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CONTENTS

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SOME DEVELOPMENTS IN THE CHEMICAL INDUSTRIES AS A RESULT OF WAR CONDITIONS[1]

IN these passing days every branch of scientific activity has many striking illustrations of the fact that its fund of knowledge and experience is being vigorously drawn upon to meet the pressing needs of the hour. Where so many sciences are making notable war records it may seem invidious to select any single one for review. But my own personal apology must be that I have not the ability and certainly a single evening has not enough hours for presenting the activities and the accomplishments of the entire field of science. While, therefore, we are proposing to discuss matters having a more or less chemical tinge it should be emphasized at the outset that we are not unmindful of the wonderful service in manifold ways resulting from the activities of the physicist, the engineer, the geologist, the bacteriologist and botanist, the psychologist, the pathologist and sanitarian: All these and many other workers in related branches of science have achieved results which are quite as fundamentally important as anything the chemist may have to offer.

A further word of explanation or possibly of warning may also be in order. The field of the chemist is so wide and his activities touch so many interests that sometimes he must be not altogether certain himself when he is treading the paths that lie outside of his own borders. Indeed he must appear occasionally, in the mind of other people, at least, to have adopted as his own the

[1] Annual address delivered before the Society of Sigma Xi, University of Iowa, February 13, 1918.

line from Kipling, which runs, "Yours is the earth, and everything that's in it." This must be the explanation, therefore, if we seem to discuss some topics where the chemical connection is but dimly discernible or possibly lost entirely.

In the first place then, let us discuss the fuel problem, that is to say coal:

It has seemed to take a war situation to shake us into a realization of the fundamental and elementary fact that coal transportation must be evenly distributed throughout the year and not left to the congested conditions of the winter months. We talk about a fuel famine due to car-shortage. It is not a shortage of coal cars that troubles us—but rather a shortage of the thinking process in connection therewith. What indeed is a car shortage? You say it is the opposite of having cars enough. Now if we mean, by an adequate railway equipment, enough cars to serve the mines and move the coal to accord with the abnormal demand of the winter months, no railroad in this country now has, or ever can afford to have, such an equipment. Mr. C. G. Hall in 1914, while Secretary of the International Railway Fuel Association made an estimate to the effect that if we were to take only five of the leading coal-moving roads of Illinois and Indiana and calculate the additional equipment they would need in order to fully serve the mines and meet the current consumption of the winter months, these five roads would require 250 additional locomotives and 30,000 cars representing, together with the necessary additional trackage and yard equipment, an expenditure of approximately $75,000,000. This would represent for this small group of railways alone, a fixed charge in the way of interest, amounting to nearly $4,000,000 per annum, with the extra equipment standing idle and non-productive for eight months of the year. Indeed, he goes further and estimates that the railways of the country already have in service coal cars over and above the number that would be necessary if the same tonnage could be handled at an even rate throughout the year, and such excess equipment represents an investment, even under existing conditions, of over $105,000,000.

But all of these features were in evidence before the present war. They still exist in even more pronounced degree, with a number of added features. We talk of eating less wheat so that our Allies may have more bread, but we ought also to have put in our coal supplies last August so that in January the war necessities and the fuel needs of our Allies might have a better chance at the coal pile. I am just in receipt of a letter from one of my colleagues who left the laboratory about four months ago. It was written in Paris and I quote a sentence or two: "We have plenty to eat but the amount of radiation allowed is very small. If I had as much coal here as I had in my cellar at home I would be arrested for hoarding. Coal is actually $70.00 per ton." The point of the whole matter is this: We must learn the art of storing coal. It is not the railroads alone that are concerned. The miners and coal operators are equally involved. Under the present system the mines are operated on an average about 200 days in the year. Such a system must have a demoralizing effect upon labor, so that many serious social as well as economic and financial questions are involved.

