ADMINISTRATION AND COORDINATION OF SCIENCE AT THE NATIONAL LEVEL

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501

CONTENTS

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502

Dr. Alan Tower Waterman, Director of the National Science Foundation, was born at Cornwall-on-the-Hudson, New York, 4 June 1892. He holds the following degrees: A.B., Princeton, 1913; A. M., 1914; Ph.D., 1916. He has been instructor, University of Cincinnati, 1916-1917; instructor Physics, Yale, 1919-1922; assistant professor of physics in 1923-1930; National Research Fellow, physics, Kings College, London, 1927-1928; associate professor of physics, Yale, since 1931; chief scientists and deputy chief, Office of Naval Research, Navy Department, Washington, since 1946. During World War II, Dr. Waterman served as vice-chairman, Division "D", National Research Defense Committee, 1942-1943; deputy chief, Office of Field Service, Office of Scientific Research and Development, 1943-1945, chief, 1945. For his war service the President awarded him the Medal of Merit "for civilian meritorious service." He was chief reader, physics, College Entrance Examination Board 1935-1941; chief examiner, physics, since 1937. He is a fellow of American Association of the Advancement of Science, American Physics Society, American Association of Physics of Teachers; and member of the American Association of University Professors, the Phi Beta Kappa and Sigma Xi Club of Graduates, New Haven, Connecticut. His editorial and journalistic work includes editor, "Combat Scientists," 1947; member of the editorial board, "American Journal of Science," 1934-1942, and he has contributed scientific papers to "The Physics Review," "American Journal of Science," "Philosophical Magazine Proceedings," "Royal Society." In March of 1951 the President appointed him Director of the National Science Foundation.

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MR. BAUM: I know you all realize from your study of Technological Progress that we cannot have progress without first seeking out the fundamental secrets of nature.

Our speaker this morning, Director of the National Science Foundation, is a firm believer in this thesis. He is a pioneer of government support of fundamental science, since it was he who initiated the practice in the Government of letting contracts to colleges and universities for projects in basic research.

During World War II he held an important post in the Office of Scientific Research and Development. After the war he joined the Office of Naval Research as chief scientist and in March 1951 was nominated by the President as the first director of the National Science Foundation.

His subject is "Administration and Coordination of Science at the National Level." It is a great pleasure to welcome back to the Industrial College our very good friend, Dr. Alan T. Waterman.

DR. WATERMAN: Mr. Baum, gentlemen of the Industrial College: I am very glad to have again this opportunity of speaking to you on the importance of fundamental or basic research to the interests of the Government, also in its relation to the Department of Defense and the military services. As, you know, it is not very long ago that I was very much concerned with research and was in the middle of research as it applied to military matters, so it is always a pleasure to address you.

In extending the invitation to me to be present today, Admiral Hague asked that I develop my remarks around the subject of "Administration and Coordination of Science at the National Level." The suggestion affords an excellent point of departure. After a year and a half of operations in the National Science Foundation (NSF), we can see more and more clearly how the very magnitude of the present research and development effort calls for an assessment of where we stand in this important area and of what we should do in order to make these efforts more effective. Before describing to you what the Foundation is attempting to do along these lines, I shall summarize briefly the nature and mission of the NSF for those in my audience who may not have heard the more detailed discussion of its history last year.

The NSF was created by the National Science Foundation Act of 1950. This action concluded nearly a decade of legislative history during which a number of outstanding scientists, engineers, businessmen, and educators urged upon Congress the establishment of a NSF that should serve as the focal point for the Nation's scientific activities. These men felt that, in spite of the large sums of money that were being appropriated for military research and development and for atomic energy, basic research, or the source of new scientific knowledge, might be crowded out of the picture. They were further concerned lest the growing needs for well-trained scientists and engineers soon outstrip the supply, with serious results for our technology. An important element in a national science foundation, therefore, was to be the support of education in the sciences, through fellowships, scholarships, and such other means as seemed appropriate. And, finally, they felt that science had assumed such importance in our national life that the formulation of a definite science policy for the Nation had become highly desirable.

There was a good deal of debate, and even controversy, as to how such a foundation should be organized and operated. However the law, as finally written, embodied most of the major recommendations put forth in the Bush Report, the Steelman Report, and others who were following the problem closely. Throughout its history it has enjoyed bipartisan support in the Congress and it still does, as evidenced by the debate on the floor of the Senate last year on the appropriation bill when both parties came to the support of the appropriation.

The principal functions of the Foundation are: to develop national policy for basic research and education in science; initiate support of basic research; initiate specific defense research on request from the Department of Defense; award scholarships and graduate fellowships; foster interchange of scientific information; evaluate and correlate research programs; maintain a national scientific register; and cooperate in international scientific research activities. This is a brief picture of the functions of the Foundation.

As prescribed by the act, the Foundation consists of a 24-member board made up of persons eminent in the fields of the physical sciences, medical sciences, engineering, agriculture, education, and public affairs. The other part of the Foundation consists of an operations staff, the Director and the following divisions: a Division of Medical Research; a Division of Mathematical, Physical, and Engineering Sciences; a Division of Biological Sciences; and a Division of Scientific Personnel and Education. The act further calls for the establishment of divisional committees to advise and consult with the Board and the Director on matters relating to the programs of its divisions.

