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The Problems and Trends of the Chemical Industry

by

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Members of the Class -

I am always a little diffident about appearing before any group of students, and more particularly such a mature group as I find here. I always think of an argument in our family when my oldest daughter, a girl in the grades, in order to close it, said: "Well, Daddy, I ought to know better than you do - I am going to school and you are not." Perhaps what I shall say here in some respects comes under the same heading.

In discussing the chemical industry, I think we might begin by trying to define it. There are many definitions of it. Perhaps you gentlemen who study statistics know that the census gives us one classification of the chemical industry.

We like to think of the chemical industry as one in which a real change in composition takes place during the process of manufacture, in contrast to mechanical industries such as machine tools, for example, where the real changes are physical in form and not changes in composition. Some would go even further and say that any industry in which a process is being utilized, where a change in chemical composition takes place, should at least be called a chemical process industry if not indeed a chemical industry. Perhaps a correct definition would

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be ~~just to say~~ that ~~the~~ a chemical industry is either one which is engaged in the manufacture of ~~the~~ such heavy chemicals as acids, alkalies, ~~or~~ and things of that sort; or ~~perhaps the~~ fine chemicals ~~(those which go into research)~~ of one type or another, those of extreme purity manufactured in lesser quantity and very much higher quality than the average heavy chemicals, though even there we find some things of extraordinarily high purity; and then perhaps the pharmaceutical industry which is a highly developed branch of the chemical industry. In the latter industry some of the most worthwhile work is now being done, particularly in those border ~~lines~~ ando between ~~chemical~~ stry and other sciences, ~~some of the best research and development work is now under way~~ particularly biology.

When it comes to a question of the products of the chemical industry, I think ~~perhaps~~ you realize that in some respects this industry ~~suffers more~~ is less appreciated than others in that the ultimate consumer in most instances does not ~~receive~~ recognize its products ~~of the chemical industry~~; to a considerable extent they are the raw materials of the next industry in the ~~whole process~~ line of manufacture. You very seldom, for example, go out and buy sulphuric acid. You are not likely to ~~go out and~~ buy many of the other acids ~~and other~~ or chemicals produced in large quantities. You do not ~~go out and~~ buy dyestuffs as such. Therefore, you are probably not conscious of the extent to which the industry serves. There is an inscription on the laboratory at Cornell University which among other things says this as to chemistry: "A Science Ministrant to Sciences". I think the same may be asid about the chemical industry. To a very large extent it is an industry which serves other industries. That is

a disadvantage in this respect: The difference between the cost of a dyestuff which is quite unsatisfactory to you in your suit of clothes, one that is not fast to light or washing, does not clean well in dry cleaning, etc., and a similar amount of the dyestuff that will withstand those things is, on the average, about 30¢ or 35¢ in a suit of clothes. But the man who manufactures the textile, the man who manufactures the clothing, when he multiplies the units he expects to sell throughout the year by this 30¢ or 35¢ is concerned with a sum which leads him too often to choose the less satisfactory dyestuff and then blame our industry for not being able to produce in America the good old dyestuffs they used to get on the other side of the water. Curious to say, this suit of clothes I have on this morning resulted from a question raised with a manufacturer as to why he continued to use German dyestuffs instead of American dyestuffs. Instead of answering my question he sent me this length of cloth with his compliments. I liked the cloth, returned a check at once for it, repeating my query; and we are still arguing over the merits of imported and American-made dyestuffs. That, of course, is a long story in which you have undoubtedly gone in your study of textiles.

Another unique thing about the chemical industry is that it is its own best customer in that some of the largest tonnage of things produced by the industry are used by that same industry. For example, the Dow Chemical Company manufactures a large amount of synthetic phenol and they use that phenol in the production of other products. That example may be multiplied a good many times.

The chemical industry, how ever you regard it from the standpoint of definition, extends very far in its ramifications and you find chemical products turning up in all sorts of places. Perhaps that is one reason why the industry as a whole survives the ordinary depression very much better than any other industry. I have not brought along a lot of curves this morning but I think if you will take ~~even~~ the present recession ~~and go back~~ and examine the stock market prices say in July and what has happened since you will find that the stocks of the chemical companies have held up better than most of the others. If I were an artist or a cartoonist I would like to draw you a sketch this morning showing a number of fairies or gnomes or magicians or something of that sort, which I should label "Research", "Production", "Management", and "Distribution", pushing up that curve of chemical stocks. It does stay above those where science is not used to a similar extent.

