REPORT OF DIRECTOR

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The National Research Council was created in 1916 when President Wilson requested the National Academy of Sciences to organize the scientific and engineering forces of the United States for the purpose of defense In May, 1918, President Wilson, by executive order, requested the National Academy of Sciences to perpetuate the National Research Council, and this was done

The Council is composed of eleven major divisions The Highway Research Board is a branch of the Division of Engineering and was organized in 1920 for the purpose of inaugurating a national program for highway research. At that time the necessary officers and six research committees were appointed The original by-laws permitted the Board to be made up of governmental departments and bureaus and of those organizations of national importance interested in highway design, construction, economics, maintenance, financing, and equipment Representatives from these organizations make up the Board and the work is directed by an executive committee of seven members and a director The Board is supported not only by these member organizations, but also by a contact man from each state highway commission and from each of 133 universities located throughout the United States, Cuba, and Mexico.

The annual meeting is held the first Thursday and Friday in December At the third annual meeting, in November, 1921, Doctor Kellogg, Permanent Secretary of the National Research Council, explained the broad and practical principles underlying the structure of the Council, which principles are, of course, to guide its component boards Doctor Kellogg stated that the Council has an extremely wide and catholic interest in science—an interest that extends from the science of the structure of the atom to the laws of the stars; from the nature and behavior of a single living cell to the nature and behavior of man, Doctor Kellogg emphasized that the National Research Council is interested in the purest of so-called pure sciences and in the most practical of the applied sciences That is an especially important statement, for it implies both the necessity of pure science and the value of applied science, and points to their union for the welfare of man

Certain workers in each field tend to overlook the importance of the other. The pure research man is concerned with the two theories of atoms, the Bohr theory and the Lewis-Langmuir theory. He seeks to ascertain which is the valid one. The Bohr theory assumes that the electrons of atoms are in rapid rotation in circular or elliptical orbits around a positive nucleus or center But, correct as this assumption may be, it does not appear to be consistent with all of the known facts of chemistry. For instance, in stereo-chemistry, evidence indicates that the primary attractive forces between atoms act in fixed directions—a circumstance that would seem to require the atoms to be arranged in a more or less fixed tri-dimensional scheme, instead of being confined to one plane, as would be necessary for rotation around a nucleus.

Stereo-chemistry, as you know, applies to those compounds which, to all appearance, are exactly alike in chemical properties but which have different physical properties, particularly in their effect on polarized light. A solution of one compound, for instance, may rotate the plane of light to the left, whereas, another may rotate it to the right. Such conditions resulted in the postulation which is sometimes known as the Lewis-Langmuir theory of atomic structure, and which differs from the Bohr theory principally in that the electrons are assumed to occupy definite positions, and to have a symmetry comparable with that of a tetragonal crystal. For the chemist, the Lewis-Langmuir system has the advantage that it conforms with known chemical facts If the electrons move in this system, they are assumed to rotate only in a small orbit about the circular portion of their place of location, with respect to the central nucleus. Now, which theory is correct?

The pure research scientist is deeply concerned to know which of the two present projected theories of the electrons of atoms is correct.

The practical research man is not so much concerned as to which is correct—he is eager to measure results

The research worker who has a personal tendency for dealing with pure science too often loses sight of the practical application of the pure research And the industrial scientist at all times leans in the opposite direction The ideal undoubtedly would be to bring about a practical union of the two

There has been, and still is, a tendency to stifle the association of pure science and industrial interests No gap should intervene between the pure or academic research and the applied science operating in the industries.

Until comparatively recent times industry had little claim to pure science. That was left to those people of analytical and research minds who sought scientific truths solely for the sake of truth. For hundreds of years these purely theoretical scientific depths were explored until the reservoir of scientific knowledge teemed with discovered truths not yet put to practical use The men who made these discoveries were not of an industrial turn of mind. They would have cared little for putting the discovery into practical use, even though they could have done so at the time. Many of the pure research discoveries of those earlier days were put to no more practical use than for the production or practice of magic, or the proving of the user's knowledge of the supernatural. Today those same truths that once produced magic have been stripped of the supernatural aspect and used to promote the progress and welfare of the human race.