During its first year of operations, the Foundation was necessarily concerned with a number of organizational and staffing matters. We were in a state of considerable suspense, programwise, for the sum of 14 million dollars recommended by the President for the first year of operations was seriously reduced, by action of Congress, to 3.5 million dollars. With the receipt of this appropriation in November 1951 we initiated modest programs for the support of graduate fellowships and for the support of basic research. This year, with staffing largely completed and the two major programs under way, we are able to turn our attention to the very important questions of national science policy and the evaluation of the national scientific effort. These are functions to which the Hoover Commission attached great importance. I know of no better statement than the one made in that report:

> "The major functions of such a National Science Foundation should be (a) to examine the total scientific research effort of the Nation, (b) to assess the proper role of the Federal Government in this effort, (c) to evaluate the division of research effort among the scientific disciplines and among fields of applied research, and (d) to evaluate the key factors that impede the development of an effective national research effort."

The President of the United States, in his last annual budget message to the Congress, emphasized the policy-making role of the Foundation. He declared:

> "The National Science Foundation has been established as the Government agency responsible for a continuing analysis of the whole national endeavor in basic research, including the evaluation of the research programs of other Federal agencies. On the basis of studies now under way, the Foundation will formulate a broad national policy designed to assure that the scope and the quality of basic research in this country are adequate for national security and technological progress."

The development of a national science policy is not, however, a subject of such specific and clear-cut action as the support of either research or education by themselves. The Foundation has taken the approach that the development of a national science policy requires considerably more factual data than we now have regarding the present status of science in the United States.

We have a fair approximation of the funds that are going into research and development in 1952, a national total of 2.93 billion dollars. We know, too, that the Government is responsible for slightly more than half of these expenditures, or about 56 percent of the national total; industry pays for about 41 percent of the national total; while the universities, where most of the fundamental research is going on, account for only about 3 percent of the national total. In terms of performance, we know that about 28 percent of the national total is being expended in government laboratories and facilities; about 62 percent in industrial laboratories; and about 10 percent in the universities.

There are many things about this national effort that we do not know, however, and that we should like to know. We do not know with any degree of accuracy, for example, how much of the national total is going into applied research and how much into basic research.

This is a rather important matter because if too much effort is spent on applied research, one finds oneself in the position of missing potential scientific discoveries and making more and more minor improvements in existing gear. This is a danger if too much attention is directed toward the applied side, if too much emphasis is placed upon development before research groundwork is laid. The development of weapons from ideas which come from basic research is important. That is where such things as radar come from and that is why this field cannot be ignored. Proper balance should be maintained between these two, basic and applied, which is what I am stressing here.

A comparison of the funds expended by industry, the Government, and by the universities furnishes only a crude approximation, for we know that some industrial and government laboratories are supporting programs of basic research to some extent and that much of the research going on in the universities, particularly the contract research being done for the military, is applied or developmental rather than basic. We lack information as to how the national total is broken down by fields; that is, how much is being spent in the physical sciences, how much in the life sciences, how much in mathematics, psychology, and so on. And, most important, we do not know whether the present distribution of funds by types of research and by fields is the one that will produce the greatest good in terms of the national welfare. Until we possess many of these facts, therefore, we have no firm basis upon which to formulate a national policy in science.

We have given considerable thought as to the best means of acquiring data of such far-reaching significance. Obviously the NSF, with a small appropriation and a small staff, could not without assistance undertake to survey all the fields of science, even if such a method appeared to be the most desirable one.

The most effective assessment of science can best be made by the scientists themselves, for the fields with which they are most familiar. A pioneer effort of this nature is being made by the American Physiological Society which, with financial support from the Foundation, has undertaken a two-year survey of the status of physiology in the United States. The survey will include a study of the content and scope of physiology in the fields of biology and medicine, the role of physiology in American education, the technique and content of physiology as science, the personnel of professional physiology, and the scientific contribution expected of physiology in the future and the plans for its achievement. Negotiations with the American Psychological Association are presently in progress for a smiliar survey of the field of psychology. On this study and appraisal of science, the cooperation of the scientific societies is welcomed and indeed well-nigh essential. For analysis and planning in special fields of a given science, the activities of committees, symposia, and conferences are of especial significance and the NSF is sponsoring an increasing number of these. Many are supported jointly in cooperation with other agencies, such as the research offices of the military departments and the Atomic Energy Commission. This will be a long-range job. Some parts of it will be finished earlier than others, but this is really the sound approach, we feel, to the ultimate answer to the problem. As we obtain information this will be extremely useful, and we want to pass this right along to other research agencies to assist them with their application of the knowledge we find.

The magnitude of the subject and the thoroughness with which it must be approached have ruled out the possibility of our being able to develop a meaningful national science policy overnight. However, science has been growing into its present position in the United States over a long time, with perhaps the period of greatest growth occurring in the last half century. We can afford to take a little more time, therefore, to develop a national science policy that will have more than temporary significance.