And where now does the chemist come in? I was passing through a neighboring town about the middle of last September and saw along the railway tracks a coal pile of about 30,000 tons, burning too fiercely to be quenched or moved and as a result the entire lot was a total loss. Other similar fires have been reported, among them the firing of a pile of 100,000 tons at Superior, Wisconsin.

A number of chemists and engineers have been quite diligently at work for a number of years on this problem of the storage of coal, and the interesting point is that these results are now available in such form as to furnish a practical contribution to this very important problem and it is certainly an opportune time for this work to have been completed. The summary of it all seems to be:

First: That coal can be stored in large masses with a very fair degree of safety from spontaneous combustion, and

Second: That the loss of heat values due to weathering or other deterioration processes is practically negligible.

As confirmatory at least of the first of these conclusions the case may be cited of a large power and lighting concern which for some time has been putting in practise the principles involved in the proper storage of coal and indeed had a very considerable stock on hand. During the recent freight embargo due to weather conditions this company was able to continue its service without interruption by drawing upon its reserve supplies. Only an occasional car of coal was received from the mines by this concern for 30 days immediately following the 5th day of January, 1918. What this meant to the operating end of the system and the community which it served may be realized when it is known that the fuel demand of their boilers amounted to from 6,000 to 7,000 tons per day. Here in fact was a storage supply that could be drawn upon and was drawn upon to the extent of over 200,000 tons. The practicability of storing western bituminous coals was thus strikingly demonstrated. The chemists have worked out the fundamental principles involved. It is up to the engineers to apply them. The storage of coal having been shown to be possible it at once becomes an industrial as well as a war measure of very great importance.

Not greatly distant from the coal question is the subject of coke. We can not win wars without iron and we can not make iron without coke. Previous to 1914 the by-product method of coke manufacture was making steady but slow gains upon the almost criminally wasteful process as carried out in the bee-hive oven. Approximately 75 per cent. of all the coke produced in the United States came from bee-hive ovens. For the current year, 1918, it is estimated that the by-product ovens will produce 50 per cent. of the total yield. Something can be understood as to the magnitude of this change when it is recalled that an equipment of bee-hive ovens can be built and put into commission for a few thousand dollars while for a by-product equipment the cost is hardly less than from \$3,000,000 to \$5,000,000. It is doubtful if anything has occurred during the last four years that will more profoundly affect our industrial activities than this revolution in our coking process. In the old bee-hive oven all of the volatile constituents of the coal were burnt and lost unless we count the heat produced as having some value in the formation of the coke. But that procedure was like burning up five dollars' worth of high-grade material to produce five cents' worth of low-grade heat. The only product of the bee-hive oven was coke. In the by-product oven the coke has almost come to be the by-product while the volatile or liquid material might be looked upon as the item of chief interest. For illustrating a point a little further along it will be worth while at this point to mention a few more important of these constituents. We will not stop to name them all, since potentially at any rate, their number would be about 7,000.

There is, then, gas, for the city mains, ammonia for fertilizers and munitions, benzol for colors, toluol for explosives, phenol, being just plain carbolic acid, for antiseptics, explosives and phonograph records, creosote oils for the wood preserver, anthracene for more colors and then just plain tar. This enumeration brings us directly to a discussion of the coal-tar dye industry.

Three years ago we were being warned that the foreign dyes would soon be exhausted, that none were made in America, that the men would have to wear white socks and neckties to match, and that gaily colored ribbons and dress patterns for the ladies would have to be forgotten. All of which delectable information was accompanied by the query, "What is the matter with the American chemist?" A number of thoroughly well informed among the brethern made reply which in substance set forth the fact that the American chemist was all right and just as competent as any other chemist in the matter of dye stuffs, but with much emphasis, they set forth the very pertinent fact that as a manufacturing proposition it required large capital. That the business was interrelated and interwoven with so many subsidiary lines that all must be built together in order that any one feature could succeed. The complete circle of establishments and processes needful for embarking in the industry is well suggested in the short list of by-products already given. Now they estimated that on the most conservative basis, the capital needed to start the dye industry could not be less than ten million dollars and what was more, the experience of a former attempt to establish the industry in this country resulted in almost complete industrial wreckage of the business caused by the dumping process from German factories. A financial record of this sort made the prospect of interesting large capital impossible without protection. Because there was at the time a total lack of protective legislation it was argued that the same disastrous experiences would result, so the chemist passed on the question and referred it to the capitalist and Congress with emphasis on the fact that it would take both legislation and money to establish an American dye industry. And so the matter rested quiescent and was almost forgotten.

