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THE OUTLOOK IN CHEMISTRY IN THE UNITED STATES.[1]

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LADIES AND GENTLEMEN:

It is the highest privilege of the president of the American Chemical Society to express to you, citizens of Boston, the Society's deep appreciation of your interest in our science and of your courtesy in providing entertainment for our numerous membership. In token of the reality of this appreciation, no less than in recognition of the honor bestowed upon me by you, my fellow members in the Society, it is my pleasant duty to address you on some subject which might interest you as an important phase of chemistry or which might bring home to you as thoughtful citizens of this great country of ours some of the important functions which our science may be expected to fulfil in the life of the nation. It is the president's happy privilege also to select his own subject. In normal times, I confess, I should have enjoyed the pleasure the scientific man finds in riding his own hobby before a large and friendly public and I should have been tempted to try to present to you some phase of those wonderfully intricate worlds of atoms and molecules and of the forces controlling them, on which the peculiar power of our science rests. But the spirit of complete preoccupation in the great test to which our country is being put, which I know pervades the minds and souls of all of you,

[1] President's address delivered before the American Chemical Society, Sept. 12, 1917, at Boston.

has led me rather to the choice of a subject of more immediate relation to our present situation. I have thought you might be interested in a discussion of the Outlook in Chemistry in the United States, with special reference to the resources of chemistry in the nation's service in war and in peace, as seen from the point of view both of chemical industry and of universities and colleges, the sources, from which our chemists and our chemical lore are derived.

The great European War and now our own entry into the world struggle of free democracies against the organized military power of the last strongholds of feudal privilege in Western civilization have brought home to the public as never before in the history of the world, the vital place which chemistry occupies in the life of nations. What is it, indeed, that is so fundamental in this science that a country's very existence in times of great emergencies and its prosperity at any time may depend on its master minds in chemistry? It is the fact, summed up in the fewest possible words, that *chemistry is the science of the transformation of matter.* Since every phase of our existence is bound up with matter, from our birth to our return to dust, we find at every turn in life that chemistry is in demand to aid man in his effort to assure to himself a safe, scientific control in the supplying of his own needs, where Nature, from time immemorial, has shown the same impersonal indifference as to his wants, his survival or destruction, that she has for every other form of life! From the transformation of our raw ores into finished metals of almost any conceivable quality and application, to the transformation of rocks and salts and the gases of our atmosphere into nourishing foods, from the transformation of the yield of our peaceful cotton fields and rich coal deposits into death-dealing explosives, to the preparation of blessed life-saving medicaments from the same crude sources—to mention only a few instances of the transformation of matter that I have in mind—it is chemistry that is giving us the power to satisfy our needs, whether it be for wise and beneficent purposes or for the fulfilment of our more baneful desires.

The crisis of the war has put this great controlling science, as it has put all other human agencies, to the fire test in every great country on the face of the earth. Acknowledgedly, chemistry has thus far staved off defeat for Germany after Joffre on the Marne had killed her hopes for a swift, crushing victory through the violation of Belgium, and had taught her that she must face a long struggle, in which, cut off from the world's supplies, she must makeshift with what her own territories could yield and her chemists could produce. In the wonderful organization of power in France and in England in the midst of war, the French and English chemists have stepped in and brought their supplies of munitions of every variety, of remedies, of their new weapons of defense and offensive poison gas and liquid fire warfare up to the point of meeting now on more than

equal terms an enemy prepared years in advance. And in our country, too, our chemists have stood the ordeal of an unprecedented time. I have in mind their splendid achievement of having solved in these three years of warfare such tremendous problems which these years have brought to us as were involved in the speeding up of the production of thousands and thousands of tons of fundamental chemical products needed by our allies and now for our own purposes—steel and iron alloys of every variety of toughness, hardness or elasticity, purified copper by the millions of pounds, aluminium for air-ships and motor cars, abrasives on which the trueness of every great and every small gun depends, sulfuric acid and alcohol for the preparation of explosives—foods, oils and scores of other essential products prepared on a scale never seen before—I think we may say with justifiable pride that our great basic chemical industries have successfully risen to the demands of a situation unparalleled in its scope and urgency. There have been times of delay and times of worry but the few failures have been due rather to financial difficulties than to a breakdown in scientific efficiency. To those of us who know that the chemist is the final controlling mind, guiding in safety for the financier these vast undertakings and expansions, the record of these years is truly a wonderfully satisfactory response to the first crucial test of the efficiency of chemistry in America.