Closely related to the development of a national science policy is the correlation of the Foundation's research programs with those undertaken by other agencies of the Federal Government and with those undertaken by individuals in public and private research groups. Here again the problem is an initial one of acquiring information. The Foundation has recently undertaken a study of Federal support of research and development in nonprofit institutions, an expanded version of a study previously made by the Bureau of the Budget. It is important that the backing by the Federal Government of nonprofit institutions be maintained in a healthy, progressive state; whether this is the case is one of the first things we need to find out. This is one of the first of a series of important studies we are making. These studies are being made with the cooperation of all the government agencies which engage in research and development.

A related study of obvious importance is the compilation of information regarding the amounts obligated and expended by Federal agencies for scientific research and development. This furnishes much needed and useful data on the apportionment of effort, dollarwise, as between basic research, applied research, and development, and also as among the three major fields of effort, that is, the biological, medical, and agricultural sciences; the physical, mathematical, and engineering sciences; and the social sciences. Although these initial studies are limited to Federal expenditures, it is expected that the information thus compiled will suggest significant trends in the total research and development effort.

We have recently set up in the Foundation a Program Analysis Office to serve as a focal point for fact-gathering activities. The Program Analysis Office will be responsible for studies of an over-all nature or those which cut across a number of fields. In addition, each of the divisions of the Foundation and our Scientific Information Office will be responsible for making studies and gathering data in its own field. In fact a number of such studies are being sponsored at the present time by various sections of the Foundation.

508

The types of studies that I have mentioned so far are essentially long-range in nature and must be carried out either on a continuing or recurrent basis. In addition, we are prepared to undertake special studies on topics of immediate significance from the standpoint of the national defense, general welfare, or those with special scientific promise. Reports on studies of this sort will be transmitted to other interested government agencies. We are initiating three such special studies on the following subjects:

1. Photosynthesis and utilization of solar energy, from the standpoint both of the biological and the physical sciences.

2. High-temperature physics, chemistry, and metallurgy.

3. The study of research underlying search, identification, and processing of mineral ores, as recommended by the President's Materials Policy Commission.

Another major type of data for which there is significant need is the large variety of information related to the scientific manpower problem. The problem itself is recent, in that it only emerged as a distinct consideration during World War II, and again became critical as the present defense program got under way. The collection of statistics is usually related to a specific need, so it is not unusual that prewar statistical data relating to the scientists and engineers of the country were fragmentary and intended for use of scientists and educators. Before World War II the scientific and technical professions responded to the normal laws of supply and demand in the open market, so to speak. The intensely technological nature of World War II created new and unprecedented demands for the special skills of the trained scientist and engineer. However, this fact became apparent at too late a date to influence decisively the Selective Service program, with the result that the war period was marked by almost complete cessation in the granting of advanced degrees in these scientific fields. This has created a gap which we were slowly filling when the next emergency came along. For example, the American Council on Education estimates "that the loss occasioned by World War II in the number of doctorates produced in science was in the neighborhood of 10,000, possibly much higher." We have made up about half of the deficit but we still have a lack of about 5,000.

A number of agencies, both private and public, are now engaged in gathering various types of data: the Committee on Scientific and Specialized Personnel under the chairmanship of Dr. Flemming of the Defense Manpower Commission, the Research and Development Board, and the Bureau of Labor Statistics, to name but a few. One of the largest compilations of information on scientists has been gathered by the National Scientific Register, administered by the Office of Education, and supported last year, in accordance with provisions in our legislation, by funds from NSF. At the request of the Foundation, Dr. Dael Wolfle, Director of the Commission on Human Resources and Advanced Training of the Conference Board of Associated Research Councils, undertook a study of the register and its functions. On the basis of his findings, we plan to continue the register, on a somewhat different basis, bringing into the picture the scientific societies, which can, through their own memberships, routinely acquire and maintain, on a current basis, a good deal of useful biographical information about people in their fields. The Foundation will work out a series of cooperative agreements with these societies whereby the information acquired by the societies could be made available to the Foundation. The societies will be asked to include in their registers, in addition to their own members, other individuals who are qualified members of their respective professions. Uniform methods for developing the information will be worked out and the societies will be asked to record the information in a common systematic manner. This information will be available, through the Foundation, for use in the event of mobilization or for purposes of special statistical studies. The societies will be encouraged to continue to serve as their own employment services and placement bureaus. The Foundation will contribute, as its part of the arrangement, professional assistance to the societies in organizing their separate registers, limited financial assistance in specific instances where help of this type is essential to the operation, and other forms of assistance.

We also in this program will deal with statistical studies made by other agencies which relate to this problem. This will be done primarily by our Division of Scientific Personnel and Education. In the meantime we have established a graduate fellowship program. You might be interested to know that in April of this year, we awarded 624 graduate fellowships in the natural sciences for the academic year opening last month. There were 569 predoctoral fellows and 55 postdoctoral fellows. As stipulated in the National Science Foundation Act, the awards were made solely on the basis of ability. In cases where ability appeared to be equal, however, consideration may be given to the factor of geographic distribution and in the final award all sections of the country were represented. Fellows are at perfect liberty to go to any institution that will accept them. These awards must be given to American citizens.