A few days ago I hapened to be passing through one of the largest department stores in Chicago and indeed of the world. My route, purely by accident of course, took me past the dress goods and ribbon counters and also through the division where neckties and socks were displayed. The profusion of colors on every hand recalled quite vividly some of the predictions of three years previous and I made mental note of the confirmation of numerous facts, which have been coming to the surface, relating to the development of the dye industry in this country. These facts are doubtless familiar enough to the chemists, but so quietly has the work gone along and so little has been said about it outside of chemical circles that a brief reference may not be amiss at this time.

Four years ago the firms in this country engaged in the manufacture of dyes and intermediates or accessory substances numbered all told about six, mostly in fact importation houses. Only two or three of these were of even moderate size or had any great amount of capital invested. At the present time there are not six nor sixty nor twice sixty, but 130 such corporations actively engaged in the business. The capitalization of these concerns, previous to about October 1 of last year, was stated to be approximately $150,000,000. Since that date the Dupont Company has announced its intention of entering upon the manufacture of dyes and associated chemicals. The especial amount of capital to be set aside for this purpose does not seem to be stated. It is perhaps sufficient to know however, that the capitalization of the Dupont Company amounts to $240,000,000. As for legislation, that matter has been fairly well attended to, so that piracy and financial submarine warfare would seem to be eliminated.

And now what about the chemical part of it? Previous to 1914 the importation of dyestuffs into this country amounted to a little over 10 millions dollars per year. The home production was insignificant even for our own use and the exportations were conspicuous by their absence. During the year 1917 we had caught up with the production of dyestuff to such an extent that the output was sufficient to meet all home demands with possibly one exception, namely, the manufacture of indigo blue which had been so largely contracted for to meet the needs of the United States Navy that there was as yet no surplus for the general trade. This does not mean that all of the possible 1,000 formulas representing that number of different dyes and which were available before the war are now made in this country. It does mean, however, that the possible 100 dyes called for by the everyday work of the dyer and meeting substantially all of his needs are at hand.

Such an accomplishment would not have been thought possible even by the wildest dreamer two and a half years ago and in itself would be quite sufficient cause for profound congratulation to all concerned, chemists, capitalists, the ribbon counters and the ladies, but that is only half and less than half the story. In addition to being able to supply our own needs the exportations to other countries for the first ten months of 1917 amounted to a total of $12,500,000 and if the exports for December last are an index for the current year, the dyestuffs sent abroad from this country in 1918 will reach a total value of over $16,000,000.

Permit me further in this connection, to paraphrase an old exclamation, "That beats the Dutch!" by saying "This beats the British," because early in 1916 it was announced that there had been formed in England and British Dye-stuff Syndicate, backed financially to the extent of about $15,000,000 by the manufacturers of dyes, the textile industries and the government, with the avowed purpose of making themselves self-contained and independent of foreign supplies. Of course the English people are tremendously busy with other things and there is no thought whatever of reflecting on their ability to accomplish what they set out to do in this *or any other undertaking,* but it is interesting to know that our largest customer last year was Great Britain, whose purchases of dyes exceeded a value of $3,000,000.

