the truth be known unless we, who have educational laboratories at our hands, make use of them.

May I then express the hope that among you, the newly elected members, there may be some who will find the subjects for their future experimental work, not in abstract research, without thought of reward, carried on in the sole interest of science, but rather in modern practical applications, in attempted solutions of the many insistent problems of labor, industry and of education, that the existence of the university may be more fully justified and the purpose of the Society of Sigma Xi the better realized.

H. N. Ogden

Cornell University

INDUSTRIAL RESEARCH AND NATIONAL WELFARE[1]

I have no justification for expressing views about scientific and industrial research except the sympathetic interest of an observer for many years at rather close range. One looking on comes to realize two things. One is the conquest of practical life by science; there seems to be no department of human activity in which the rule of thumb man has not come to realize that science which he formerly despised is useful beyond the scope of his own individual experience. The other is that science like charity should begin at home, and has done so very imperfectly. Science has been arranging, classifying, methodizing, simplifying everything except itself. It has made possible the tremendous modern development of the power of organization which has so multiplied the effective power of human effort so as to make the differences from the past seem to be of kind rather than of degree. It has organized itself very imperfectly. Scientific men are only recently realizing that the principles which apply to success on a large scale in transportation and manufacture and general staff work apply to them; that the difference between a mob and an army does not depend upon occupation or purpose but upon human nature; that the effective power of a great number of scientific men may be increased by organization just as the effective power of a great number of laborers may be increased by military discipline.

This attitude follows naturally from the demand of true scienific work for individual concentration and isolation. The sequence, however, is not necessary or laudable. Your isolated and concentrated scientist must know what has gone before, or he will waste his life in doing what has already been done, or in repeating past failures. He must know something about what his contemporaries are trying to do, or he will waste his life in duplicating effort. The history of science is so vast and contemporary effort is so active that if he undertakes to acquire this knowledge by himself alone his life is largely wasted in doing that his initiative and creative power are gone before he is ready to use them. Occasionally a man appears who has the instinct to reject the negligible. A very great mind goes directly to the decisive fact, the determining symptom, and can afford not to burden itself with a great mass of unimportant facts; but there are few such minds even among those capable of real scientific work. All other minds need to be guided away from the useless and towards the useful. That can be done only by the application of scientific method to science itself through the purely scientific process of organizing effort. It is a wearisome thing to think of the millions of facts that are being laboriously collected to no purpose whatever, and the thousands of tons of printed matter stored in basements never to be read—all the product of unorganized and undirected scientific spirit. Augustus De Morgan denying the divinity of Francis Bacon says "What are large collections of facts for? To make theories *from,* says Bacon to try ready made theories *by,* says the

[1] A statement made by the Honorable Elihu Root at the initial meeting of the Advisory Committee on Industrial Research of the National Research Council, held in New York on May 29, 1918.

history of discovery; it is all the same, says the idolator; nonsense, say we." Whichever it may be, the solitary scientist is likely to put a great part of his life into the pathetic futilities illustrated by De Morgan in the "Budget of Paradoxes." He needs chart and compass, suggestion, direction, and the external stimulus which comes from a consciousness that his work is part of great things that are being done.

This relation of the scientific worker to scientific work as a whole can be furnished only by organization. It is a very interesting circumstance that while the long history of science exhibits a continual protest against limitations upon individual freedom, the impulse which has called in the power of organization to multiply the effectiveness of scientific and industrial research to the highest degree is the German desire for military world dominion, supported by a system of education strictly controlled by government. All the world realizes now the immense value in preparing for the present war, of the German system of research applied at Charlottenburg and Grosslichterfelde. That realization is plainly giving a tremendous impetus to movements for effective organization of scientific power both in England and in the United States,—countries whose whole development has rested upon individual enterprise. It remains to be seen whether peoples thoroughly imbued with the ideas and accustomed to the traditions of separate private initiative are capable of organizing scientific research for practical ends as effectively as an autocratic government giving direction to a docile and submissive people. I have no doubt about it myself, and I think the process has been well begun in England under the Advisory Council of the Committee of the Privy Council for Scientific and Industrial Research, and in the United States under the National Research Council. I venture to say two things about it. One is that the work can not be done by men who make it an incident to other occupations. It can be encouraged of course by men who are doing other things, but the real work of organization and research must be done by men who make it the whole business of their lives. It can not be successful if parcelled out among a lot of universities and colleges to be done by teachers however eminent and students however zealous in their leisure hours. The other thing is that while the solution of specific industrial problems and the attainment of specific industrial objects will be of immense value, the whole system will dry up and fail unless research in pure science be included with its scope. That is the source and the chief source of the vision which incidently solves the practical problems.