Only comparatively recently has industry had its arm around science. But since that alliance has been made, so much of the completed pure science has been utilized and applied by industry that industry has actually been accused of harvesting without sowing, a situation that is untenable and impossible to continue. Gradually, scientific necessity has more or less forced the industries into research and to such an extent that today great armies of trained men are employed solely for research purposes, carrying on investigations in pure science that may be used for the benefit of the industries.

To carry on and discover scientific truths for the sake of pure science is highly intelligent and laudable, yet there is not now, nor has there ever been, any stigma attached to industry's using for the benefit of man these truths that were discovered in the pursuit of pure scientific inquiry even though such usage may, perchance, enhance the wealth of industry It is not less laudable, nor does it seem to be an evidence of less intelligence if industry, knowing of a particular truth that it may desire to ascertain, carries on research, not for the elevation of science but because the industry happens to need that particular knowledge for the furtherance or completion of its projects.

It seems to me, therefore, that an exceptionally close relation should obtain between industry and those agencies that conduct research.

It has been said that every advance in civilization is a rearrangement of materials, first physical and then chemical. Highway progress today has drawn on the previously completed pure research and

on that now being carried on by certain states, counties, cities, governmental departments and bureaus, and a few industries, but in the main, highway progress has consisted of the physical re-arrangement or manipulation of natural materials Outside of contributing a few materials, chemistry has done little for the highways as compared to what it has done for other industries. Inasmuch as most of our progress up to date has been physical, I hope that we are now on the eve of the chemical re-arrangement, whereupon I predict far greater economic progress

A glance at the statistics of highway conditions will demonstrate the necessity for such economic progress There are today about 3,000,000 miles of roads, only 500,000 of which have an improved surface, leaving 2,500,000 miles of unimproved road. It is true that much of this is secondary road, yet a great deal of it will have to be improved Vast expenditures have already been made. It is quite obvious that these cannot be duplicated immediately, even though it may be considered that at the time they were made they were excellent investments The solution of this situation lies in research; research physical, and research chemical, whereby cheap and abundant material that today is unfit for road construction may, by the aid of physicist and chemist, be made into satisfactory road material. This result cannot be attained without pure research, yet unless that research is given practical application it will be of slight value.

The function of research today is to translate pure science to a using public.

To complete any research, three things are necessary time, effort, and genius. If any one of the three is lacking, it must be made up by the others In the past, highway progress has largely been the result of research completed by geniuses working in cities, states, governmental agencies, and in a few industries Much of it has been completed as a by-product or as an absolute necessity brought about by rule of thumb, yet showing the unmistakable earmarks of genius Those who have thus indirectly completed research have learned how, but for many reasons, principally for lack of time and proper financial support, their work has failed to materially affect the highway program as a whole Yet there are the trained men, the geniuses of research, ready to proceed with the problems Give them the time and the money and they will solve many problems which, if quickly solved, will add much to the economic wealth of the nation as affected by its highways.

If time, effort and genius are required to complete research, and if time be lacking, but the geniuses be available, the remaining requirement is effort, and that is best supplied by finances.

In the end the user of the highway pays, whether it be the expenses ever present with poor roads, or the taxes paid, and in turn used to pay, for the construction and maintenance of the roads If a new method can be devised or a new material created which has a new economic value, then the user of the highway is bound to reap the benefit, generally reflected through industry, either in the manufacture of material, or in price of equipment.

If industry is needed to supply the new material or the equipment, and if industry will reap its proportional share of the benefit, why should not industry supply at least part of the effort required to complete research? So, again, it seems a wholly logical association, that of industry and research—an association that by combined effort can supply the time, the effort and the genius required

That industry can supply the funds for research without fear of biased reports or of criticism has been demonstrated, as shown in the Highway Research report on "Economic Value of Reinforcement in Concrete Roads," by Hogentogler In that particular case the industry furnished approximately $12,000, the survey lasted nearly two years, and the results were accepted without prejudice

A glance through the list of industries will show most wonderful practical applications of pure research Volta invents the electric cell, and for the first time generates a continuous current of electricity, Faraday discovers induction; and years later Edison applies these principles to the building of a generator and motor Such instances of industrial and engineering progress almost invariably follow in the wake of pure science

In some cases this progress has consisted in the industries borrowing from the storehouse of pure science, in others they have determined what research was necessary, and have then organized on a satisfactory scale for completing it

With the exception of a few examples of research, all of which are physical, and in no way parallel to the importance of the highway industry, no great research programs or projects undertaken will compare with some of the extremely important practical applications in the industries