Before leaving the subject of dyes, it may not be out of place to mention a circumstance, involving, perhaps, too much of detail or possibly of personal interest to be included in this discussion. However this is the item: About eighteen months ago a chemical graduate from one of these land-grant colleges which we now dignify with the title of state universities, one of my own students in fact, completed his investigations in a government laboratory upon the possibilities of a dye which he had developed from the wood of the osage orange. The results of this work are now almost everywhere in evidence, because of the utilization of this dye as the coloring matter for the khaki uniform cloth of the American army. I wonder if his acquaintance with the osage orange does not result directly from its introduction, throughout the upper Mississippi Valley, some fifty years ago by Professor Jonathan B. Turner, the father of these same state universities, the educational prophet of the generation preceding our own and the personal friend of Abraham Lincoln, the weight of whose influence and whose signature to the Morrill bill in 1862 made possible the founding of these universities, may we not say, of the common people.

Intimately associated with the coal-tar dyes is the subject of munitions. Some months ago in conversation with the chief chemist for one of the largest munition plants of the country, the question was asked if he was able to keep reasonably busy these days, at least so that Satan could not readily find some mischief still for his idle hands to do. His reply was significant and made without note or comment. It did not need any. He said our total output of explosives at the present time amounts to a million pounds per day. Of course a very large part of this output is used in mining and blasting, but the aggregate of high explosives, which before the war was insignificant, now approximates something over two billion pounds per year.

The substances from which the three main types of explosives are made are glycerine, phenol and toluol, but the greatest of these is toluol. Where are we to get the toluol? The question has been partly answered in the great increase of by-product coke ovens. But if twenty million tons of coke are made in these ovens during the current year and the yield of toluol is one half gallon per ton then we only have in sight from this source about ten million gallons of toluol, only about one quarter of the amount required for making the munitions needed for our own army. But the call has already gone out for "toluol and more toluol." The first measure to meet the demand, and which is now being inaugurated, is the stripping of city gas of this material. It can be spared without any great detriment to the gas and amounts to approximately .04 of a gallon per each 1,000 feet of gas. Ten of the largest cities of the country where this process is to be first installed are estimated to yield approximately an additional 10,000,000 gallons. However, the problem is really in process of solution. It is an extremely vital question, and is causing anxiety in some quarters but it will doubtless be met and answered in good time.

It may be interesting to note in passing that for each gallon of toluol, there is produced from five to six gallons of benzol. Even now this material is being produced in such quantities that the usual channels for its use are more than satisfied. This primarily has a bearing on the dye industry since it forms the starting point for the largest part of the dyes. But benzol has now come to be the starting point for the manufacture of carbolic acid and carbolic acid, or phenol, is the starting point for picric acid, another explosive, and also for the manufacture of Bakelite, which has almost completely replaced gutta percha in electrical appliances, and then, coming nearer home, it is Bakelite which furnishes the material for the manufacture of phonographic records. One more possible adaptation of benzol is of interest. It is miscible in all proportions with alcohol and when so mixed furnishes a motor spirit in some respects superior to gasoline. Indeed a well-authenticated report seems to indicate that about 70 per cent. of the motor spirit used in Germany at the present time is made up of this material. These various items will serve at least to show the interrelated character of the very large and important group of interests which are associated with and grow out of the coking process. But time would fail me if I attempted a mere enumeration of all the interesting developments connected with the coking of coal.

As for gasoline, the output last year exceeded two and one half billion gallons. But that is not enough. The current year will probably see this amount increased by possibly 10 per cent., through the extension of the stripping of the condensable material from natural gas and from the extension of the cracking process, especially the method now developed to such a practical stage by Dr. Burton, of the Standard Oil Company.

And what about potash? We are told that the production for 1916 was ten times what it was for 1915, but that does not mean much, for we made less than 1,000 tons in 1915. The output for the current year will doubtless exceed 40,000 tons, but even that loses much of its significance when we remember that our previous importations from Germany amounted to about 275,000 tons per year. But recent, almost monthly developments are exceedingly interesting and encouraging. There is first the brines, especially of western Nebraska and southern and southeastern California. This is at present by far the largest source. Then come the Kelps of the Pacific coast, still in the developing stage but moving rapidly and encouragingly—and then come the alunite deposits of Utah, a real producing proposition, but relatively as yet on a limited scale. We are just beginning to get glimpses of the possibilities from cement furnaces, from the green sand of the Eastern States and from the feldspars in widely distributed localities. At the present rate this problem seems in a fair way of solution.