Most people I think will agree that the chemical industry in the United States goes back ~~for its beginning~~ to about 1835 to 1840, when some very crude beginnings were made along the Atlantic seaboard, ~~of course~~ principally in New England. There were in Virginia some industries which we ~~at least~~ like to call chemical industries.

By the time of the World War the United States was pretty well leading the world in the inorganic chemical field with respect to tonnage, ~~and~~ value and ~~that sort of thing~~, but we did not have anything to speak of in the way of a synthetic organic chemical industry. I have often said that if the United States got anything out of the

World War it was a synthetic organic chemical industry. In 1917 I wrote a little piece which was published in the Journal of Industrial and Engineering Chemistry called "The German Alarm Clock" and the theme of my story was that how ever the war came out, through awakening the rest of the world to the utility of applied science in industry thereafter Germany would suffer loosing export trade. I am not a prophet but you know what has happened as a result of calling the attention of the world to the potentialities of science. In that group I suppose the ones of greatest interest to us are the synthetic medicinals and pharmaceuticals; secondly, the dyestuffs upon which we depend for so many things. For my part I think I could get along without dyestuffs but I am told by the psychologists that I would soon find myself feeling differently if all color for manufactured goods were cut off. In any event those were products upon which Germany had a monopoly at the time and they tried to use the power that gave them to force a change in the position of the United States. Cut off the dyestuffs, the pharmaceuticals, and medicinals, and the cries from labor and the pleas from the people in the hospitals would be enough to break the neutrality of this country. As you know, that did not work and it never can work because we are now not only independent but I think it could be shown that we are in a position of leadership in synthetic organic chemistry. To the two great groups of products noted above must add the synthetic perfumes, photographic chemicals, flavoring extracts, and the long list of things that come out of that rather smelly, unpromising mess that we know as coal tar.

Part of the growth of the chemical industry since the World

War is unquestionably due to the action taken by the Government in consenting to the setting up of the Chemical Foundation, Inc. You will recall that that was a device ~~set up~~ to take over the patents that were held by the Germans in this country at that time. There has been a great deal of controversy about the whole thing. As a matter of fact, it has been through three courts (finally settled by the Supreme Court of the United States), each court ruling in favor of the Chemical Foundation when the Government, during the Harding administration, brought suit to dissolve that corporation. The fundamental reason for taking over those patents was that for the most part they were product patents and no matter how clever you might be in devising other ways of reaching the objective there was a patent on that product after you made it and the control of that patent by an enemy was being used against the United States quite as much as any other resource of value in conducting a war. There seems to have been ample justification for purchasing those patents and licensing them freely to those American citizens who might care to use them. That, together with some very material help in the way of tariffs in the beginning, has built up this great industry which makes us quite independent in respect to a number of things that have strategic importance and certainly are always worthwhile from the standpoint of the general public.

The size of the industry may be of some interest to you. Going back to the census, if we take Group 6, the United States Census of Manufacturers, which is chemical and allied plants, we find them in every state of the Union, with the greatest concentration in the highly populated areas of New Jersey, New York, and of course Illinois and

some in Missouri. ~~However,~~ You will find some of these plants everywhere throughout the United States, being located for the most part with respect to raw materials since the transportation of the finished products makes it advantageous to get near raw materials and markets, though the reverse is true in some cases. ~~The~~ products in the last census were estimated to be worth $2,837,000,000.00 for the year ~~that is, of~~ Chemicals and allied ~~products~~. ~~If you come down to~~ In Group 608, which is that miscellaneous group of chemicals not elsewhere classified, we find ~~the census giving us~~ 570 establishments in the country with salaried officers and employees of 14,541; wage earners, average for the year, 65,838; salaries amounting to something over $37,000,000.00; wages $80,500,000.00; materials, including the purchase of power, containers and that sort of thing, in excess of $329,000,000.00; value added by manufacture nearly $340,000,000.00; and a total value production of $668,697,448.00 - ~~to get it down to its eyeball there. That is one measure of size.~~