And this result justifies the faith that we will win out just as surely in the hundreds of newer problems brought to us by our own participation in the war. Some of these problems have been brought to the attention of our members by the chairmen of the two chief chemistry committees, which are coöperating with the government—by Dr. W. H. Nichols, chairman of the committee on chemistry of the National Defense Council, an industrial committee, and by Dr. M. T. Bogert, chairman of the chemistry committee of the National Research Council, a research committee. From San Francisco to Boston, from Minnesota to Texas, our chemists have shown the all-pervading desire to bring to the immediate practical assistance of our country every ounce of strength and every grain of intelligence, and have stepped into line for service not only with splendid enthusiasm, but still better, with the grim determination of purposeful men, who know well our enemies' strength but who will do our share to eliminate once for all, unscrupulous militarism from the politics of the world! The immediate response to the tender of the services of our membership to the President of the United States and of the organization of the members for such service through a census of chemists has been an increase in our membership from a total of some 8000 to over 10,000, an unprecedented growth, which shows unequivocally that the chemists of the United States are of one mind in ranging themselves on the side of organized, whole-hearted and forceful support of our government in this

war! Indeed, one of our chief difficulties has been to restrain our men in their eagerness until proper organization would enable the central committees to designate to each man the field in which he could serve best. To the impatient chemists, waiting for their "marching orders" it may have appeared that invaluable time has been wasted and that progress even now is all too slow. But work on all the most important problems really was quickly organized and already important results are available. As an illustration of this fact we have the brilliant and speedy success of Dr. Day and his collaborators in producing optical glass, so much needed for range-finders, which will bring our shots home to the enemy. The very nature of most of the problems makes it impossible to name them here, but I may say that improvements in explosives, multiplication of the sources of supply from which to manufacture explosives, including the utilization of the atmospheric nitrogen for the production of nitric acid, providing protection for our soldiers and sailors against poisonous gases, the making of chemicals for which we have hitherto been dependent on importations, these are some of the problems on which many of our ablest chemists have been working with all the power and concentration that the occasion demands. I may be more explicit in regard to the problem of the home manufacture of so-called synthetic remedies, for the supplies of which up to the present time we have turned to our present enemies. We need large supplies of salvarsan for our hospitals and for our armies, we need local anesthetics, substitutes for cocaine, for our surgeons, we need safe hypnotics to insure blessed sleep to sufferers in home or hospital, we need a long list of products to relieve the numberless ailments to which man is subject. Many of the best of these products are protected by patents but the Adamson law will make it possible for American manufacturers to prepare these remedies in this country. There is nothing wonderful about their preparation—the scientific skill and experience of American chemists is coping with them as easily as an expert chess player solves his problem in chess—and, indeed, with much the same kind of enjoyment. For instance, the obstacles in the way of the preparation of some drugs, most needed but prepared with considerable difficulty, such as salvarsan and atophan, have already been overcome in a way that leaves no doubt, if any ever existed, as to our ability to stand on our own feet, once Congress has removed the legal disabilities. University men and industrial firms have united in the vigorous attack on this problem.

This question brings me to another phase of my subject. Looking beyond the immediate future to the years ahead, why should we ever again be dependent on any foreign country for such fundamental needs of a nation as the best remedies for its stricken people—or, enlarging the question—for such fundamental industrial needs as dyes and dozens of finer chemicals, the need of which has seriously handicapped manufac-