And meantime what of the industries using potash, for example in glass manufacture? Soon after the outbreak of the war, the chief chemist for one of the largest glassmakers of the country was asked what he was going to do for potash. His reply was that he had for some years urged upon his firm the advisability of experimenting with soda as a substitute for potash, but they insisted upon "letting well enough alone." But now since they were obliged to try it by force of circumstances they were so well pleased with the results that they would not return to the use of potash even should it become again available.

Similarly the gold miners were distressed to know where their supply of potassium cyanide was to come from when importations of potash salts ceased. At the Secoud Chemical Exposition at New York in 1916 one of the large chemical concerns had on exhibition some fine-looking sodium cyanide. The question was asked how it was working out. The reply was that it was proving advantageous over the potassium cyanide in numerous ways. It had a higher percentage of the active principle per unit of weight, was cheaper to manufacture and they would not return to the use of potassium salt even should the supply of potash again become available.

Again, take the crucible situation. The manufacture of graphite crucibles is an exceedingly important one to practically all of the metallurgical interests, from steel to gold. The clay used in their manufacture must be high grade and possessed of special properties. It all came from a particular locality in Germany. The stock in hand of that material lasted about a year. Meanwhile a vigorous search for substitutes had been going on. The first of this new material was put out about two years ago, the shipments of these crucibles bearing a tag which constituted a sort of apology, stating that the supply of foreign clays had become exhausted and asking for some care and some indulgence if the quality of the new crucibles was found to be not quite equal to the old.

I have myself had occasion to use these new crucibles under quite as exacting conditions and certainly under quite as high and probably higher temperatures than those commonly employed. My conclusion is that the manufacturers should now send out these wares with a new label, which would be in effect an apology for the first apology and say, "These crucibles are made in America, of American clays and we take pleasure in guaranteeing their superiority over anything formerly manufactured from foreign material."

Then there is optical glass. It all came from Germany. In their own experiments in attempting to develop a high-grade optical glass the Germans published to the world the results of their experiments for about ten years. When they began to get valuable results the government stepped in and there has been an impressive silence for the years following. At least no one outside of Jena seemed to know how to do it. The French and English each had a single factory which was making a good glass but all of their output was needed at home and was at once commandeered. Here then was an immediate and imperative need, for both the navy and army must have range finders, field glasses, cameras and telescopes without number. The problem was taken up by the government laboratories and by scientific calculations and deductions coupled with skillful experimentation they are now able after ten months to produce not only a better but a greater variety of optical glass than the Germans had been able to produce in ten years.

And now just a word about nitrates. When we note the mere names of the explosives manufactured it is apparent that they are all nitration products and that nitric acid is an essential in the making of every one of them: Nitroglycerine, Nitrocellulose, trinitrotoluol, trinitrophenol, ammonium nitrate and even the niter in the old style of black powder confirms this fact. Nature, it seems, has been very partial in her distribution of nitrates in quantities to be at all worth while, Chile alone being the fortunate country. But with four fifths of the air nitrogen, one ninth of the water hydrogen and all the rest of both being oxygen, we at least can be said to have the raw material in sight, or perhaps better, at our very doors, at all times. No wonder the question is being rather nervously asked, "What are we doing to insure an adequate supply of nitrates?"

As a protective measure, while we are doing our thinking the government is spending $35,000,000 on reserve supplies from Chile, but already Professor Bucher, of Brown University, and the chemists of the General Chemical Company each along separate lines has developed successful processes for the manufacture of ammonia, the present most effective starting point for the manufacture of nitrates and nitric acid, so that already work has begun on the establishment of a plant at Sheffield, Alabama, capable of producing 60,000 pounds of ammonia per day. Germany, of course, has been doing her own developing, for it is assumed that she did not have a stored-up supply of Chile saltpeter sufficient for more than about a year, but it is now evident that we will out-nature nature and incidentally out-Germany Germany since we have in sight for the coming year the certainty of meeting all of our needs in this line.