Another measure of size is perhaps the total tangible assets of some of the companies, and I have put down just a few here to give you an idea. The size of duPonts, for example, exceeds $536,000,000.00; Union Carbide and Carbon $247,036,000.00; Allied Chemical and Dye Corporation nearly $191,000,000.00; Aluminum Company of America $166,901,000.00; Eastman Kodak Company $142,208,000.00. Perhaps you will not class some of these companies, as I do, in the chemical field. I will be glad to tell you why I do it if you are interested. Proctor and Gamble $115,835,000.00; National Lead Company $79,735,000.00;

Pittsburgh Plate Glass $94,701,000.00; American Cyanamid ~~over~~ $41,611,000.00; Park Davis over $36,000,000.00; Texas Gulf Sulphur ~~over~~ $57,730,000.00; Sherman Williams Company ~~over~~ $44,294,000.00; Monsanto Chemical Co 29,344,000. Dow in excess of $25,000,000.00; and from there on down. I have only taken a few of them to indicate in a general way something of the size and distribution of the industry. I think that while many of the concerns are on the Atlantic seaboard, from the standpoint of production for the country in the case of emergency, they are fairly well scattered and you will find some ~~examples~~ of nearly all of the really essential manufactured products in other parts of the country that are very well protected, as for example the Charleston, West Virginia area. That ~~mountain~~ valley in the last several years has become an extraordinarily active place chemically and Charleston has ~~been~~ become one of the most ~~perhaps~~ prosperous ~~perfect~~ towns in the whole United States ~~in the last stage~~. Western Vaco Chlorine Products Corporation have a capacity of 500,000 pounds of chlorine every 24 hours. I submit that is quite a lot of chlorine and most of it is being used locally, for example, by Carbide and Carbon Chemicals Corporation in the manufacture of various solvents. There we have industries built up on the natural resources of that location. Carbide and Carbon is built up on the products of petroleum, some of the olefines, unsaturated hydro-carbons. Operating on the salt supply of that area with the natural gas available makes it attractive for other industries. manufacture of solvents, fertilizer chemicals etc., duPont's great plant for fixation of atmospheric nitrogen is in the vicinity, the Bell Alkali Works, and the glass factory in ~~last~~. One industry begets another and we have a great area developing in that

particular location.

There is one thing peculiar about the industry often overlooked in consideration by those who are studying the labor situation and that is the very large capital investment per worker, which I think can be shown to exceed that of any other industry in the country. Some of the recent figures I have seen indicate that in at least some companies there is a capital investment approaching $10,000.00 for every man who is employed in the plant, ~~and~~ When studies are made of the share labor ~~has and their wages, etc.~~ is paid, in some of these companies you will ~~get~~ Each the wrong conclusion unless you take into consideration the very large capital expenditure necessary for this type of industry. It is also worth noting that, whereas in industry as a whole throughout the country, according to the National Industrial Conference Board, about 13% ~~(I have forgotten the fractions)~~ are of the salaried technical class, in the chemical industry this runs ~~up to~~ above 28%, so you are getting into a different sort of personnel and consequently a much lower turnover in labor than is true in many other industries. Those of you who study statistics will also find that the recovery made by the chemical industry was much more rapid from the standpoint of employment than many other of the industries, and long before most of them ~~we had exceeded in~~ the chemical industry, ~~the~~ had raised its employment above that of 1929 with satisfactory hours and a higher return per worker, ~~getting down now to the class of~~ including common laborers. I have not brought along those figures because they are easily accessible to you ~~and if they are wanted I can dig them up later for you~~. From the standpoint of employment, wages paid,

capital invested, and ~~all that sort of thing,~~ we are ~~as a matter of fact~~ rather proud of the record of the chemical industry.

In addition, ~~to these~~ we ought to consider the raw materials, which of course come from everywhere ~~not only in minerals but also in other types of raw materials~~. I thought it might interest you ~~to~~ give a few figures showing the purchase and use by one chemical company of farm products. The example I have chosen is duPonts, for they use annually 47,000 tons of wood pulp, 85,000 bales of cotton linters, 30,000 bales of cotton staple, 40,000,000 gallons of molasses, 1,300,000 bushels corn, 42,000,000 pounds of vegetable oils, and 5,000,000 pounds of turpentine. If any one has the impression that agriculture does not benefit from the utilization of its products by the chemical industry they are somewhat mistaken. I believe there are now estimated to be 26,000,000 acres of our land producing products that go into non-food uses, largely through the chemical industry.