Those familiar with the development of television might ask: "What development in road building can be considered as represent-

ing similar effort?" I will answer: "The development of a special gasoline" That story reads like a novel, and proves that important industrial applications of science are seldom a matter of change, but of well-directed efforts of genius

A special gasoline was discovered as the result of trying to find some remedy for a knock in gasoline motors, at one time called a "spark knock." To begin with, it was necessary to find out just what took place in a gasoline-engine cylinder, accordingly, an instrument was devised for that purpose. With the aid of that instrument the various fuels were studied, until it was found that the cause of the knock was not the peculiarities of the spark, nor of pre-ignition, nor ignition before the spark, but the properties of the fuel itself. It was found that some gasolines knocked more than others, and that some fuels did not knock at all, but these were found in comparatively small quantities and were expensive It was finally discovered that a pinch of iodine in the gasoline would cause the knock to disappear entirely, but this also was very expensive The investigators worked diligently for a long time, trying almost every conceivable method, until their efforts were at last rewarded when they hit upon the organic compound of lead that now forms the active ingredient of the special gasoline. Chemically, this is called "tetraethyl lead," and one part in 1300 is sufficient to eliminate the knock in a gasoline fuel This anti-knock development took a long time and meant that many uncharted courses had to be laid, but in the end the result was accomplished The result was to simplify the rate of the combustion of the gasoline vapors—a trifling detail in itself, but of enormous importance.

I mention the discovery of tetraethyl lead as an anti-knock compound for gasoline simply to call your attention to the fact that such discoveries are not accidental, but that they are the results of well-thought-out plans and continuous efforts. Such plans and efforts we must have in highway research.

An analogous problem in highway construction not yet so solved is the treating of clays—the treating of them in such a way as to change their characteristics so that they may serve as satisfactory road surfaces and not remain the detrimental element that they are today.

It has been said that research is dependent on time, genius and effort The Highway Research Board is significantly associated with men of genius who have been active in research accomplishments, but owing to the arrangement of the departments or organizations that

these men represent, the research has too often been merely the by-product rather than the product In many cases states and other divisions cannot use money for research, and so must depend upon others to do this work.

During the past year the committees of the Highway Research Board have made excellent progress and obtained splendid results. If that same talent could be supplied with funds, the research men might continue and economic results be obtained With the builders of highways prevented from supplying funds for research of a general nature, it seems quite logical that those funds should be supplied by the industries and thus a real co-ordination of efforts made to bring about results.

During the early meetings of the Research Board the attendance largely consisted of the members of the various committees, with very few state highway departments represented. With the enlarged scope of the organization and its increased activities, the general attendance has grown rapidly, and exceptional interest has been shown by those interested in highway problems The organization has been extended, until today it includes a contact man appointed from each state highway department of the United States. This has brought the Highway Research Board into close contact with the highway departments and has increased the activities and interest of these organizations. Appointment of contact men in universities has still further increased the interest of the university research workers

Under the present organization there are eight research committees made up of members who volunteer their efforts The members of committees are men especially fitted for the class of work of their particular committees In some instances the voluntary committees can work as effectively as those with paid chairmen, but this is possible solely because of the personnel at the present time.

The work of these voluntary committees has been exceptionally satisfactory, but it is evident that if the committees were guided by chairmen retained to give their entire time to the work; or, if the committees were furnished with full-time secretaries to assist the present chairmen, far greater results could be obtained In the case of voluntary committees, it is impossible for the chairmen to set aside their own routine duties and give more than a short time to the committee work In the case of the paid personnel, it is possible that each day a certain amount of the committee work might be accomplished.

Such an arrangement would mean an increase in the budget of the Research Board, but an increase that would be well worth while

Research men have a most vital interest in research problems. That vital interest keeps them constantly working at such problems However, it is quite necessary that the Research Board should offer to the individual some reward for his active efforts, not necessarily a reward in the shape of finance. It might well be in the shape of credits that could be kept and that would indicate the part the individual had played in solving certain research problems. I recommend that the Research Board consider seriously the matter of such awards.

In closing this report I wish sincerely to thank the various committees and their individual members for the enthusiastic interest they have taken in the preparation of the reports that are to be made during the coming sessions, and for their untiring zeal in making this meeting the greatest of any research meeting yet held