But almost everything chemical requires sulfuric acid. Indeed this acid is said to be the index finger which points out the chemical activity of a country. The finger for 1917 indicated that the manufacture of sulfuric acid of all strengths for 1917 amounted to five and one half million tons, an increase over 1916 of over 600,000 tons. Now recall that all of the nitration processes above referred to in the methods of manufacture of explosives employ nitric acid primarily and also sulfuric acid as an accessory to the deed, as the lawyers might say, and the further fact that a total of over two billion pounds are made per year at the present time. This is nearly 300 times the output in 1913 and over half of it is exported. Now the question is, "What sort of apparatus can stand up in use under the action of these acids, especially in the manufacture of these enormous quantities of explosives?" The answer has been worked out and can be fairly well read in the advertisements in the chemical journals of "Duriron," "Tantiron," "Buflocast" and so forth. Five years ago we were familiar with what by comparison might be termed toy samples of apparatus made from this material. To-day the magnitude of the apparatus made takes on really huge proportions. One might almost say that some of them would house a coach and four. We can now understand, I think, a remark made at the second Exhibition of the Chemical Industries held in New York in 1916. A professor in one of our oldest universities in passing by the various exhibits, stopped in front of the display showing the various forms of Duriron. After a moment's pause he remarked impressively, "Ah! it is this which has saved England."

And so we might go on almost ad infinitum. But the time would fail me to tell of magnesite, an essential for high temperature furnace linings, formerly all imported from Austria and Hungary, now produced in California and Washington more than enough for our own needs. Of rare and unusual chemicals such as dimethylglyoxene, heretofore only "made in Germany," an indispensable reagent for analytical work with nickel steels, of photographic materials, of remedial agents and synthetic drugs such as novocaine, a local anesthetic of great value: of thermometers and graduated ware, of glassware and porcelain equal to the best of former importations. The chemists of the country seem to have been awake at the switch and I think we must agree that they have been singularly effective in their work.

I would like to discuss for a moment some of the underlying causes which I believe have been of fundamental importance and largely responsible for this effectiveness. The mere enumeration of the above items is informational and may even be interesting, at least to the chemists, but to my mind it should serve an additional purpose of even greater importance. It seems to me therefore that we may well devote the few minutes remaining to pointing a moral and making the attempt at least of furnishing a little adornment to the tale.

The great underlying fact which must be evident to any one who digs but a little way below the surface in seeking an explanation for the success of the chemists is this: The most pronounced advancements of the art, the real achievements, that have, with such seeming readiness and almost as if by calculation promoted these strikingly successful results have been brought about by men of thorough training in the purely scientific principles of their art. Here in the universities of the country has been going on in a quiet way for fifteen or twenty years past a type of preparedness which I believe may be worth our while to study.

The method of training the chemist is almost uniformly on the principle that if you are going to make a scientist in the field of chemistry, then surely he must know the science of chemistry and if you are going to make an applied scientist in the same field, he must still know the science before he can have anything to apply. It is not possible, at least it is not possible any more, to make a rule-of-thumb chemist and turn him out to practise what in his case could only be a black art.

You say that chemistry lends itself especially to this method of procedure, but it is not different in this respect from the other sciences. There is no greater truth in evidence in all of the sciences than this, that the men who are accomplishing things are the men who have had the training in the theoretical as their real preparation for the practical ends which they are to accomplish. The state universities were founded immediately at the close of the Civil War almost before the noise of battle had died away. It is not strange that the provision was made that attention should be given to military instruction and so that sort of preparedness has been going on through all the years since. Nor am I belittling its value, for I believe in it thoroughly, but in its relation to the real preparedness of the country the value of that work shrinks almost to the zero point in comparison with the quiet, undemonstrative but effective training in the sciences that has been going on in these same universities. We have heard not infrequently and indeed seen it demonstrated that you can make a soldier and an army if you have to in two years, but it takes twenty years to make a scientist and there is no fact that stands more clearly demonstrated to-day than that for great emergencies you must have a vast number of scientifically trained men and there is not a little satisfaction in the further fact that they are equally good material to have around either in peace or in war.