For another way of viewing the size of these plants, I may say that 82% of all chemical wage earners are in plants that employ 1,000 or fewer employees; 56% are in plants employing 500 or less; 38% in plants employing 250 or less. Now at the other end of the scale is ~~an outfit~~ company like duPonts who currently employ between 53,000 and 55,000 employees. I sometimes think that if the people who are ~~worrying~~ critical ~~about~~ of big industry had to meet a payroll of that sort every week they might have a very different idea of the responsibilities of industry and its true relation to the general economics of the country. Some of us have to worry

about meeting the butcher or grocer each week, let alone paying 53,000 to 55,000 people. That at least is another way of looking at what the industry is like.

Another unique feature about the chemical industry is the extent to which it conducts and relies upon scientific research. Recent estimates say that 4 3/10% of the total gross sales in the organic chemical industry are devoted to research; that is, out of every $100.00 of sales they spend $4.30 on research. In the inorganic industry that ~~runs~~ is $2.25 out of each $100.00 - not because the inorganic industry is less progressive but in the nature of things there is not quite the amount of research ~~apparently available~~ to be done at present ~~that should be carried on~~ in inorganic chemistry.

It is very difficult to realize how vast is this field of organic chemistry. Dean Whitmore of Pennsylvania State College says that ~~there are at least 500,000 possible compounds of carbon.~~ We know a little something about 500,000 compounds of carbon, but the number that are possible will run into astronomical figures. The tremendous number of things that can be ~~made~~ and ~~that we know~~ are made involving the element carbon gives us some appreciation of ~~the size and therefore of course~~ the opportunity for research on a very large scale. I know of no other industry that ~~approaches that continual~~ makes so large an annual expenditure, which probably runs not less than $20,000,000.00, ~~maybe more than that, per year~~ in ~~the industrial~~ its establishments ~~of the country~~, not counting the work which ~~they show of the difficulties~~ its supports through fellowships and ~~the like~~ other grants in our educational institutions.

Another thing of interest is the obsolescence that we find in chemical plants, not merely because they are so often dealing with corrosive materials that would ~~of course~~ of themselves cause obsolescence, but ~~due to~~ because new processes and new products ~~and all that sort of thing that~~ are always ~~strived for~~ sought. At one time, for example, when ~~they were having~~ there was some difficulty with cellulose nitrate used in sheets in ~~our~~ safety glass, ~~before it was superseded by other compounds,~~ I knew of one plant where $20,000.00 were spent on one mixing apparatus, ~~when~~ The stainless steel used was quite new, ~~in the hope~~ and it was hoped that by using ~~stainless steel~~ it higher purity and consequently better quality of material could be produced. There was no way of ~~finding it out~~ definitely knowing except by spending $20,000.00 on one mixer. There are numerous examples of that sort of thing where ~~a~~ new ~~process comes along~~ equipment is devised that is so much better than the one that has been used that ~~they have to~~ scrap ~~whatever is being worked with and go to the new equipment and a new plant~~ the old is ed in favor of.

The cooperative effort among industry is also, ~~I think,~~ notable. The Manufacturing Chemists' Association is one of the oldest associations in the country. It runs back more than seventy-five years, I believe. ~~In~~ Through that association (it is by no means or in any sense a price-fixing organization) ~~these people have~~ the industry has accomplished many things in safety, in developing better types of containers, ~~working on~~ in improving the transportation of hazardous materials, and all that general type of work. Then there is the Synthetic Organic Chemical Manufacturers' Association of the United States. That is the kind of name evolved, I think, by a committee after an all night's session. ~~That is what they call~~

~~themselves, and they tie in together this very important group of synthetic organic chemical manufacturers.~~ As you know, there are pharmaceutical groups and the like in addition to these trade organizations and they do cooperate very closely with the scientific societies, such as the American Chemical Society, which owns the journal for which I am responsible, The American Institute of Chemical Engineers, etc. There is more change of opinion among the scientific men in the industry in these meetings than one would ordinarily suppose. I think it is quite generally recognized that it is worthwhile to tell something of what you know in order to gain from the other fellow. Some years ago there was a meeting of petroleum technologists, I understand, where there was a great air of secrecy and the men were asked, without signing their names or giving any pertinent information, to indicate on a slip of paper the one thing that they valued highest as a trade secret of their organization. These were put in a hat and afterward sorted out and it was found that 57% of the men present ~~there~~ treasured the same secret ~~as the most valuable secret in their industry~~. That is very likely often to be the case.