turers and to a certain extent is still interfering with normal activity? It has been publicly urged in Germany—I am quoting from an excellent article by our friend Dr. Baekeland—that German dye manufacturers after the war should allow only a limited and conditional quantity of dyes to go to foreign countries, including the United States, in order to give her home industries a great lead in recovering the commerce of the world in textiles. Even if this suggestion should not be put into effect, for Germany has more to lose than to gain by a policy of trade-war after the re-establishment of peace, we may be sure that her own manufacturers will get the best of her supplies and every possible advantage. Our textile manufacturers and many other brances of industry will be at the mercy of competitors, assisted by government direction, unless we have a declaration of chemical independence in this country! Every thoughtful chemist, I am convinced, and I trust that every other thoughtful citizen, will acquiesce in the policy that henceforth in our basic needs, at least, we be independent of the friendship or enmity of foreign nations! And that conclusion brings me to one of the most important points in my discussion this evening: What are some of the main conditions, from a chemist's point of view, that must be fulfilled, if we are to look forward to successful industrial and scientific development and independence, when the tremendous competition of peace must be met. These conditions are to be sought not only in the field of applied chemistry—and applied chemistry includes every great national industry, from agriculture to the manufacture of steel—but they involve also our universities, technical schools and colleges, the great sources from which our chemists come, not only equipped technically for their work, but carrying also the inspiration, the orientation, which will make or mar them and with them, will make or mar that part of the nation's life which will be dependent on chemistry.

Turning first to the field of applied chemistry, I would like to emphasize that in my opinion the most important single factor which could lead to a tremendous increase in power in our industrial development is not immediately a question of scientific achievement but a factor found in a simple psychological analysis of our industrial situation. Let our manufacturers but awaken to the great significance, to the full meaning of the simple old behest that the laborer is worthy of his hire, and they will be astounded at the results. American manufacturers at present on the whole do not treat their chemists, and especially their research and directing chemists, fairly. The tendency is to exploit the chemist as an employe, instead of treating him as a partner, who brings scientific experience, skill and acumen to the aid of capital and commercial experience and standing. Manufacturers are willing to coöperate essentially on the footing of partners with great lawyers, who solve their legal difficulties

—usually a wholly sterile performance as far as the welfare of the nation as a whole is concerned—but they have not learned to coöperate in the same fashion with men of our profession, who solve their technical difficulties to the direct enhancement of the nation's wealth and welfare! Our chemists know and feel that they are being exploited and in conscious or unconscious resentment, after one bitter disappointment or the other in their employers' fairness, they lose their fresh enthusiasm and their capacity for the whole-hearted, unstinting effort that goes with work in which the heart and soul support the mind! All this is wrong. Research and managing chemists should be sure that success means partnership in the fruits of their success, that success will yield immediately and not in some hazy future of a soon forgotten promise, an equitable share in the actual benefits of the work done. This is one of the real but unrecognized sources of the unquestioned leadership of Germany in fields chemical: Dr. Bernthsen, director of the Badische Anilin-Fabrik, probably the greatest of the many great German firms, told me some fifteen years ago that from the lowliest workman up to the highest chemist in his employ, every individual is guaranteed by contract a royalty, a definite share in the money earned or saved by any suggestion or discovery on the part of the individual. Contrast this wise policy with what is common knowledge concerning the situation in the great majority of American plants. Any chemist can multiply indefinitely the single specific illustration of this attitude that I will give. One of our doctors of philosophy of the University of Chicago, as chief chemist for one of the very largest manufacturing concerns in the country —a unit in a "trust"—perfected a device, simple in itself, that saved the corporation perhaps $80,000 a year: his reward was a princely increase of $200 or $300 a year in salary! Incidentally, let me say that I promptly took him away from this corporation—we cannot afford to waste good men in such places. In case after case that has come to my notice from some of our leading men, chemists have been cuddled and patronized until their improvements have been completed and then recognition has come munificently in the form of a few hundred dollars a year and—oblivion. These men, leading men, let me remind you, have acknowledged to me that this treatment killed outright all the fire of enthusiasm with which they had been wont to work! There are a few noteworthy exceptions among corporations, but their strength and prosperity confirm the validity of the appeal I am making, for they have recognized that in large measure their continued prosperity has been the result of the brain-work of their chemists, coöperating with the brain-work of their directors and the capital of their corporations. There are also prominent exceptions among individual chemists: we have men in our Society who have worked their way to positions and incomes on a par with those of successful lawyers

and physicians—but manufacturers should heed well that almost invariably these are men who withdrew from their original direct employment by corporations and have developed their own independent establishments, either as consulting chemists or as independent, competing manufacturers! How much wiser it would have been for the manufacturers —I am not saying, for the chemists—if these brilliant, forceful men had been kept in their establishments, as they would have been abroad, by fair treatment as partners in success as well as in effort!