You may be interested in the method of choice. The announcement of our fellowship program was made in colleges and universities throughout the United States and its territories. Predoctoral applicants were required to take fellowship examinations for scientific aptitude and achievement, administered by the Educational Testing Service, at Princeton, N. J. The qualifications of candidates were reviewed by National Research Council panels of outstanding scientists in the respective fields of the candidates. The panels considered test scores, academic records, and individual recommendations regarding candidates' abilities. Postdoctoral candidates were not required to take examinations but their qualifications were also judged by panels of the National Research Council. The recommendations of these panels were forwarded to the Foundation, which made the final selections.

The largest group of fellowships (158) were awarded in the biological sciences. In other fields the numbers of awards were: chemistry 140, physics 137, engineering 75, mathematics 62. This last was a surprisingly large number by the way. Apparently a lot of able boys and girls are selecting mathematics to a greater extent than in the past. The same is true of physics. In other fields the awards were: earth sciences 36, agriculture 7, astronomy 6, and anthropology 3.

The fellowship program for the academic year 1953-1954, applications for which will shortly be announced, is planned to be maintained at approximately the same level as this year's program. A certain portion of the fellowships will be renewed.

I should mention here a problem which you know is acute, that is, the problem of the exchange of scientific information. There is at the present time a very rapidly increasing volume of this information, the exchange of which takes place in the scientific literature where our publications are striving to keep up with it. It also takes the form of industrial reports on research and a very large number of government reports on research. In addition there is the problem of how best to distribute this information to those who are interested and perhaps an even more acute problem is to see that the recipients do not get material which they do not want. As you know, in the distribution of reports, it is so easy to route everything to everyone with the result that no one has time to read any of them.

There must be good, practical interchange of information, close communication between scientists in a given field, to avoid undesirable duplication of effort. One important thing to note here is that a person working on basic or fundamental research will not duplicate unnecessarily if he knows what other people are doing. This is ingrained in him. A scientist is given recognition for work that is sound and original; but he will get no credit for something someone else has done. If one can maintain a full exchange of information in a given field between the scientists working on it, one automatically avoids the major part of duplication which is undesirable.

We have made a considerable study of the means of disseminating scientific information. We have inquired as to what is going on in the publication field and have made studies of reports. We hope we can come up with some solution, but this is a very large problem. As you know we are in close cooperation with the Armed Services Technical Information Agency. We have given emergency assistance to a few scientific periodicals which were in serious financial difficulties. Two, which we regarded as most important, were "Biological Abstracts" and "Physical Review." Altogether though, we find that by well-conceived and intelligent effort most scientific journals are not in bad shape. They are aware of the problem and there is close cooperation all around.

You may be interested in one matter to which we are paying special attention--a survey of the translating activities and needs in the Federal Government with respect to the Slavic languages. There appears to be need for a good English-Russian dictionary. The Foundation has therefore entered into a contract with Columbia University, which will survey the need for improved Russian-English dictionaries or glossaries in various fields of science and recommend the types of additional translation aids that should be compiled.

In December 1951 a symposium on Russian science was sponsored by the American Association for the Advancement of Science, at which a number of scientists presented an appraisal of science in the USSR and specifically of the present status of Russian research in the fields of genetics, physiology, pathology, soil science, psychology and psychiatry, mathematics, physics and chemistry, and social sciences. In order to make this information readily accessible to American scientists, the Foundation has made a small grant to the AAAS for the publication of these papers in a single volume. This grant will permit sale of the book at a nominal price, probably of one dollar or less, which will be based only on shipping and handling costs and a portion of the printing costs. The book is expected to appear within the next few weeks.

In the area of international science, the Foundation has felt that its limited funds could best be utilized at the present time to augment American attendance at international congresses and meetings abroad. The postwar decade has been characterized by a diminution in international scientific activities, principally because of the barriers raised by the Iron Curtain countries. There have been other dislocations produced by the war and all these circumstances enhance the importance of the international meeting as the most important means for the cross-fertilization of ideas so vital to the healthy growth of science. As of the present date, the Foundation will have helped to make possible the attendance of some 35 scientists at international congresses and meetings. For example, the Foundation sent 18 delegates to the International Biochemistry Congress in Paris earlier in the summer, 5 delegates to the International Congress on Astronomy in Rome, and also assisted in sending a large delegation of radio engineers to Australia this last summer, in cooperation with the Office of Naval Research.

I should now like to say a few words about our program of research support. The major portion of our appropriation is divided about equally between the fellowship program and the program of research support. For the current year our appropriation is only 4.75 million dollars. What is our aim? As you know, the NSF is directed to emphasize basic research and the fundamental aspects of science. What are our relations with other agencies of the Government? Ours is the only Federal agency authorized to support basic research in the general field of science without regard to special practical missions. Our mission is to support research in general, with an awareness of what government interests are in other agencies such as the Office of Naval Research, the Atomic Energy Commission, the National Institutes of Health, and in the research programs of the Army and the Air Force. What then may be said of this part of the mission of the Foundation?

