statement which I should like leave to submit for the record next week, if I could.

Chairman PATMAN. It will be inserted as part of the record.

Mr. RUTTENBERG. Thank you.
(The statement referred to is as follows:)

STATEMENT BY GEORGE MEANY, PRESIDENT, AFL–CIO, TO THE SUBCOMMITTEE ON ECONOMIC STABILIZATION, JOINT ECONOMIC COMMITTEE, ON AUTOMATION AND TECHNOLOGICAL CHANGE

I appreciate this opportunity to provide the committee with a few comments on the far-reaching technological advances that are taking place in American industry.

The committee is to be commended for devoting special attention once again this year to this critical problem.

Most of the people from whom the committee has heard, both in last year's and this year's hearings, have been either engineers who have been responsible for developing the new automatic equipment or businessmen who have had the responsibility for marketing or utilizing the new equipment. These are the individuals most qualified to explain the latest devices to the committee, and to give the committee a feeling of the future developments in this area.

I feel, however, there is some danger that from these witnesses the committee may be learning about only one aspect of this broad issue. Committee members may be learning a great deal about the new types of automatic equipment and about the vast new potentialities that are opened up by the development of these new machines.

Such a presentation almost inevitably leaves the listener with a feeling of awe and wonder. Under such circumstances, there is the danger that the committee will neglect some of the real impact problems that are inextricably bound up with adoption of the new automatic techniques. This committee should ask representatives of business corporations to indicate what their companies have done or intend to do in the way of introducing automation. They should be asked to discuss manpower and skill requirements, industrial migration, retraining, and collective-bargaining implications resulting from the impact of the installation of automatic equipment.

It is the duty and responsibility of organized labor to be very insistent in calling attention to the human element in automation. Questions of designing, installing and maintaining the new equipmet are all problems which lend themselves to scientific treatment; they can be solved by the engineer. It is the human problems, the questions of adjustment to change, or preparation for new assignment, and of economic impact to society as a whole that cannot be solved in such a mechanical fashion but must be subject to the most imaginative thinking that all of us can give.

I cannot in this short presentation discuss in any detail the many human problems that will arise with the introduction of these new automatic machines. I would like, however, to focus attention on the following particular problems which I feel have received inadequate attention.

I. THE POSSIBILITY OF LARGE-SCALE SOCIAL DISLOCATIONS

The maintenance of high national levels of employment during the coming decade is an essential requirement if we are to achieve social and economic adjustments to the new technology, with a minimum of social disruption.

Declining markets and layoffs due to production cutbacks would only magnify and aggravate the many problems that accompany radical technological change. We must do all in our power to avoid such a situation.

A rapid introduction of automation equipment and production processes in the next 5 to 10 years may produce large-scale layoffs and unemployment, unless markets grow fast enough and working hours are reduced. Even if we are sufficiently wise and fortunate to avoid widespread layoffs, there is the possibility that the economy may not produce enough new jobs, in the transition to the new technology, to provide employment opportunities for a growing labor force. Many companies have boasted of adjusting their work forces to the new production processes, without layoffs, but without hiring new employees.

The Nation is now entering a period in which the labor force will be growing more rapidly than in the past. The high birth rate since 1939 is increasing the number of young people entering the labor market. The labor force, which increased by an average of about 700,000 a year, between 1950 and 1955, is now growing at an average annual rate of about 900,000, between 1955 and 1960. According to the Census Bureau, the yearly rise in the labor force, between 1960 and 1965, will be about 1,200,000. Will there be job opportunities for such a rapidly growing labor force in this coming period, when the new technology spreads through the economy?

To maintain high levels of employment in a period of technological change and a rapidly growing labor force will require intelligent action by private groups and government. Expanding consumer markets will be needed—requiring adequate wage and fringe-benefit improvements, reductions in hours of work, and a relatively stable price level. The Government's fiscal and monetary policies must be sensitively geared to the requirements of full employment, and in the event of a general economic downturn, the Government must be prepared to act, without delay, to forestall the spread of unemployment.

By maintaining high national levels of employment, we will be able to provide a general environment in which the problems that accompany radical technological change can be more readily solved. The development of dangerous, large-scale social dislocations can be avoided by maintaining the general health of our national economy.

The maintenance of high national levels of employment in this period of widespread changes in production processes should be considered a No. 1 objective of domestic economic and social policy. But even if high national employment levels are maintained, there will be scores of other problems that we will have to deal with, a vast multitude of adjustments that will be required.

II. MIGRATION OF INDUSTRY

The requirements of the new types of automatic equipment are such, according to various engineers, that it will be cheaper in many cases—if not most of them—to build entirely new automated plants in new locations, rather than to rebuild old plants. Furthermore, since automation may mean substantial changes in cost relationships—labor costs become a smaller part of the cost of production, for example—the shifts in plant location may well be from one State or region to another. The construction of a newly automatic factory in one locality could thus create dislocations in other communities if it forced the shutdown of older factories and idled workers in other localities.

Thus, we are faced with this critical question:

To what extent will these improvements in technology speed up the trend toward the migration of industry leaving older established communities without sufficient job opportunities for their residents?