I have dwelt long on this plea because I consider this message to our manufacturers from an outside observer, a university man without any industrial affiliations, to be perhaps the most important service I can try to render our country in this privileged address. Let me summarize my point with the aid of an analogy which I owe to my friend Dr. Eisenschiml's remarks after a presentation of this subject to our local section in Chicago: Just as Napoleon let every soldier feel that he carried a marshal's baton in his knapsack and thus secured the enthusiastic and self-sacrificing support of his hundreds of thousands, so our manufacturers should let their chemists feel that each one carries in his brains a contract of partnership —and all that is involved therein! If this is done, we will witness through the tremendous power of the combination of psychological momentum and trained, scientific minds, the dawn of an era of power and prosperity in our industries, in which no one need fear the after-the-war competition for which all Europe is now preparing. Enlightened self-interest is slowly revolutionizing and improving our whole social fabric by a fairer, more honest conception of the relation of capital to workers—with harm to no one, least of all and to their own surprise, to those who have blindly been opposing the movement. And my plea for fairer treatment of productive chemists is the point at which the great world movement touches our scientific body.

Another vitally important factor in the outlook for chemistry in the United States is the adoption by our legislative bodies of a definite national policy looking toward the establishment of that independence of our country in the matter of chemical supplies to which reference was made before. Action in this direction has been happily inaugurated in the fundamental matter of the fixation of atmospheric nitrogen for the manufacture of explosives in war times, of fertilizers in peace and war. The fixation of nitrogen plants in Germany have unquestionably saved her thus far both from a military collapse and from starvation. As has been indicated before, it is important too that we become independent in as large a measure as possible also in regard to all manufactured chemicals and particularly also the finer organic chemicals, including the dyes and the synthetic drugs. The most important measure necessary to this end is protection by duties such as a non-partisan commission of

experts may find necessary. American textile manufacturers, who have opposed this action in the past as far as dyes are concerned, have, I trust, learned their lesson, and will not, I hope, need a second more sharply pointed one. And other manufacturers, having found their supplies of needed chemicals cut off or enormously increased in cost, will also, I imagine, favor the establishment of conditions making home production possible. It is a source of gratification to me to state that the United States Tariff Commission, which is making a scientific study of the vexed tariff problem, most courteously asked for, and received, the coöperation of this Society in the choice of an unprejudiced expert on the chemical schedules.

Wise patent legislation is another fundamental consideration in a declaration of chemical independence. The public—that is their representatives in Washington—should understand what is obvious to any professional student of the problem, namely, that independence is altogether a question of capital, not of science—of dollars, not of chemists. Our unqualified success in every line of applied chemistry in which investment of capital has been an attractive proposition is positive evidence that we have the chemists and the knowledge to achieve this independence, if wise legislation by tariff and patent laws will insure to capital a return sufficiently attractive and stable to have it enter these needed fields.

To illustrate concretely what this policy would mean for the nation let us consider the following: Much more than a question of coloring materials is concerned in a conscious policy to have our dye industries established on a permanent basis. It has often been emphasized that the manufacture of dyes is so closely related to the preparation of explosives that a flourishing dye industry in times of peace means ample facilities for explosives in times of war. No American would care to contemplate what our position would be in the matter of large scale production of explosives if we had become engaged in a struggle with a first-class power without the benefit of the great expansion in our dye and explosives factories which our commerce with England and France brought about after 1914! When peace comes, let no American forget this lesson! One way of insuring ourselves against a lack of facilities for a sudden expansion in the production of explosives is to keep capital invested in dye factories.

Independence in the preparation of medicinal remedies, especially also of the finer modern products which we call synthetic drugs, should be as conscious an aim of the United States as independence in the manufacture of dyes. It is worth noting that the two aims support each other, for nearly all of the basic products needed for the large scale preparation of synthetic remedies are either prepared in aniline dye factories as inter-