In order to give you some idea of the problems ~~(the time gets away here I find as it does elsewhere)~~ and trends in the industry, I want to mention some of the things that have been undertaken and carried through to success. For example, breaking a monopoly in materials ~~particularly if it is a~~ nationally controlled ~~monopoly~~ elsewhere is, because it enables us to avoid any pressure that might be attempted, I think, always a worthwhile proposition in the United States. I need only mention the fixation of atmospheric nitrogen which ~~came out of~~ resulted from Haber's work in Germany and the ~~arcatic~~ improved American processes,

to ~~remind you of~~ illustrate ~~the~~ point ~~ideas that~~ I have in mind. Some said we could not fix nitrogen, but that has been done. Then they said: "You will never be able to make sodium nitrate in competition with Chile." That has been done and is being done ~~in Hopewell,~~ at Hopewell, Va. by bringing the sodium carbonate made from salt in N.Y., Syracuse, and combining it with the fixed nitrogen ~~there~~, on such an economical basis that we have actually exported considerable tonnages ~~of that~~ in competition with Chile. A recent ~~work~~ development in California has broken the Chilean monopoly of iodine. You are probably familiar with the story of the superb physical chemistry research carried ~~on~~ out on Searles Lake salts by the American Potash and Chemical Corporation which resulted in helping to provide potash and a ~~considerable~~ number of other ~~materials~~ chemical during the World War. with notable expansion since.

There is also the story of bromine, which is another example of applied research in the chemical industry to break a monopoly. In the old days Germany had a world monopoly of bromine and when the Dow Chemical Company, under the late H. H. Dow, began to separate bromine from ~~there~~ brines in Northern Michigan, Germany tried her ~~stunt~~ policy of dumping bromine here at a low price and raising the price at home in the hope of driving Dow out of the business. Mr. Dow ~~told me the story. However,~~ I never ~~learned~~ knew the intimate details of how ~~he got the method of~~ learned a way to send bromine to Germany, as he did, and selling it at a high price ~~in Germany~~ while the Germans sold theirs at a low price here. That continued for a time and the ~~One man could not be handled that way — so Dow continued to produce.~~ Germans decided here was a man they would have to allow to remain in business.

~~Concerning~~ High compression motors require anti-knock motor fuel, ~~you have to have~~ and bromine is essential in the use of ~~that~~ fluid. There was not tetra ethyl lead

enough bromine in the wells in Michigan, and the fellows there, in working out ~~the very last~~ the utmost of ways of getting it, even from the most dilute ~~washing of their~~ brines, developed a process which, with the cooperation of the Ethyl Gasoline Corporation, led to the Ethyl-Dow plant at Kure Beach ~~down here~~ about twenty miles from Wilmington, North Carolina. Bringing the sea water in contact with the chemicals for less than a minute, they separate 60 of the 65 parts of bromine per million parts of water, at a rate that runs into hundreds of thousands of pounds of bromine every month. They are now pumping, or are equipped to pump, a hundred thousand gallons of sea water per minute ~~down there in North Carolina~~ and we are independent ~~safe~~ so far as bromine is concerned.

We have many examples of things that are produced to meet special needs. Let us take the most recent of our big industries - air conditioning. There was a great need there for a non-toxic, non flamable ~~infallible~~ refrigerant that could be used in large ~~those~~ systems for apartment houses and other buildings. ~~and immediately there came to the front~~ was developed and fully met the requirements. Dichlorodifluoromethane. There is something in that meter that certainly should inspire some poet to write about it - dichlorodifluoro methane. ~~Some one really should write about it~~. There was a case almost of an invention to order - just as with tetraethyl lead. You have heard Kettering talk and know the story of the development of tetraethyl lead. They had to know something about what took place in the cylinder before they found out what made the knock and the result was a search to control the flame propagation.