We have seen the devastation that has been caused in the textile industry by the wholesale migration of plants from the New England to the southern part of the country. In large measure the motivation behind this mass movement of industry has its roots in problems of machinery and new equipment. The mills in New England with their older equipment and inefficient plant layout were admittedly becoming obsolete, with the result that tremendous savings could be made by establishing a new plant in a new location. At the same time, the South offered special subsidies to migrating plants as well as a generally lower level of wages and a climate of opinion more hostile to unions.

The resulting movement of the textile industry has produced very difficult problems in New England where the costs of this migration have had to be borne by the local townspeople in Lawrence, Lowell, and other textile centers throughout the area. There are already indications that automated factories have been built in new areas away from older plants. This results in loss of employment in the older areas, with expanded employment opportunities in the newer ones. How extensive this is is not fully known. But this committee could well look into the problem of whether we are now likely to create new distressed areas because the urge for automatic equipment provides special incentives for industry to build new plants in new locations. This committee, too, should examine the needs of distressed communities and establish the basis for a long overdue program of Federal Government assistance for communities of chronic economic distress.

III. TRAINING

Organized labor welcomes the new advances in technology. We want to see the new equipment introduced as promptly as possible so that we and our heirs can receive the benefits of the lowered operating costs and higher productivity.

At the same time, we insist that all of us—labor, management, and the public—plan ahead for any problems that might develop in introducing this new equipment. In particular, we thing it is important from the point of view of the entire economy that any displacement of workers be kept to the irreducible minimum.

In this connection, special problems of training are bound to arise. Workers whose jobs will be eliminated by installing the new equipment must be the first to be considered for work on the new equipment. Many of them will be mature people to whom learning new skills may not come easily. They must be given full opportunity, at company expense, to acquire new skills. It will require the best brains of labor, management and vocational training specialists to develop new types of training programs for these workers so that they can make their maximum contribution to their new jobs.

This will not be an easy task. In some cases it may seem impossible to adapt the worker who has been used to a semiskilled assembly-line job to become an integral part of one of the newer-type electronic machines. However, we are confident that if we start now to work on this problem, there is no reason why it cannot be solved.

Part of this retraining effort will have to be worked out by unions and management. But cooperation and assistance will be required from Federal, State, and local governments to provide vocational training facilities and instructors, wherever needed, and improvements in the unemployment insurance system to provide compensation for employees, if they are not receiving their pay during the retraining period.

IV. ADJUSTMENTS IN COLLECTIVE BARGAINING

A host of other problems are bound to arise involving the particular plant or company introducing the new equipment. New job titles and new wage rates will have to be negotiated for the new jobs on the basis of new skill requirements, new responsibilities, and added output. Some workers will probably be downgraded in the process of change—will they retain their old wage rates? Existing job evaluation plans will probably have to be discarded.

Work on the new automated jobs will not lend itself to a wage incentive system, existing incentive programs will have to give way to straight-time rates or another wage system particularly geared to the new jobs.

In same cases revisions of the wage structure of the entire plant or office will be required as a result of the changes for automated jobs. Special efforts will have to be made to provide continuing employment for older workers who find it difficult to adjust to the new production techniques.

The entire question of seniority, promotions, and transfers will have to be carefully reviewed in collective bargaining. Clearly the shifts in production processes brought out by the new machines may force revisions in the plant's job structure, promotion ladder, and transfer arrangements.

Collective bargaining provides the mechanism for working out the complicated details of these adjustments. This mechanism will be able to perform its function, only if the parties bargain in good faith.

Joint consultation between labor and management, in advance of the installation of new equipment, is required to develop the necessary adjustments affecting workers due to radical changes in machines, production processes, and work flow. Companies usually plan technological changes long in advance—1, 2, or 3 years before they become effective. Management carefully plans and revises the financial and cost aspects of such changes. It would be well for managements to consult unions long before the new production processes are placed into operation—to work out the required shifts in the work force, the changes in jobs and skill requirements, the necessary retraining of workers. Only through such advance consultation and planning can orderly procedures be developed to achieve equitable adjustments in the factories, offices, and other places of work.

These are but a few of the specific issues that are bound to arise as the new automatic machinery takes its place in modern industry.

Labor is raising these issues because we feel that they require thinking and planning in advance of the actual installation of the equipment. We do not know at the present time how serious these problems may become. It may well be that the questions we are raising will prove only a minor irritation in the process of adopting the new techniques. Certainly that is our hope. However, unless these questions are discussed fully and frankly in public and at the bargaining table, there is a real danger that misunderstandings or difficulties may arise.

What is the role of the Government in meeting these problems? We are not here to ask the Government to solve these questions for us or for American management. We do think that because of the far-reaching implications of the new automatic equipment, the government has a responsibility:

1. It should collect and publish relevant information on current technological developments regarding the new types of automatic equipment.
2. It should conduct studies drawing on the experience already obtained in industry that would prove helpful to labor and management in planning the introduction of the new equipment.
3. It should provide Government agencies with adequate funds for case studies concerning the social and economic effects of automation and the extent to which the new production processes are spreading in various parts of the economy.
4. It should encourage and stimulate universities and private research groups to study the social and economic implications of the new technology.

In addition, of course, we urge this committee to continue its very real interest in these problems, reviewing the latest technological developments, bringing to light possible problems, and where necessary prodding the Government to undertake programs that will help to minimize social and economic disruptions.