mediate steps toward the dyes or are so closely related to such compounds that it would be a mere detail to include these products in the normal output of a dye factory. As an instance pointing in this direction, recent correspondence with a prominent American firm, which has invented and is manufacturing what promises to be a valuable substitute for cocaine in producing local anesthesia, brought out the fact that the chief difficulty in the way of the production of the drug on the large scale which the situation demands, lies in the securing of sufficient quantities of the chemicals diethylaniline and cinnamic acid. Now, the former could and should be manufactured in dye factories with the greatest of ease, side by side with dimethylaniline, which is a common intermediate in the manufacture of many dyes, and cinnamic acid could be prepared from benzaldehyde, another intermediate. Furthermore, large research departments in well organized dye factories will be centers of research in applied organic chemistry and practically all of our valuable synthetic drugs are such organic compounds. Indeed, it will be a matter of time only—and I should like to see that time shortened as much as possible—when some of our best equipped and most progressive dye factories will turn to the problem of these remedies as a question of the economic utilization of their equipment. That has been the history abroad and it will be the same here. In fact, together with our long-established great pharmaceutical houses, they should find even richer, unexploited fields of effort in the problems of synthetic drugs than in those of dyes. Without question the average man spends on necessary drugs for his family at last a thousandfold the value of the dyes in the wardrobes of his whole family —the ladies, of course, included. The twitchings of rheumatism or gout, sleepless nights or a cantankerous cold are most urgent and persuasive drawers on a family purse. My professional friends in the audience know well how the modern dye industry has been built up on an accurate scientific knowledge of the connection between color and what we call the structure of the molecules, those minute worlds on the knowledge of which our power to reconstruct matter rests. We know too that the dye industry has reached, or almost reached, its full maturity and capacity. But we are only on the threshold of exactly the same kind of development in the discovery of improved remedies for curing human ills because the connection between the structure of our molecular worlds and their medicinal effect is just beginning to be systematically elaborated. Great industrial establishments founded on organic chemistry, like the dye manufacturing and the great pharmaceutical houses, collaborating with research laboratories in universities and in medical institutes, would hold out to this country the promise of a share in realizing a duplication of the conquest of the world of color, which has occurred in the last fifty years, by the greater conquest of the world of scientific medicine!

A brilliant beginning has been made in this campaign by the preparation of excellent substitutes for cocaine, less toxic than cocaine itself—by the elaboration of salvarsan, by the isolation in our own country, and the artificial production, of adrenalin, a vital regulating principle produced by an organ, the suprarenal capsule, in our bodies. The isolation and exhaustive study by Kendall of the active principle of the thyroid gland, which no doubt will be followed by its artificial preparation, is a second brilliant instance of American success in this great field! When we consider the countless number of animal preparations—gland extracts, serums, and antitoxins—the pure active principles of which are all we really want, but which are injected into us or fed to us, with an extraordinary amount of unnecessary and often harmful animal matter, we can realize what a boon to humanity this line of effort really means. Let me emphasize again, it is chiefly a matter of wise and foresighted legislation to make our independence and possibly our leadership in this great field possible—we have proved that we have the scientific ability—it is a question only of putting this work on the basis of an established industry!

There are other important considerations bearing on the outlook for chemistry in the U. S. from the point of view of industrial chemistry—such as a law making possible commercial agreements and divisions of labor among competing houses, which exist abroad—but I must neglect no longer to turn to the third important theme embraced in my subject, the outlook for chemistry from the point of view of our universities and colleges, in which I will include the outlook for the development of the theory of our science in this country.

One cannot well overestimate the importance of the standing of chemistry in our universities and colleges, they are not only the main sources of supply of chemists in the United States, but they are also the fountain-heads for the knowledge which keeps us in touch with the progress of chemistry the world over and which makes available for rapid absorption in any field of pure or applied chemistry new discoveries, new methods of attack, new, clarifying points of view. Let me remind you that applied chemistry includes not only industrial chemistry, but also fundamental and most promising fields of effort in other major sciences. Botany, through the inspiration of Liebig, was probably the first of our sister sciences to apply chemistry to the solution of many of its problems. Physiology followed and now we see even zoölogy awakening under the stimulus of chemistry from its long morphological trance to a live science of animal life. In fulfilment of the promise contained in the life of our great fellow-chemist Pasteur, chemistry is now at last guiding not only the physiologists but also the bacteriologists, pathologists and laboratory clinicians toward the raising of medicine from the uncertain realm of art to the safer one of science. All life is indeed but a transformation of matter

in its loftiest phase and the world is at last realizing that the fundamental science of the transformation of matter holds the key which should unlock the secrets of all aspects of life, of birth, health, disease and death, and probably even of such subtler manifestations as heredity and character.