In the first place one must be careful to distinguish between basic research on the one hand and applied research and development which are frankly aimed at practical goals and end items. For example, of the 1.6 billion dollars appropriated for research and development last year by the Department of Defense, probably not more than 3 percent went into the support of basic research. This is only about one-tenth of 1 percent of the total defense budget. So we are not speaking about a large amount of money.

What is our philosophy here and how is it related to the emergency. It is simply this: As the emergency exists now, it is of uncertain duration. We have to be prepared over a long period. There should be, therefore, a balance between basic science and applied science. I am not implying any degree of superiority of one over the other. Both must be observed. We have to maintain this balance because, if not, we will not succeed in keeping what one might call supremacy on the scientific front. Our technological advances result from what we can develop from basic scientific research. There is not the amount of basic research done nowadays which can be done and which we believe should be done.

What the NSF should do and what other agencies should do has been stated by us a number of times; it has been mentioned in various connections. The latest one comes from a statement of policy by the Research and Development Board (RDB) in connection with basic research sponsored by the military departments. This is as follows:

> "Basic research sponsored by the Military Departments in university and nonprofit institutions is generally of two kinds:
>
> "1. Basic research performed as an integral part of programmed research committed to specific military aims.
>
> "2. Academic research that promises ultimate military application.
>
> "It is characteristic of (1) above that the immediate aim of the sponsoring agency is to discover and exploit applications to particular military problems with which it is confronted, whereas the characteristic of (2) is the desire of the sponsoring agency to foster basic research in a field in which it believes that new information is likely to find important application to military problems. Basic research of both kinds must be wisely planned and energetically supported by the Military Department to provide the strongest possible foundation for a constantly increasing level of technical development."

In the view of the Foundation, it is important indeed for other agencies to be engaged in basic research. Their work, however, should be done in fields directly related to their statutory missions.

We in the Foundation can undertake general-purpose research, such as research in pure mathematics. This includes a comprehensive program to assure that we have adequate training in research and adequate background data for applied studies no matter where they may be needed.

Let me stress this by a specific illustration, the development of the very important high-power microwave generator. This is a modification of the klystron which will give in its current application 15 megawatts of power at a wave length of 10 centimeters. This is a factor of over seven times the most that one could get out of the cold magnetron. This came as a by-product of a research project at Stanford University where a research scientist was trying to create a billion-volt electron beam. It came as a result of strictly basic research.

I wish to give an example of the economies that can result from basic research. This again is in the field of radar. It turned out during the war, as you know, that for some purposes microwave radar became more and more useful as the wave length was decreased. The first application was at 10 centimeters. As the art improved, the 3 centimeter was developed. This was useful and more effective in making clearer definition of the target. So the next step was to see if the art would go further. It did and the wave length was dropped to about one centimeter which gave fine definition of detail. However, the production sets found difficulty in getting any appreciable range. It turned out that waves of this particular wave length, which was chosen arbitrarily, were stopped by the absorption of water vapor in the atmosphere. Many millions of dollars went into a development which should not have been used for this purpose. That wave length would not have been selected, if there had been more time for basic research to determine what the right wave length should be. This is where basic research, the cost of which is small, could have saved an immense amount of money.

To return to the program of the Foundation--our program in grants for research totaled nearly 1.2 million dollars last year and grants were made in all fields of science. Reports on these will be available to any research agency and we expect to be in close contact on distribution. Sixty institutions, 35 states, and the territory of Hawaii are represented. The average grant was for $11,032 and the average duration was about two years, or about $5,800 per year. For the most part we are supporting individual investigators.

We had a total of 13.5 million dollars of applications for support of research and about 30 percent of these were of excellent quality. There are plenty of research men to do this kind of work. Mostly these are lone workers, who would not fit well into industrial work. The educational atmosphere is where they do their best work. To support them where they are, at educational institutions, is one good way of increasing scientific manpower available for research.

In this country as everyone knows, we have in the past been experts at putting things to practical use. It is only recently we have been able to come to the lead with respect to the fundamental type of research. At the present time we have really high-class scientists in this country available to work on research problems, and we must capitalize on them. They are a prime asset.

In closing I would like to read to you a statement by Alexis de Tocqueville, who made one of the best studies of the United States. He wrote these observations about 117 years ago, and his comments with respect to science in America have characterized our tendencies ever since--tendencies which only now are being corrected!

"In America the purely practical part of science is admirably understood, and careful attention is paid to the theoretical portion which is immediately requisite to application. On this head the Americans always display a clear, free, original, and inventive power of mind. But scarcely any one in the United States devotes himself to the essentially theoretical and abstract portion of human knowledge. . . . These very Americans, who have not discovered one of the general laws of mechanics, have introduced into navigation an engine which changes the aspect of the world. . . .