NO AUTOMATIC ADJUSTMENTS

Let me add that I am not pessimistic about the ability of American society to adjust to the new technology. Neither do I believe, however, that the adjustments will be automatic.

There is no machine, automatic or otherwise, that can produce customers for an expanding economy. Nor are there self-correcting machines that will automatically provide jobs for a growing labor force. And there is no mechanical device that will automatically train a technically skilled work force or spread the benefits of automation to all groups in society.

It is not characteristic of the trade-union movement to sit back and let the future take care of itself. If the adjustments are to be made, they will take foresight, planning, and cooperation between business, labor, and Government.

I have no doubt that automation's promise of improvements in national strength, living conditions, and in leisure will, in the long run, be achieved. These long-run achievements, however, will require the efforts of all groups in American society to ease the process of human adjustments to the new production techniques.

Mr. RUTTENBERG. That concludes the formal statement of Mr. Meany.

Chairman PATMAN. I want to ask you, do you see any unfavorable signs in the economy at this time?

Mr. RUTTENBERG. Do I see any unfavorable signs in the economy at this time?

Chairman PATMAN. Yes, sir.

Mr. RUTTENBERG. Well, I do, Congressman Patman. I am particularly concerned about what is happening in the housing market with home construction declining, new housing starts on the decline. We are even running now, I think, currently at an annual rate of less than a million starts a year.

Chairman PATMAN. Don't you think we should build up around 2 million houses a year in order to take care of the market properly?

Mr. RUTTENBERG. I can't agree with you more fully, Mr. Patman. We as an organization have strongly advocated that there is a need now for at least 2 million new homes a year, and that these ought to be built, and as we look into the next 4 or 5 years, there will be need for even more than 2 million homes a year to meet the new family formations that are occurring in American life, and it is unfortunate that various developments are now retarding the housing market. I think that is an important area.

Chairman PATMAN. It is principally the tight money, the hard-money, high-interest policy, isn't it, Mr. Ruttenberg, that you are talking about?

Mr. RUTTENBERG. Again I must agree with you, Mr. Patman. I really think that the interest-rate question of moving interest-rate structure now to where it takes to get an FHA loan 5½ percent, including a half percent insurance, as against 4½ percent a year ago, more than a year ago, and 5 percent within the last year or so, is a very unfavorable sign.

I think VA loans are now almost not available because——

Chairman PATMAN. That is right.

Mr. RUTTENBERG. It takes legal change by the Congress to up these rates. But upping the rate is not going to solve this problem.

Chairman PATMAN. May I suggest there is something else there that is a deterrent. They must give additional amounts in the form of discounts, and if the buyer can't pay it, the seller must pay it. It is going on all over the country. It is disgraceful. It ought not to be permitted in a civilized country, it is terrible, 10, 12, 14 percent in addition to all these others, high interest and everything else.

We had a provision in the law against that. It is a form of racketeering, that is what it is, and we wrote a provision in the law against it a few years ago.

And in some way or somehow, there was a provision in the law in 1954 that repealed it outright.

Do you know about that?

Mr. RUTTENBERG. No; I do not.

Chairman PATMAN. I don't think Members of Congress realized it. You know that is one thing that I have a criticism of Congress about, that Congressmen are not equipped to do their jobs, things go through that they don't even know about.

I don't think that would have ever been allowed to go through, if Members had known about it generally. But they don't have administrative assistants to go around to the different committees and keep up with the different bills and keep their Members fully informed.

They are just not equipped to do it. They don't have the time themselves to do it.

I am not criticizing the Members, the hard-working Members, and I served with 3,000 Members of the House since I have been a Member of it, and I don't believe you could find finer or better or any more conscientious or harder working people in the world than the people who serve in Congress. But they are just not equipped to do the job.

And I think there is an outstanding example of permitting a provision to go through and become a part of the law to repeal that provision which really stopped the racketeering against the veterans in housing a few years ago. But that went through in 1954.

Pardon my interruption. I wish you would go ahead with your statement.

Mr. RUTTENBERG. Well, there is another area of the economy that is disturbing, I think, and that is one which you were previously discussing with Secretary Siciliano a moment ago, and that is distressed areas.

It in part is implicit in some of the testimony of Mr. Meany here today.

It seems to me it is an interesting and probably sad commentary upon the American economy in which we have relatively, and I say relatively advisedly, full employment, where we are running in the neighborhood of currently about 2½ million unemployed, where we are down to almost a minimum, although I think the unemployment ought to be lower than that, but generally speaking where we have relatively few unemployment that we still have, I think by the latest count, something like 15 major labor-market areas, and something between 45 and 50, if I am not mistaken, of minor labor-market areas in which unemployment is today in excess of 6 percent of the labor force.

Chairman PATMAN. Are they the chronic areas?

Mr. RUTTENBERG. These are mostly chronic areas of unemployment, and, of course, over the period of the last 2 years, the number of areas were even greater, they have declined in the past year, there is no question about that, and they tend to get down now to those that are more chronic as against those that periodically move in and out of the so-called distressed areas, and this is a segment of the economy that needs to be taken care of, and I think needs some attention by the Congress of the United States.

And I should hope that they would begin consideration once again of the bill which passed the Senate in the closing days of the last session, and came to the House, and almost got through, but not quite, as a result of the Rules Committee bottling the bill up. This is one area.