I have outlined some of these far-reaching applications of chemistry in order to emphasize the fact that if we are to meet all of these demands on chemistry, if the outlook not for chemistry alone but for all of these lines of human progress which are dependent on our science is to be one of sure promise in the United States, it behooves our people to see that the departments of chemistry in our universities and colleges be kept not only prolific as to the output of men—the vast expansion in laboratories and attendance bears witness to quantity being insured if the war does not affect us too severely—but that they also be maintained on such a high level of scientific quality that the product will consist of the very best type of men! We have received from the period from which we are now passing a magnificent heritage of world standing and ideals in our university life. The last twenty-five years witnessed an era of expansion of our resources for research and instruction, of the raising of standards of scholarship and productivity of such moment that many years before the war began the migration of our students, especially also of our chemistry students, to Europe for the pursuit of graduate work and the securing of the highest type of professional training had practically ceased. It has no longer been a question of Berlin or Munich, of Goettingen or Heidelberg; for the prospective chemistry student it has been a choice of Harvard or Johns Hopkins, of Chicago or Columbia, of Illinois or California, the Tech or Cornell—I could extend the list much longer but fear it would tire you. And it has been so because our young men have felt that they could secure just as thorough an education here as there, just as inspiring guidance from men whose research had made them masters in their own fields. Our Remsens and Michaels, our Richardses and Nefs, our Noyeses and Gombergs, Lewises and Morses—to mention only a few of our leaders of this period—founded that independence in university education in chemistry which our country has the right to demand that we maintain.

Now, thoughtful men in our Society, looking ahead, see that this great uplift in our scientific life is facing dangers which, unless they are met frankly and effectively, will bring on a period of depression which will be a grave menace to all the varied fundamental interests in the life of the nation that depend on chemistry.

The first and greatest of these menacing developments has its root in the recent unprecedented demand of our industries on our schools for research men. From university after university, from college after college, the combined lure of great research opportunities and of much larger finan-

cial returns has taken from our academic life far too many of our most promising young men, the very men on whom the country has been depending for the filling of our great university chairs as the older men now holding them gradually will age and retire. Unless prompt measures are taken we shall witness in a few years such a dearth of first class tried material for professorships that second rate men will be placed where the national welfare needs the best we have, and third and fourth rate men will be occupying positions in which we should have young men of the highest promise in the period in which they are reaching full maturity. Indeed, it is greatly to be feared that even now we are witnessing a gradual lowering of standards. It would be futile to appeal to our industries not to call the men they need, although in the not distant future they will suffer most severely from the situation which is developing, if the present tendencies remain unchecked. The only possible source of relief lies, I believe, with the presidents and trustees of our great universities and to these the second main plea of this privileged discussion is addressed. These authorities should recognize the fact that their institutions have now entered a period of severe competition between the industries and academic life for chemists of the highest type and greatest promise. They have already learned the only method of meeting this kind of competition successfully, for they have faced the same problem in two other professions, medicine and law: in the face of the tremendous financial attractions of the practice of either of these professions our most progressive universities have simply put their law and their medical faculties on a higher, more nearly professional scale of endowment of professorships than obtains for their other faculties. They must, it seems to me, take the same measures with their chemistry staffs; it is primarily a question whether they can be awakened to that need now or whether they will let the country suffer from their lack of foresight and let us learn from the most efficient of our teachers, bitter experience. Wise provision now would not only safeguard our present standing in a critical period of our history, but in this time when the importance of chemistry has been brought home to our young men as never before, the new attitude, properly announced, would attract a larger proportion of the men of brains, talent and ambition, who enter professional life but tend to study law of medicine as holding out much greater opportunities for the satisfying of their ambitions.