"If those who are called upon to guide the nations of our time clearly discerned from afar off these new tendencies, which will soon be irresistible, they would understand that, possessing education and freedom, men living in democratic ages cannot fail to improve the industrial part of science; and that henceforward all the efforts of the constituted authorities ought to be directed to support the highest branches of learning, and to foster the nobler passion for science itself. In the present age the human mind must be coerced into theoretical studies; it runs of its own accord to practical applications and, instead of perpetually referring it to the minute examination of secondary effects, it is well to divert it from them sometimes, in order to raise it up to the contemplation of primary causes."

As I say, there is much food for thought in that philosophy and it has persisted down to the present time. We are now beginning to overcome it. It is part of the duty of the NSF to adopt this approach and to see that this kind of balance is maintained. This, I repeat, is essential if we are to keep the lead technologically.

Thank you very much.

QUESTION: Dr. Waterman, in your coordination and the passing of information back and forth, is it contemplated to get on an international scale?

DR. WATERMAN: In time. This happens, of course, in international congresses best and it happens best in the kind of way that scientists prefer, namely, in their own fields. That is, in a specialty like biochemistry, when the scientists can get together and speak the same scientific language. This is where they get the fastest and best exchange of scientific information. If it is done in a special field, it is done most effectively. The State Department is assisting in this by its scientific attaches.

QUESTION: Do you think it would be a free passing of information? For example, if one country discovers an element, would it be free to pass that along? What success do you expect along that line?

DR. WATERMAN: Obviously it depends on the country. Most countries pass the news along quickly. Scientists are most interested in comparing notes in their own fields. If they come up with something that they regard as important, they are anxious to know what others think of it. It is a sort of quid pro quo. They freely exchange the information they have with others. The majority have that frame of mind. Obviously there are exceptions as we all know.

QUESTION: You mentioned the fact that fellowships are granted to boys and girls. To what extent are women entering this field?

DR. WATERMAN: Almost not at all in engineering; to some extent in the physical and the biological sciences. I would say--I forget the exact figures--out of our 624 fellowships there were 30 to women. There are more of them in the field of biological science than in physical science. There are more of them in mathematics. More should be done with the use of women in science because of the manpower problem. In many women's colleges and coeducational universities, women take to scientific work and do well. I have heard comments from industry that there is something like a mortality of 75 percent in employment of women scientists, but many of them feel it is worthwhile for the 25 percent they retain.

QUESTION: You have mentioned a training program being set up toward getting higher caliber people with advanced training. That may create a situation where advanced training ends up with more complicated equipment for the armed forces, requiring a higher level of ability to maintain and keep equipment in operation. In that case wouldn't you be in the position of having all chiefs and not enough Indians?

DR. WATERMAN: We figure that in our first year of operation we would concentrate on the highest level because that is where we get highly trained people fastest. If we start with the undergraduate colleges, the time for having them available would be delayed, but if we start in the graduate schools, they will be available in one, two, or three years. We are now thinking about what can be done to stimulate science in college and also in the secondary schools.

There is an alarming fact about the latter: In the secondary schools about 40 percent of the top 25 percent, as judged by intelligence tests, do not go on with their education. Even in college 25 percent of the top students, judged by their IQ's do not go on to graduate school. The problem has to be tackled down in the secondary schools.

Replying more directly to your question, I would say we have to get over the idea that whenever we want a scientist we must have a Ph.D. There are plenty of jobs where scientists can be useful--sales work, administration, military work where you want personal qualities besides research ability. The best way to get it is to go after it. You have to get the Indians as well as the chiefs. We must have chiefs and Indians. But much should be done to overcome the feeling that one must have a Ph.D. for every job where a scientist is wanted.

QUESTION: Going back to the problem of the shortage of students in science and engineering, it is obvious that before we can have the students we must have instructors and professors. This problem may not be the specific responsibility of the Foundation, but do you know what is being done, if anything, at the national level to encourage people to remain on as college professors in those fields?

DR. WATERMAN: That is part of the question which is considered by the Committee on Specialized Personnel of Office of Defense Mobilization. They have come out with instructions to all the agencies concerned to see to it that in every possible way the importance of this is stressed.

Specifically in the Foundation what we are doing in the Division of Scientific Personnel and Education is to find ways of making teachers most effective. Recognition of good teachers is one of the things. Teachers are of course largely underpaid. Much can be done by giving the teacher the opportunity to learn more about his subject by attending summer school, by giving him a year off for research, or allowing time for research along with their teaching.

QUESTION: The NSF is concerned with the basic research of the country, responsible for the basic research of the good old USA. Now the RDB is concerned with providing additional research and for the basic research of the military. How does the RDB basic researchwise, get closely married to you people?

DR. WATERMAN: In the policy statement which has just been made, I have been in touch with the people who made it. We have agreed that this is a wise policy. I am in touch informally with the RDB in this way and will continue to be.

The right formal approach is for the head of the Foundation to be in touch through the Secretary of Defense with the chairman of the RDB, and through the latter also with the military departments in all these matters. The aim in any scientific work is to get direct contact between the groups doing research in the different fields, to maintain contact between those

DR. WATERMAN: The engineering societies give us a lot, more perhaps than other sciences. We are working with those industries that have research departments to some extent. We visit them and know something about their programs. We are also interested in developing through research organizations in industry better means of contact with what industry is doing.