Another area which disturbs me, as I look at the economy with a long-run gage of more than just the new few months, is the relationship between the expenditures in the national economy for new plant and equipment or business expenditures on the one hand and consumer expenditures on the other.

The proportion of gross national product or national income going to business investment is going up. The proportion going to consumer expenditures is declining, and I think this is creating a distortion in the economy, that could prove to be a difficult economic problem, a difficult problem for economic adjustment as we look into the future.

I think this has to be handled in some way, particularly because—and here I don't want to get into a technical problem—but because I think there is now developing a greater productivity of capital than we have ever had before in our economy, whereby for each additional dollar of capital invested there is a larger output per product coming from that dollar of invested capital, and this, if true, and I think the figures now developed by various research organizations, particularly the National Bureau of Economic Research in recent studies and others shows this to be a fact, or at least developing it as a fact.

If this is true, then we are exaggerating the relationship between capital and business investments on the one hand and consumer investments on the other even more, by the large-scale business investments that have taken place during the last year, and will by current reports continue into next year.

I could go on and list a few other areas.

Chairman PATMAN. That is all right.

Would you like to ask any questions, Dr. Moore?

Mr. MOORE. Mr. Ruttenberg, you were in the room when I asked Mr. Siciliano, or referred to the Standard Motors strike in England?

Mr. RUTTENBERG. Yes.

Mr. MOORE. Are you aware of any important labor disputes or strikes in this country that have arisen with the automation being a primary issue at all?

Mr. RUTTENBERG. I am not aware of any serious strikes that have occurred as the result of protests against the installation of new machinery such as the strike in England was.

You do, of course, have strike situations in grievances developing that probably do not get to strikes where the unions are terribly concerned about this other area, the third area that I discussed in the paper here, how you handle the collective-bargaining problem of adjusting wage scales or adjusting incentive system to a totally new approach to the problem of mass production.

So this creates internal problems. But I think I ought to say quite clearly and I think quite unequivocally on behalf of the labor movement, that there is no opposition on the part of organized labor to advances in technology in the American economy.

You will find, of course, certain fringe situations here and there where local groups tend to object, but the basic position of the American trade-union movement is quite sound in this connection and it differs considerably from that of the economics of Europe and England in the fact that they strongly support new developments in the field of automation and technology.

We say only that in these developments the benefits resulting from them must be shared equally by the workers and the consumers and the corporations installing the equipment.

Mr. MOORE. That is all. Thank you.

Chairman PATMAN. Dr. Ensley, would you like to ask any questions?

Mr. ENSLEY. One question.

Mr. Ruttenberg, you heard the question I asked Mr. Clague with respect to recent trends in output per man-hour. Do you have any observation you would like to make on that?

Mr. RUTTENBERG. Well, only to lend support to what Dr. Clague said, that I think the data available so far for 1956 on which certain tentative conclusions seem to be or are being drawn, is not sufficient really to draw any real sound conclusion, and I think that while there may have been a temporary lag in productivity advances in 1956, and I don't thoroughly agree with that as a concept, but even if there was just this temporary lag, I think the whole notion of the billions of dollars that are being spent on new plant and equipment now, carry into the future the concept of substantial advances in productivity.

I agree with Dr. Clague that business and corporations in this country would not be investing such money unless it was for the purpose of reducing costs.

Mr. ENSLEY. That is the only question I have.

Mr. Chairman, in light of your earlier questions with respect to the problems of the aging, I just this moment received an interesting statement by Chairman Seymour Harris of the department of economics of Harvard, a statement on economic problems of the aging for the New York Legislative Joint Committee on the Aging, which he presented December 11, and with your permission if it might go into the record.

Chairman PATMAN. It may be inserted in the record.

(The statement referred to follows:)

STATEMENT ON ECONOMIC PROBLEMS OF THE AGING FOR THE NEW YORK LEGISLATIVE JOINT COMMITTEE ON THE AGING HEARINGS, NEW YORK CITY, DECEMBER 11, 1956

By Seymour E. Harris, Chairman, Department of Economics, Harvary University

I. THE PROBLEM

By the old I mean those aged 65 and over. Those 55 to 65 face problems similar to those of the aged but in a less intense degree.

The problem is that the old, increasing relatively twice as rapidly as the rest of the population, numbering 3 million in 1900, 13 million today, and an estimated 21 million in 1975, are confronted with inadequate and uncertain income. They are not sharing in the prosperity nearly to the extent of the whole population. Their savings are disproportionately small; their numbers on relief rolls, 6 times their proportion of the population; their income, on the average, one-half of the Nation's average; their state of health below average as suggested by the fact that two-thirds of the aged beneficiaries under the old-age and survivors insurance program (OASI) suffer from chronic diseases; their days in the hospitals about 3 times those of the whole population and yet only 15 percent covered by hospitalization insurance; their housing and institutional facilities far below need; their access to jobs blocked by ignorance and lack of flexibility of management; and the contributions of the Government, though greatly increased in 20 years, still inadequate.

Allocations of resources

The problem is largely one of allocation of resources and financing. Annual outlays on highways are likely to approach $10 billion yearly in the next decade. Yet Government makes but $7 billion, exclusive of insurace, available for the old, inclusive of veterans. The amount provided is less than 2 percent of the Nation's gross national product of $415 billion.