We are thinking now mainly of science as applied to war; but practically the entire industrial force of mankind is being applied to war, so that our special point of view takes in the whole field. It is quite certain that if the nations on either side in this war had been without a great fund of scientific knowledge which they could direct towards the accomplishment of specific things in the way of attack and defense, transportation and supply of armies, that side in the war would long since have been defeated. Germany had the advantage at the start, because she had long been consciously making this kind of preparation with a settled purpose to bring on the war when she was ready. It would be the height of folly for the peaceable law-abiding nations of the earth ever to permit themselves to be left again at a disadvantage in that kind of preparation. Competency for defense against military aggression requires highly developed organized scientific preparation. Without it, the most civilized nation will be as helpless as the Aztecs were against Cortez.

We are not limited, however, to a military objective, for when the war is over the international competitions of peace will be resumed. No treaties or leagues can prevent that, and it is not desirable that they should, for no nation can afford to be without the stimulus of competition.

In that race the same power of science which has so amazingly increased the productive capacity of mankind during the past century will be applied again, and the prizes of industrial and commercial leadership will fall to the nation which organizes its scientific forces most effectively.

MAXIME BOCHER[1]

MAXIME BÔCHER was born in Boston on August 28, 1867. His father, Ferdinand Bôcher, came to this country from France at the age of fifteen. His mother was Caroline Little, of Boston, a descendant of Thomas Little, who came to Plymouth in the early days of the colony and in 1633 married Anne Warren, the daughter of Richard Warren, who came in the *Mayflower*. Ferdinand Bôcher was the first professor of modern languages at the Massachusetts Institute of Technology; he was called to Harvard shortly after Mr. Eliot became president. Thus Maxime grew up under the shadow of the college, attending various schools in Boston and Cambridge; but it was chiefly by the stimulating influence of his parents, he tells us in the vita of his dissertation, that his interest in science was awakened.

He graduated at the Cambridge Latin School in 1883 and took the bachelor's degree at Harvard in 1888. Then followed three years of study at Göttingen, where he received the degree of doctor of philosophy in 1891, and at the same time the prize offered in mathematics by the philosophical faculty of the university. From 1891 till his death, which occurred at his home on September 12, he was a member of the department of mathematics. He married Miss Marie Niemann, of Göttingen in 1891. His wife and three children, Helen, Esther and Frederick, survive him.

He came to Göttingen at a time when Felix Klein was probably the most inspiring teacher of mathematics in the whole world. Breadth and accuracy of scientific knowledge and a true sense of proportion, combined with extraordinary powers of presentation, were characteristics of this great leader, whose scientific productivity had already secured for him high standing among mathematicians.

It was from this environment that Bôcher came to Harvard to take up the profession of mathematics. His skill as an expositor in the classroom, before a scientific audience, and on the printed page shone out from the beginning of his career, but the originality of his mind saved him from ever becoming a mere expositor. As a lecturer he was preeminent among American mathematicians.

It is not difficult in science to find important problems which can not be solved, or unimportant ones which can be. Bôcher was successful in discovering subjects on which the advanced student could work with a reasonable prospect of securing results of value. He did not foster research by excessive praise, and his pupils sometimes felt that he was unappreciative. But a scientific contribution of real merit never failed to secure his attention, and he had infinite patience in helping the student who was really making progress to develop his ideas, to see that which was new in its true perspective, and to put his results into clear and accurate language.

As a scientist Bôcher was highly critical. It was, however, the constructive work called for when criticism has exposed errors or disclosed deficiencies, not the destruction with which an unimaginative mind is content, that to him was the important thing. He had extraordinary powers of judgment, both within the domain of pure science, and in things relating to the policies of institutions. His judgment of men, too, was accurate. For these reasons he was unusually well qualified to take a leading part in the affairs of the American Mathematical Society, which came into existence at the beginning of his scientific career. He became its president, and he served with marked success on the editorial board of its *Transactions*. He also contributed in no small measure toward helping the university to build up a strong department of mathematics.

The decade in which Bôcher's career as a university teacher began was marked by an awakening of the science of mathematics in this country. His scientific contributions were

[1] Minute on the life and services of Professor Bôcher placed upon the records of the faculty of arts and sciences, Harvard University, at the meeting of October 22, 1918.