Now, of course, industry is in one sense parallel to the military in that, corresponding to security classification, as you know, industry has its own "company confidential." But many of them feel that fundamental research is one area, just as it is in the military, where things are not in the beginning classified from either standpoint. Industry approves of this. In fact, we have been talking to representatives of the research committees of such agencies as the National Industrial Association. Their research committees are quite interested in this question.

QUESTION: Could you elaborate a little further on the matter of technical information. I am not thinking so much of a way of saving someone working on a doctorate the possibility of duplicating but rather I would like to know what your assessment of the present situation is just from the standpoint of technical information. Is it being systematized so that we can get to it quickly and avoid time and money spending in these emergencies? Could you tell us what the situation is as to when we might look to have something concrete?

DR. WATERMAN: It is a rather serious situation. I don't think there is any quick answer to it but I am sure something can be done. We are making studies as quickly as we can on that. When one wants to have information, one needs a source to which to go. There must be a central spot to which people can turn when they want to locate information. The information itself would be decentralized. To put all the information in one spot would be hopeless.

To accomplish these objectives, one has to have a system of classification on incoming material which is sound and which is valid, so it can be used; one has to have a means of storing the material; then a means of record searching; then a means of identifying the information in a form which the officer or research man can understand, such as an abstract or a brief paragraph about the work. The goal might be that if you wanted information in the field of science, you might go to the Library of Congress where people have had a lot of experience; we are working with them on the problem. After you have posed a question, they would have a quick-search method of identifying the things you might be interested in and send the items to you to choose what you want in detail.

This study involves studies of classification, studies of storage--do you store physical copies or microfilm? How do you find them? Electronic search methods of some sort are being studied. When you have the reference, how do you communicate it? There are a lot of technical problems

A good example is the transistor development by the Bell Telephone Laboratories. This is going to revolutionize the whole electronic industry. Out of basic research comes the application. I am not sure I have answered your question very well, but these are some of the considerations.

QUESTION: Referring back to your mention of the incidental development of the 15 megawatt microwave generator, that reminds me of the story at MIT about Dr. Woo. While he was working on his thesis he came across quite a few equations; he went off on a little side track for a few years and worked out some charts on these equations before he went on with his main thesis. No one remembers what Dr. Woo was working on for his main thesis but they are still using his contact charts. My point here is tha a great deal of effort and money were wasted in attempting to develop thi 15 megawatt generator. Why wouldn't it have been better to go to fellows who were engaged in basic research and have them explore these possibilit

DR. WATERMAN: I suppose one answer is incentive. You can't get sci tists to do this unless it is in line with their own interests. We scien tists are an independent group. A man gets interested in a project and h wants to do it his own way. This man's interest was nuclear physics. To accomplish his goal, he came out with a design for a powerful microwave generator. If you had asked him to do it, he probably wouldn't have want to try to do it. His heart wouldn't have been in it and he might not hav succeeded, either. There is a great deal here in personal enthusiasm. I a man is carrying a torch to reach a certain goal, by hook or by crook, h will do it. If somebody asks him to do something, he doesn't put the sam effort into it. In creative work incentive is all-important.

QUESTION: I would like to ask if these fellowship students are permitted to select foreign universities. If so, to what extent are they studying outside the country?

DR. WATERMAN: As I said, they must be United States citizens. They can, however, study outside the country, and those who do are mostly postdoctoral fellows. I think we have 14 going abroad and about half a dozen predoctorate people going to England. The postdoctoral are divided, some going to England, Switzerland, the Netherlands, Sweden, Denmark, and South America.

QUESTION: Dr. Waterman, does the Foundation have any branch or field offices through which they funnel or channelize some of this information or is it all run from here?

DR. WATERMAN: It is all run from here. By the way we can't operate any laboratories of our own, which is a good thing, I think, in this progr

QUESTION: What is your source of contact with industry? Do you have any through the societies?

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This study involves studies of classification, studies of storage--do you store physical copies or microfilm? How do you find them? Electronic search methods of some sort are being studied. When you have the reference, how do you communicate it? There are a lot of technical problems here which should be solved by technical people familiar with the problems, working with and cooperating with scientists. The job is not easy. The problems are appreciated and if we can see how to get at them, I think we can make progress.

QUESTION: What about farming this job out to the technical societies with the scientific register? Have a central location to identify the question and send it to the appropriate scientific society, for electronic research, for example.

DR. WATERMAN: That might be possible in basic research, but many of the societies don't want to go beyond that. This is where you would have to do something additional. They can, of course, and do have their own research facilities but there should be contact with other agencies which have an interest. Scientific societies, except the very largest, are not generally so well-informed or interested in the applied side.

QUESTION: I wonder if the NSF is thinking of supporting that or helping its budget on that?

DR. WATERMAN: Yes. In general the staffs of the societies are small and need additional help. This is certainly one way of getting at it.

QUESTION: I heard a prominent educator from one of our big universities say recently that the military personnel policies are holding up research, that we are not using effectively the people we have. Would you comment on that?