Cost in relation to income

The costs of an adequate program should be put against the income not of today but of tomorrow. In a thorough study, the Twentieth Century Fund showed that if 5 to 6 percent of the gross national product of 1980 were available for the old (inclusive of their own contributions), then each retired worker and his family would have an income of $200 per month. Then 9 percent of the population would receive 6 percent of the Nation's income. This compares with an average income of somewhat less than $200 per month per employed old today, of $62 per retired worker under OASI, and of $55 under old-age assistance (OAA).

In his statement Where Does the Money Come From, Governor Stevenson estimated that with a rise of income of the old population from 50 percent, the current rate, to 75 percent of the average of all incomes, the additional cost would be $4.3 billion per year; the additional gains of the old, $800 per family. Since an improved hiring policy would absorb part of the cost, the net addition to the Government of this proposal would be about $3 billion, or less than 2 percent of the expected rise of the national product in the next 10 years.

The lags of incomes of the aged

Perhaps one of the toughest problems is the effects of the steady rise of income upon the economic status of the old, the rise in part reflecting inflation, in part increased productivity. Insofar as past accumulation provides the income of the old, this is a serious problem. Today insurance provides about one-quarter; in the future its relative contribution is likely to rise. In 1955, the face value of survivors' life insurance alone under OASI was $339 billion.

But the average old man or woman accumulates these credits over a period of 40 years, the mid-year point being 20 years before retirement and about 27 years before the mid-year of the retirement period. In a period of 27 years, average incomes double aside from inflation. In addition, inflationary pressures are great. Hence the retired receive much less than they bargained for in dollars of stable purchasing power and even more so relative to the income of the active members of the population.

From past experience we draw the conclusion that the old, dependent primarily on savings, inclusive of pensions and annuities, will be confronted in retirement years not with the income anticipated at the time of accumulation but perhaps one-half as much, and vis-a-vis the income of the active population, their income at time of retirement, to the extent it is based on past accumulation, will be substantially less than one-half, and might even fall to one-quarter of anticipated amounts.

II. SOLUTIONS

Full employment

Continued full employment lightens the burden on the economy of supporting the old. Hence the need of full-employment policies. In 1949, a recession year, unemployment of those aged 65 and over was 4.6 percent; in 1953, a prosperous year, 1.9 percent.

Stability in the purchasing power of the dollar

Perhaps no group is injured as much as the old by inflation. First, because they are dependent on savings, inclusive of insurance, pensions, and annuities. Second, because large numbers are off the labor market and hence, unlike members of the labor market, they are unable to adjust income as prices rise. Third, because their income is low relative to all income. The Government should, for this reason and others, pursue a vigorous anti-inflation policy.

Improved medicine

Since the old require much more medicine than the active population and since they are disproportionately excluded from medical insurance, medical aid is imperative. Outlays on medicine are an economical approach, since the payments are made only to those in need of this kind of help. Here are some alternatives:

Encouragement of private voluntary comprehensive insurance for the whole population and coverage of insurance fees of the old under OASI and old-age assistance.

Discouragement, by legislation or otherwise, of the increasingly popular practice by insurance companies and even by nonprofit associations (e. g., Blue Cross) of insuring only the best risks and, therefore, endangering genuine comprehensive insurance which should cover all risks on the insurance principle. With 3 out of 5 aged suffering from chronic diseases and but 15 percent covered even by hospitalization insurance, this is indeed an important area of exploration; for it is especially the old, who are not good risks, that are excluded from insurance.

Housing

Related is the procuring of nursing homes and other housing especially suited for the old. A beginning has been made in providing nursing homes under the Federal hospital construction legislation. Much more should be done here and also in providing special financial facilities for the building of home to serve the old—e. g., a home that provides common medical facilities (but much less elaborate than hospitals), recreational, dining, and service facilities.

Institutional care

One of the most perplexing problems is the provision of adequate institutional care. This is especially important for the very old. In 1900 public institutions provided for 47,000 aged; in 1950, only 60,000. The provision from private sources rose from 18,000 to 157,000 (largely nursing homes) and of mental hospitals from 13,000 to 141,000. But even today all these institutions can provide for but 2 to 3 percent of the old.

Private pension funds

These now cover from 12 to 15 million workers and may ultimately cover twice as many. The effectiveness and contributions of these plans will be greatly increased if, as recommended by the Senate Labor Committee, the managers were required to register and make full disclosures.

Liberalization of benefits under Government programs

Average payments under OASI are inadequate, even granting that they will rise as is provided under present legislation. On the basis of past experience, the growth of income and inflation are most likely to make anticipated benefits inadequate. Hence we need a built-in escalator clause which should raise benefits not only as prices rise but even to some extent as per capita incomes rise. We do not want a repetition of the experience in the 1940's, when retired workers received two-thirds as much in 1949 as the grossly inadequate benefits of 1940 in dollars of stable purchasing power, even as factory wages rose by 25 percent in stable purchasing power—or a relative loss for the retired workers of almost one-half.

Increased jobs

Above all, the old want jobs. They should have them. In an overemployed economy the case is stronger than ever. We need more workers. The old want to work, as is evident from the fact that a large proportion of those eligible for OASI stay on the labor market; as is evident in the average age of 68½ (instead of 66) at which beneficiaries first obtain benefits.