If our own system of education in the sciences and their close linking with the industries is not sufficiently convincing, turn for a moment to Great Britain. At the opening of the war their eyes were suddenly and most distressingly opened to the opposite aspect of the picture. They had been sailing the seas and trading in goods and had left the bulwark of their technical industries, their men trained in the sciences, altogether too largely to wear also the label, "made in Germany." This is not my criticism. To the credit of the Britisher be it said that when he sees the truth he is not afraid to speak it. In this matter he has been his own relentless critic. Read some of his conclusions: H. E. Armstrong in an address before the British Association, August 1914 (*Nature,* 94, p. 213) refers to Huxley, who in 1861 pronounced these prophetic words:

> Physical science, its methods, its problems and its difficulties will meet the poorest boy at every turn and yet we educate him in such a manner that he shall enter the world as ignorant of the existence of the methods and facts of science as the day he was born. The modern world is full of artillery, and we turn our children out to do battle in it, equipped with the sword of an ancient gladiator. Posterity will cry shame on us if we do not remedy this deplorable state of things. Nay, if we live twenty years longer, our own consciences will cry shame on us.

Professor Armstrong proceeds,

> Now after more than fifty years, not twenty merely, we still go naked and unashamed of our ignorances; seemingly there is no conscience within us to cry shame on us. I have no hesitation in saying that we have done but little through education to remedy the conditions of public ignorance which Huxley deplored. In point of fact he altogether underrated the power of the forces of ignorance and indifference; he failed to foresee that these were likely to grow rather than fall into abeyance.

Sir Ronald Ross, in *Nature* for 1914, p. 366, says this:

> The war now raging will at least demonstrate one thing to humanity—that in wars at least the scientific attitude, the careful investigation of details, the preliminary preparation, and the well

thought-out procedure bring success, where the absence of these lead only to disaster.

You will remember that an attempt to remedy this situation resulted in the organization of an advisory board composed mainly of eminent scientific Englishmen to cooperate with a committee of the Privy Council. An editorial in *Nature* for 1915 says of this scheme:

By its inception and publication the government acknowledges and proclaims its appreciation of the work of science, and by this acknowledgment alone gives scientific workers that encouragement and prestige in the eyes of the country which has too long been withheld.

May we not venture to note that in our own land this propaganda on behalf of science has been active and indeed effective through the work of our universities for so many years that we have almost forgotten the early struggles of the advocates of this type of educational work.

I have said that it takes twenty years to make a scientist. We often hear it said that graduation, after four years of study, is only the commencement of things. This is nowhere more true than in the case of the sciences. Real effective training in these lines does not come and can not come except as a result of application and toil and devotion and the intensive training which accompanies research work. See how wise the great industries are in this respect. How their research departments have grown in number and what a corps of thoroughly trained and theoretically trained men they have put in charge. And not the pity of it but the danger of it is that they are drawing upon our universities for their best and strongest men to direct and develop their work. How long and to what extent will it be wise to allow these inroads to be made is a serious question, which perhaps can wait awhile for settlement. The immediate and pressing obligation now is to continue without let or hindrance in the task of training men even more profoundly and thoroughly in the fundamental theories of the various sciences. To the universities, to the Sigma Xi and to scientists everywhere this situation ought to come as a call to the colors. Yours is not the glamor or the pomp and circumstance of war but you have the goods, and your quiet and steadfast continuance in the work of scientific development has in it the very essence of patriotism. Your satisfaction and compensation must come from the witnessing on every hand and from every line of scientific endeavor to the inestimable value and far-reaching influence that flows from your work.