Adequate compensation is important for a research man—and to his type in university and college I must restrict my remarks—it is important both from the point of view of his self-respect and also especially for the sake of comparative freedom from worry concerning a fair provision for his family. But inadequate compensation is not the only danger seriously threatening the outlook for chemistry in our universities. Let us remember

that healthy progress in our science is dependent primarily on university men pursuing great lines of original investigation. It is true that we have now well endowed national institutions of research, such as the Rockefeller Institute and the Carnegie Institution, but universities cannot afford to surrender to these the main burden of insuring progress in the theory of our science, because these *are not teaching* institutions. To take from our universities the choicest of our research men would deprive our young men of that inspiration and fertilization of their minds in the period of their greatest acceptiveness, which early intimate association with great investigators alone can give. To my mind it is clear that if universities would fulfill their highest mission they must remain the seats of the best type of research. But such research is the product of an extraordinarily sensitive state of mind: Only the greatest powers of concentration of thought make it possible. The investigator is groping for truth in unexplored regions, wary of every pitfall, most fearful indeed of possible illusions of his own highly excited imagination. Let any one imagine himself groping in a dark and unfamiliar room and he will easily realize that the undisturbed concentration of his every faculty is the only way for him to attain his goal! Let the rush of an automobile or the screech of a locomotive detract his attention but for an instant and he may well have to rue a stubbed toe or a grazed shin! Now, figuratively speaking, there are too many noisy automobiles and screeching locomotives in the lives of our distracted investigators. American universities, in general, have the unfortunate custom of loading down their best investigators as heads of departments with administrative duties of all varieties, ranging from clerical functions to committee work, important for the institution, but always a grave obstacle in the path of successful research. Younger men, even when they show marked research ability, are too often worn out with excessive duties of instruction and laboratory detail, when their minds need their keenest edge to cut their path to the elusive truth! Men in whom the research instinct is inborn and overpoweringly intense, will break through these difficulties—usually at the cost of the neglect of other duties—but our system is one that means an extraordinary waste of talent for the highest type of work on duties that minds of lesser fineness could do just as well or better. On top of these older defects, which we have been slow in recognizing and removing, have come in the last few years the further distracting duties of necessary public service. Let me repeat what I stated earlier in the evening: Every one of our great chemists, as well as of our less well-known ones, is eager to devote every particle of his knowledge and strength to the sacred duty of the moment. Theoretical work has been set aside except as it contributes directly to the cause of national defense. But let us begin to realize now that when peace comes, we must let our investigators re-

turn to the service of pure science, we must leave them severely alone, free from committee work of any kind, so that they may recover that opportunity for concentration which is needed for productive research of permanent value! Some of our research men, I dare say, are being spoiled forever for this service, exactly as many a returning soldier will have lost in a craving for adventure his fitness for ordinary civic responsibilities.

There is a strong movement too in our Society to bring universities and industries into closer relations, a laudable movement with which I am in heartiest sympathy, but which can bring unmixed benefits only if it is most wisely guided. It would be fatal if it were allowed for the sake of temporary advantages to injure in any way that search for truth for the sake of the truth itself, on which after all the great structure of our science as of all sciences rests. Let the large proportion of members in our Society, who are primarily interested in applied chemistry, recall as a typical illustration of a very general truth that chemists had tried for fifty years to manufacture sulfuric acid by the contact process and had utterly failed, and that success finally came only when the laws of physical chemistry, products of the research of guileless university professors, were available and were applied to the problem! Who can doubt that we still need the efforts of new Faradays, van't Hoffs, Roozebooms, Bertholets, Kekules! The question has impressed me as so vital a one for the outlook for chemistry in this country that as president of our Society I have put on the committee charged with the development of relations between industries and the universities primarily university research men, with the understanding that they will give to pure research in our universities the benefit of every doubt in their recommendations. I trust that our Society as a whole will realize that it were better that our industries suffer somewhat temporarily than that our national strength in chemistry be crippled at the source. My personal opinion is that we can attain both of our objectives—to use a war phrase. Thus, our present war duties are making university men personally acquainted with numerous practical problems which in many cases after the war will probably form the basic material for investigations of theoretical relations. Even if they are only in a measure as successful as those of Baeyer, when through the study of the structure and synthesis of indigo he opened up the great theoretical fields of knowledge of tautomerism, of the theory of unsaturated compounds and of cyclic derivatives, they will advance both branches of our science, applied and theoretical chemistry. Efforts along the lines of developing the theory of the connection between molecular structure and physiological or medicinal properties are now taking root in a number of our universities. But, on the whole, I would recommend that technical research problems—routine analytical and control work