As a result of the increase in life expectancy and other factors, the average worker now voluntarily or involuntarily spends about twice as many years relatively in retirement as 50 years ago.

Through State legislation (as in Massachusetts), through cooperation of business (tapering off of older workers, adjustment of jobs to advancing years, nondiscrimination against old), and through Federal measures (e. g., reducing the penalty under OASI for annuitants who work), it is possible to increase the contribution of the old to their own support. It is well to remember that policies appropriate in a great depression are not the ones to support in prosperity.

Integration of programs

A dollar contributed by Government might become a more potent dollar with improved integration of the various programs. For example, the administration of veterans' benefits (Veterans' Administration), of OASI, and of OAA (old-age assistance) should integrate their programs. Duplication of benefits is not unknown.

Excessive allocations to aged veterans may be costly to other aged. There are some issues of justice and distribution involved here. As we approach universal service, the distinction between veteran and nonveteran becomes blurred. The Bradley Commission on Veterans' Benefits in the United States was eloquent on this point. Our obligations are already substantial (pp. 112–113).

"The Commission's projects indicate that under existing laws the cost of veterans' benefits to our World War I, World War II, and Korean conflict veterans for the past and the future will total $371 billion. Of this, 52 percent would be for non-service-connected pensions, 21 percent for service-connected compensation payments, and 27 percent for medical, readjustment, bonus, and other benefits. Of the total of $371 billion, $306 billion yet remains to be paid.

"Assuming the enactment of service-pension legislation in the future, the aggregate disbursements for veterans' benefits, past and present, for these 3 wars would be $762 billion. Of this sum, 77 percent would go to non-service-connected pensions.

"* * * the $306 billion of veterans' benefits outlays yet to be made would have a present value of $140 billion. If the service pension is assumed, the present value would be $290 billion."

CONCLUSIONS

Finally, let me say, how much we can afford for the old depends upon our national product, the drains on the economy of the military and other essential programs, such as education, highways, health, development of resources. There must be proportions among these programs. The more the old contribute on their own, the less the subsidies required. The less the inflation, the less the burden on the taxpayer. The more that can be put upon insurance programs, the less the cost to taxpayer. Of this I am sure: Today, given our rising income, we can afford to assure the old an income three-quarters of the national average, an amount which would roughly take care of their needs and certainly not bankrupt the Nation.

Chairman PATMAN. I would like to make one observation, Mr. Ruttenberg.

You mentioned about expenditures for new plant equipment going up and up and up, and about expenditures, consumer expenditures going down.

Now, that is a serious problem, I think; and I think it is being greatly aggravated by high interest.

Do you have one of the economic indicators here, the last ones, November? Do you have a November indicator, Mr. Moore?

You take, for instance—let me have the reference to personal interest income.

It is personal interest income—we will take for instance, in 1954 it was $10 billion. Even in 2 years, here in 1956—I had it wrong—it was $14,900 million in 1954, personal interest income, whereas just 2 years later, hardly 2 years have expired, September 1956, the personal interest income has increased until it is at the rate of $17,700 million, in other words, almost $3 billion a year increase right there, and that partly because of higher interest, of course.

And you know, Mr. Ruttenberg, as people have to pay more and more in interest and servicing the debt, why they will just obviously have less to spend for durable goods and for comforts and conveniences of life.

That is inescapable. And I think it is a serious problem right now that the plant and equipment expenditures are going up at such a rapid rate and the consumer expenditures are leveling off.

I think it is something that we must watch carefully. I am glad you brought it to our attention.

Mr. RUTTENBERG. I think it is the fringe person, as it is the fringe company.

Chairman PATMAN. Yes, sir.

Mr. RUTTENBERG. That really is hurt by the rise in interest rates, and this is the unfortunate thing which occurs as we follow a tight money policy, that we allocate the resources, the loan resources of the country through the banking structure, and as a result it is only the best risks which get the loans, it is only those companies or those individuals who can afford to pay the higher interest rate who get them.

And the facts really show that the higher interest rate policy has not materially curtailed expenditures either on the consumer or the business side, but it has discriminated internally between the types of borrowers, and this is a very serious aspect of the tight money policy.

Chairman PATMAN. In other words, the bankers become the rationers of credit?

Mr. RUTTEBERG. That is right.

Chairman PATMAN. It is another OPA but it is handled by the bankers.

Mr. RUTTENBERG. Well, we talk about being against controls and having an indirect system of taking care of the economy, but actually we do have a system of controls but instead of being carried on by the Government they are being carried on by the banking institutions.

Chairman PATMAN. That is right. No question about that.

Now, of course, there is a reason why these expenditures are going up for plant and equipment. The large concerns are able to fix their own prices, and even when the excess-profits tax was repealed, although Members of Congress were told and the people of the country were told that that would cause a lowering of prices, it didn't cause any prices to go down.

We were told that if we took off controls the free market, competitive market would cause prices to go down, but prices did not go down.

And by reason of these high prices, and I can see why a lot of the manfacturing concerns were not anxious to lower prices, and looking at it from their side, why they have a lot on their side.

They have been caught before, you know, with frozen prices down low, and the atmosphere was favorable for emergencies all the time, and they didn't know when another emergency might come along, and they didn't want to reduce their prices and have their prices frozen low. I can see their point.