The industrial world to-day not only welcomes but demands this type of trained men. Their reception to-day as they leave the universities is in marked contrast to what it was twenty-five years ago. I recall an editorial in one of our metropolitan newspapers, written just at the time of year, a long time ago it seems now, when the universities were sending forth their quota of graduates. Their inexperience and unadaptableness to this worldly world was expanded and more or less flippantly dwelt upon under the caption, "What can they do?" In any review of what this type of the genus homo is doing to-day in medicine, in surgery, in sanitation, in food products and food production, as seers, as prophets, as wizards, if you please in unraveling and setting in order and at our disposal the material things of the universe, granted as I have already said that they be given the necessary opportunity for aftergrowth in lines of study and research—there seems to come an echo from that old-time newspaper dissertation which calls for another article in quite a different vein and indeed whose purpose would be to set out in their proper perspective the work of these same university products. The proper and fitting caption of such a dissertation, it seems to me, would be "What can they not do?"

Fellow workers, companions in research, I profoundly believe that research must mean a different thing after we are through with these passing days of frightfulness. It was counted upon by Germany as her greatest asset. It must prove to be America's bulwark of defense. It has been sufficient in the past that your impulse has been the search for truth for truth's sake. It is inevitable that that impulse must now be raised to an inspiration with a very passion for truth for humanity's sake. As you have worked unwittingly, but none the less effectively for preparedness, so may it be your part to work unremittingly and with equal effectiveness towards the building again of the temples of peace, to turning the dark clouds inside out and contributing to the greater successes of a better day.

S. W. Parr
University of Illinois

THE NEW HOPKINS MARINE STATION OF STANFORD UNIVERSITY

The project of the development of a marine biological laboratory in connection with Leland Stanford Junior University owes to its origin to Professor Charles Henry Gilbert and Professor Oliver Peebles Jenkins. Recognizing the value and importance of such a foundation, they set actively to work during the first year (1891) of the University to secure its realization. After a careful examination of various sites along the coast, Pacific Grove, upon the southern side of Monterey Bay, was selected as combining the most desirable features. Through the generous cooperation of the Pacific Improvement Company a suitable site and a sum of money sufficient to erect the first building was donated. A plain two-story frame structure, twenty-five by sixty feet in ground dimensions was erected on Point Aulon, a low rocky headland, and the first session of the new laboratory was held during the summer of 1892. In recognition of the active interest and liberality of Mr. Timothy Hopkins the station was named the Hopkins Seaside Laboratory. Funds for the purchase of books and equipment were provided by him from time to time, and in the following year he erected a second building. The two buildings contained four general laboratories, a lecture room, seventeen private rooms, and a large concrete basement for special physiological work. The salt-water piping for the aquaria in the second building was constructed of pure block tin throughout, with hard-rubber stopcocks.

During the first twenty-five years of its existence the laboratory while nominally a part of the university and freely using its library and apparatus, was dependent for its upkeep and extension chiefly upon student fees and private gifts, the latter mainly through the constant sympathetic interest of Mr. Hopkins. Despite these limitations it offered its facilities to many investigators and students during that period, and contributed materially to the solution of biological problems on the Pacific coast.

With the passing years it became increasingly evident that the site upon Point Aulon was inadequate to the needs of the laboratory. In 1916, through the efforts of President Wilbur and the Board of Trustees, a new location was secured nearly five acres in extent and comprising the main portion of Almeja or Mussel Point, situated a half mile eastward of the old site. This point will be recalled by former visitors to the Seaside Laboratory as that upon which the fishermen of the picturesque "Chinatown" used to dry their large catch of squids. Chinatown disappeared in a blaze about fourteen years ago, and was never rebuilt. The new situation insures complete control of the coast line of the point, including an excellent sheltered landing place and harbor for boats of considerable size (used in the old days by Chinese fishermen).

Close to this cove the first building of the new station was erected during 1917. It is of reinforced concrete construction approxi-