should be altogether barred from our universities—that technical research problems be limited in universities to picked men interested in applied chemistry and holding possibly professorships or other appointments in industrial chemistry. In time, these men will become dependent on their colleagues devoted to pure science for keeping step with the progress in our science. I would urge, too, the perhaps novel recommendation that remuneration for such work be made a departmental and not an individual affair. This wise provision is being enforced in those modern medical schools which demand research work of their staffs, fees for practice reverting to the university hospitals and not to the individual. As applied to chemistry such a provision would be desirable, in the first place, because it would to a large extent reduce the temptation of financial inducements for the men whose talents fit them for work in pure science and whom the country needs for such work. In the second place, one will find that the university man interested in a technical problem is after all less useful in a teaching department than the man devoted to pure research: the pressure from outside will lead him to throw a greater mass of administrative detail, of instruction or of the care of research men, on his colleagues. The result is that the department and not the individual really carries the burden of the problem in applied chemistry—exactly as in the medical schools, which still allow their staffs to practice for their own financial benefit, this is all too often done with the drawbacks of inefficient teaching, the ignoring of administrative responsibilities and the leaving to the care of others the provisions for education in research.

I have dwelt on the details of this great problem which is confronting our society, because I would protect the outlook for the growth and success of theoretical chemistry in our country by every means in my power. We have a splendid record: we are easily leaders in the domain of knowledge based on the exact determinations of atomic weights—a knowledge which leads among other results to habits of more exact, more critical methods in all fields of our science. Arrhenius told us that America is leading in the difficult work of the rigorous examination of the theory of ionization and of establishing it on a finished basis. The development of the field of free energy relations is more intensely cultivated here, I imagine, than in any other country. In the application of modern theories of atomic structure and of the electron theory of valence to all branches of chemistry, especially also to organic chemistry, we are, I believe, easily in the front. Our very youth, as a people, has preserved to us in science as in national sentiment, that whole-hearted enthusiasm for ideals, which in world politics has made us the most altruistic nation on the face of the earth and which in science finds its expression in the pursuit of knowledge for the sake of the pure truth alone, a pursuit characteristic of the best research in our universities and colleges!

And so let me conclude my remarks on the outlook for chemistry in America by emphasizing that we have a goodly heritage of success both in our great industries and in our great universities, which will form the safe basis of a brilliant future, if we will but approach the problems of the moment and of the immediate future in characteristically American fashion with a spirit wisely combining altruistic principles with practical, worldly common sense. This means the "square deal" in industrial life for the product of the brains of the research chemist, combined with wise laws to insure to capital a fair and tolerably safe return for investment in chemical industries, needed to make our country chemically independent. And it means too the placing of chemistry in our universities on a plane with the other great professions, law and medicine, in order to hold in this great science, so important for the welfare of the nation, the needed numbers of men of brilliant minds and energetic ambitions—combined with the devotion on their part to the search for the truth, to the establishment of the great laws of our science, for the sake of that truth, that science, alone!

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HEATS OF DILUTION: I. A CALORIMETER FOR MEASURING HEATS OF DILUTION. II. THE HEAT OF DILUTION OF THREE NORMAL ETHYL ALCOHOL.

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A number of years ago E. W. Washburn suggested to one of the authors that a promising method of attack on problems connected with aqueous solutions lies in the accurate determination of heats of dilution. With the aid of such measurements, and the freezing points, the vapor-pressure lowerings of the solutions can be calculated thermodynamically. Aqueous solutions of alcohols constitute an important class of solutions since, due to the similarity of methyl and ethyl alcohol to water, the "thermodynamic environment" will change but slightly with the concentration. A knowledge of the vapor pressures of such solutions is evidently desirable, as it represents the behavior of aqueous solutions when the effect of changes of the medium or "thermodynamic environment" is at a minimum. Direct-pressure measurements by any of the present methods are not possible with such solutions as the constituents of the solutions are both volatile.

This article describes the calorimeter used in measuring the small amounts of heat evolved during the addition of water to aqueous solutions of alcohol. The results of a series of determinations of the heat of dilution of three normal alcohol, with varying amounts of water, are also included. The authors wish to take this opportunity to thank E. W. Washburn for