Nevertheless, prices remained high, and in remaining high, they have been able to collect enough from the public not only to pay all their expenses and everything in connection with their operations and to pay liberal, generous dividends, but to set aside in retained earnings generous amounts.

In other words, these excess earnings to the extent that they are excessive earnings, I don't claim that all retained earnings are excessive, but those that are excessive, are there because the people have paid higher prices to make it possible.

So in that way they are getting their capital for plant and equipment expenditures from prices, higher prices. They have taken it from the consumers. Instead of the concern going into the free market and selling stock in the concern, and letting these people buy stock and become a part of the private enterprise system or buy bonds of the company or debentures, this is an involuntary investment.

Mr. RUTTENBERG. I like to call that, Congressman Patman, costless capital.

Chairman PATMAN. That is a good name for it. That is what I have called it over the years. I think it is just that, costless capital, because it is costing nothing, it is taken from the consumer. I mean, the person who bought the goods, of course, the consumer. It has been going on all the time and going on right now.

Well, you take that kind of earnings, retained earnings and depreciation allowance account for about two-thirds of the expenditures for plant and equipment.

You know that is pretty large. Out of 35 to 40 billion dollars a year, two-thirds of it is coming from those two sources, and therefore, they are not retarded the least by this high interest policy.

They can go into the banks because large concerns are naturally affiliated with large financial institutions, and they can get loans, short term from the banks, and they can anticipate a rise in interest, and they will go in in advance and get their funds a year ahead, and that makes it harder on the little people who are scrambling to get the necessary funds to stay alive, to stay in business.

So that hard money policy is hitting us terribly right there, and I think it is devastating to our economy at this time, and I think you point out mighty well just exactly what the score is when you said that while new plant and the expenditures are going up, consumer expenditures are not.

Mr. RUTTENBERG. I would just like to make one comment in connection with this.

Chairman PATMAN. Yes, you may.

Mr. RUTTENBERG. Actually the tight money policy in moving interest rates up tends to create a situation in the equity market whereby less interest is shown in securing funds from equity because the dividend payments or the return or yield on the equity stock is getting to be in many instances less than the yield that can be gotten from bonds, and, therefore, people are not—are moving out of the equity market, corporations have not really moved into the equity market, so that it tends to even discourage those few who want to go into the equity market from even going there for sources of funds.

I do agree with you fully, and the steel industry is the very best example. They have publicly said within the past year, one executive after another, with the exception of the officials of the United States Steel, and they have taken a slightly different tack, but the officials of most of the big steel corporations have said they intend to raise their prices in order to increase their profit so that they will have enough retained earnings to finance the cost of doing business.

I think this is a serious, most serious, development in the economy and runs contrary to the concept of most conservative economists, sir.

Chairman PATMAN. I thought that was wholly bold and brazen when I saw it in print, people admitting that they are raising prices for the purpose of getting more expansion capital.

Not only the steel companies but others admitted it which, in effect, is saying, "We are going to make the consumers pay more than they should really pay for the products they are buying in order to have excessive retained earnings so that we can use those earnings to put into plant and equipment expenditures."

In other words, they will get the profits from what is made by reason of those expenditures, and the person who made that involuntary investment will get nothing.

So that is destructive to the private enterprise system, isn't it, Mr. Ruttenberg?

Mr. RUTTENBERG. I should think so.

Chairman PATMAN. It is not going in the direction of private enterprise.

Mr. RUTTENBERG. I think further the concept of retained earnings for expansion is a monopolistic practice because it tends to keep the same number of shareholders participating in a greater value per share of stock by the retained earnings, rather than to go into the public and enlarging their holdings, and enlarging the number of individuals who are participants in the corporation through the equity market.

It does just the opposite. And I think in a big corporation it tends to be a monopolistic practice.

Chairman PATMAN. Thank you very much, Mr. Ruttenberg.

Before closing, there are two matters which I believe ought to be put into the printed record of these hearings.

One is a letter from the Washington Plate Printers Union in response to our request as to the outcome of the consequences of the case of technological displacement which was brought to our attention last year. I am afraid the record is not a very happy one, but serves to bring forcibly to the attention of the Congress and everyone else the severe personal hardships and dislocations which follow forced reductions. I would like to remind all of those interested that, in its report last year, this subcommittee suggested that Government itself try to be a model employer in this respect, and urged that the executive departments and agencies while seeking economy and efficiency ought also to keep a special watch over the personal problems occasioned by displacement of this sort.

The other item for inclusion is a letter from Mr. Robert T. Sheen of the Milton Roy Co., describing a feature of his company's pension and retirement system which he believes to be extremely helpful and might serve as a pattern for others in minimizing the employment discriminations against older workers because of pension considerations.

(The letters referred to are as follows:)

WASHINGTON PLATE PRINTERS UNION,
Washington, D. C., December 15, 1956.

Hon. WRIGHT PATMAN,
Chairman, Subcommittee on Economic Stabilization.

DEAR CONGRESSMAN: Referring to previous correspondence which you will find in the hearings of October 14 to 28, 1955, in which we reported on the case of craftsmen in the Bureau of Engraving and Printing, of whom over 80 had been reduced in force because of technological advancements and increased production, we would like to report, after 1 year, on the present economic status of the last

48 plate printers who were reduced in force or otherwise downgraded on October 31, 1956.