DR. WATERMAN: I suppose that is true to some extent of any large job

QUESTION: Personnel policies--we are not using properly the people we have.

DR. WATERMAN: There are problems there, of course. If you take a man on for any job, you have to match his qualifications against the job you want him to do and you have to get a pretty good appraisal of what his qualifications are in order to succeed. In the past a scientific man was often taken on for a job with a misunderstanding of the kind of qualifications the scientist had. This can lead to trouble. In general, I would say the scientist is like anyone else. If he is a good one, he wants to be assigned responsibility. He doesn't want to be solely an adviser. This is because he is primarily an operator. He wants to maintain his standing in the scientific world and, like any other man, he wants responsibility over something which is his and which he can handle. Scientists don't take to the job of adviser with a great deal of facility and they do not stay in such jobs very long. For one thing, one can't continue to advise in science indefinitely without getting stale. One has to get back into the game again to give good advice. This requires rotation, some opportunity for working in your own field to keep fresh in it.

QUESTION: I wonder if certain abstracts like fear, superstition, suspicion, distrust, even mass hysteria like the Orson Welles event would not have a concrete drag in basic research? They did in the Middle Ages--maybe these are the dark ages with so much ahead of us. Is there such a thing as a drag to basic research in these activities?

DR. WATERMAN: You mean by drag a tendency to keep away from it, discouragement about the whole thing?

QUESTION: Some individuals would be suspicious of further atomic research; it might blow us all up.

DR. WATERMAN: This is a tough question. I suppose the best answer to it is that this situation has always existed. We are in the modern phase of it, but people were equally scared of the first bow and arrow and the first gun. I wish I could remember a quotation to give you which you would swear applied to the atomic bomb and which, in fact, came out in England with respect to the invention of the rapid-fire gun. This kind of thing always happens.

I would say the answer is that we ought to keep the flow of information going about scientific developments and let people know that these developments are always under control. The basic research is necessary. The hysteria comes about when people are not sure of what can be done and they exaggerate the possible effects. The important thing to keep in mind is that the public should be well-informed as to what research can do and told what the limitations are. Another way of looking at this is that since life is competition, one can't stop competition in scientific development. It is going to go forward. If it is things like atomic development which are part of our struggle for existence--if you want to put it that way--you can't stop it. If we don't do it, someone else will.

QUESTION: You mentioned that the Federal Government now is the principal financial sponsor of research and development and the military accounts for a great portion of that. Most of our research for the military has a confidential security classification. A lot of research and development of the military is secret or top secret. What effect will that have on the spread of scientific knowledge?

DR. WATERMAN: In working out any application, usually the only effect on science would be a long-range one, so that it is not so troublesome when progress occurs in development. Here is why: Because a practical development often becomes a technique for acquiring information in the study itself. Let me give you an illustration, which is a rather good one, by the way. Going back to radar again, the research by which scientists developed radar was not basic research at the time and occurred during the war. The basic principles had been known for a hundred years, but had not been developed practically. Now the practical development of radar, the techniques of generating and transmitting microwaves, the plumbing out of how to transmit from one place to another, microwaves, led right away after the war to some highly important discoveries in basic research, notably in studies of the magnetic properties of the atomic nucleus. The techniques came out of radar but the results were in basic research that had nothing to do with radar. Keeping developmental work under wraps has no very important effect on basic research except as to providing techniques in scientific applications.

QUESTION: Considering the exchange of information world-wide, you spoke of Russian achievements, when the Russian scientists leave their country and go to world meetings, I know they are information seekers but do they put their own knowledge above their greed and give out as well as take in?

DR. WATERMAN: Most of them, from what I hear, don't talk. Furthermore they are followed by a bodyguard. There is always someone with them wherever they go. But they don't talk except in generalities at most of the gatherings where I have known them to come.

QUESTION: I would like to have your assessment of the excellence or otherwise of the Russian scientist. Could you give it briefly, sir?

DR. WATERMAN: In basic science they have some very good men. I think perhaps that the number of good ones they got from Germany has been exaggerated; they did get some. A large number of these people are experienced in techniques. They have been good in certain branches of science. They have been good in aerodynamics; they have been good in physics. They have gone rather strongly into engineering but they have not been quite so good in engineering. They have used our instructions very largely. They are good thinkers in the fields they go into. At present they have an official "party line" in the science of genetics, as you know. This will do them no good in the end.

QUESTION: I wonder if you would care to comment on the value of the NSF technique extending into social science?

DR. WATERMAN: We decided in the first year that we would not spread ourselves too thin. We decided to confine our work in social science to psychology, geography, and anthropology. We have decided to study the problem before we go any further. We will survey what is going on and what the need for work in social science is. In the meantime we have approached it somewhat on those three subjects, but we expect to survey the need. The Ford Foundation has entered that field strongly and it has a lot of money to spend. We would want to get in touch with it on anything we would want to do. We are going to make up our minds, but we have done nothing as yet.

MR. BAUM: Thank you very much, Dr. Waterman, for another very excellent lecture and a very stimulating discussion period.

(17 Dec 1952--350)S/sgh