Primarily, I believe that you should know that plate printers are paid a comparatively high hourly rate because of their unique skills and training: ($3.86 per hour or approximately $8,000 per year). Of these 48 plate printers only 3 could find a market for their skills in private industry, 4 elected to take reduced retirements, 25 still are working in the Bureau in downgraded positions, specifically, 1 as a carpenter ($6,240 per year), 13 have GS-3 guard jobs ($3,685 per year), 7 have level 3 unskilled labor jobs ($3,328 per year), 1 has a GS-5 clerical position ($4,480 per year), 3 have semiskilled positions (about $4,000 per year). Of the others not in the Bureau of Engraving, 2 have transferred to other Government agencies, salaries unknown, 4 are working at various printing jobs in private industry, 1 is an automobile salesman, 1 is an insurance agent, and the others have left Washington, D. C., and their present economic status is unknown.

It can easily be seen from the survey made by our union that in this case the economic setback for these displaced personnel was not temporary, and it seems unlikely that any or very few of these highly skilled craftsmen who have lost their jobs because of new machinery and technological improvements will ever again regain their former economic status.

The Bureau of Engraving and Printing is at this time planning to buy presses from a foreign manufacturer, that could conceivably replace 75 percent of the remaining personnel in the plate printing or currency division and would adversely affect all other auxiliary personnel in the Bureau.

Although the Director of the Bureaus, Mr. Holtzclaw, has made observations to employee representatives that these presses could be introduced with very little impact on personnel, both craft and noncraft, we can only look back to 1952 when these same observations were made to us.

Our union is of the opinion that more than oral promises, no matter how well intentioned, are necessary to protect the jobs of all employees, both in Government and private industry, who may be replaced and their economic status affected by technological improvements.

We feel that the Congress of the United States should set an example for industry by passing some legislation to protect the jobs of Government employees who have over 10 years of satisfactory service. A recommendation of this nature by you or your committee would be a most humane and progressive step.

I hope that this report on the economic status of replaced personnel, and the future outlook for craftsmen and other employees in the Bureau of Engraving and Printing will be of value to you and your committee. It is comforting to know that the Congress and a committee of this nature is concerned about the impact of automation on the workers of this country.

I am, respectfully yours,

THOMAS G. GILL,
President, I. P. P. D. S. & E. N. A. No. 2.

PHILADELPHIA, PA., *December 19, 1956.*

Re hearings before the Subcommittee on Economic Stabilization of the Joint Economic Committee, December 12, 13, 14, 1956.

Representative WRIGHT PATMAN,
Chairman, Subcommittee on Economic Stabilization, Joint Economic Committee, House of Representatives,
Washington, D. C.

DEAR MR. PATMAN: In the course of the hearings, just concluded, you queried several of the witnesses extensively on what plans were being made to utilize older workers. You seemed particularly interested in their role in the advances of instrumentation-automation.

Milton Roy Co. has recently started a second plant operation in St. Petersburg, Fla. We have a research and development group working there now and have just started a small amount of light manufacturing. As our operations become larger, we plan to make available work to older people, possibly on a 4-hour shift basis, which seems to be particularly desired. We understand that a number of other industries locating in Florida have already started such operations claiming that a 4-hour shift on light work is particularly attractive for this type of worker.

Several years ago we carefully studied our obligations to our employees in establishing a plan that would build the necessary fund for retirement. One of our objectives in this plan was to avoid any program that would make it any more costly for us to hire older workers. We believe that we have found the happy solution to that problem in establishing the "Milroy retirement savings plan." This is a profit-sharing plan so designed that the employee assists in determining just how large his retirement fund may be. This takes the place of any pension fund where the age of the employee at the time of joining us would have an effect on the thinking of the company because of the expense of contributing to such a plan.

Briefly, this retirement savings plan calls for a minimum contribution of each employee of 1 percent of his total wages or salary. In addition, any member may elect when he enters the plan, or before the beginning of any later year, to contribute up to 5 percent of his total compensation. The company contributes twice the amount of each employee's contribution provided the percentage of profits available for distribution will permit. Over the several years that this plan has been in operation, the company has consistently had available from its profits a sufficient fund to meet this requirement in full.

At the time we started this plan several years ago, 102 employees were eligible to join the plan and 100 percent of them did. Any employee has a 100 percent interest at all times in his own contribution and any earnings on it. Each empolyee has a vested interest in the company's contribution equal to 5 percent multiplied by the number of full years of service. After 20 years of service, or upon reaching retirement age, whichever comes first, the employee is entitled to 100 percent of the company's contribution and any earnings on it. Thus, an employee joining the company at age 55 would have 10 years in which to build his own retirement fund on this liberal basis that will give him a substantial fund to supplement social-security payments. We have found this plan to be most satisfactory to date and believe that it is an excellent answer to the encouragement of the hiring of older workers. We have no bar on the hiring of older workers and in fact welcome them wherever their training and aptitudes will permit their association with our organization.

I'll be happy to send you any further information that you may desire on the details of this plan and hope that this information will be of some value for your records. I'm also enclosing for your information a copy of the Philosophy of Milton Roy Co.

Sincerely yours,

MILTON ROY CO.,
ROBERT T. SHEEN,
President.

Chairman PATMAN. The subcommittee will stand in recess, subject to the call of the Chair.

(Whereupon, at 11:40 a. m., the subcommittee adjourned.)

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