The development of new products is the one thing, I suppose,

in which the industry is most outstanding. It is in a state of constant change. Some of the fellows begin to worry if ~~nothing~~ no change is made in a process in five years. They think something must be wrong if ~~there has not been something~~ nothing has been done to improve the process in that length of time.

The synthetic resin story is one of the best examples of the rapid growth of new products that have been synthesized. An experiment in organic chemistry ~~It~~ did not yield ~~result~~ in the ~~white~~ crystals expected. ~~they wanted~~ and ~~they threw~~ so the mess was thrown into the slop jar ~~and wrote it up~~ but the research was reported in the journals. That was Dr. Baekeland's ~~Baker's~~ opportunity. He is frequently jokingly introduced as "the anonymous discoverer of bakelite". ~~That~~ His was the first pioneering ~~of~~ in synthetic resins that now run into hundreds in their trade names and special characteristics.

Rayon is another one of those good examples, ~~begun~~ It originated with Count de Chardonnet in the gay nineties when he thought he could do as well as the silkworm and began his work on the mulberry leaves. Now we ~~mill miles of it — nitrocellulose.~~ know how to make it from any good alpha cellulose.

Photochromy ~~is~~ Kodachrome is another one of those simply impossible things. Perhaps I should tell you the story of the two musicians who conceived this idea of ~~photochromy~~ Kodachrome. They knew they could not develop it without ~~the~~ facilities such as ~~that~~ might be had in the Eastman Kodak Company. That company became interested, contracts were made, and Dr. Mees told me ~~(after the 16 mm had made such a success)~~ that in 1933, when times were bad and the directors said they would have to spend less on development, he would have dropped ~~the photochrome~~ this research and development because at that time it looked ~~was~~ so unpromising but ~~they had~~ for those contracts which ~~and~~ had to be fulfilled ~~them so they continued.~~

~~their work~~. The thing broke in March 1935 and 16 mm ~~photo~~chrome came on the market. By the middle of October they had sold $1,000,000.00 worth. Last year the 8 mm came on the market - and so we go - impossible things! If any of you fellows ~~here~~ are movie fans and ~~feed~~ the ~~cheaper~~ camera, as I do, you know how an 8 mm film ~~enlarges~~ the details of a great landscape. I would ask you then to remember that here we have a ~~film and~~ film base with five different ~~dimensions~~ on it, three of them sensitive to ~~these various~~ colors, with a neutral film between the three. In the development all the silver is taken out and what we have as a result of the 28 processes involved ~~in development~~ are three superimposed dyed images that give a beautiful effect on the screen. I say it is just as impossible as the farmer's giraffe or kangaroo, yet it is a modern development from the application of fundamental research to industry. My friends in the photographic industry tell me that within a decade we will all forget about black and white entirely; that we will be making color prints and everything will be in color. ~~That will suit me down to the ground.~~

The manufacture of starch from sweet potatoes now going on in Laurel, Mississippi is another indication of the development of a new product. Here is a starch being made from sweet potatoes that ~~really~~ competes with other starches, and ~~it~~ cuts down imports.

There is a long story in safety glass. Here again ~~there~~ is a case of obsolescence. We started out with cellulose nitrate, went to cellulose acetate, and now we are ~~trying~~ ~~phenol~~ acetate and acrylic resins All are successive improvements, each one ~~making~~ obsolete what has been

done ~~up to that time~~ before; obsolete because these newer things do not become brittle at low temperatures as does cellulose nitrate, they have better visibility, can be made in continuous sheets, and are better for the pressing of the glass on either side of it, ~~and all that sort of thing.~~

While on Cape Cod for the summer with my work, ~~being interested in what~~ and hearing much about boats, I was very much interested in that quadrilateral jib of the Ranger - a four thousand square foot sail made out of "cordura" rayon, the first time rayon has been used for such a sail. The British expert, who was on the ~~British~~ committee boat when that quadrilateral jib was broken out, commented on the radio: "The Ranger is going away equipped with a set of sails that we do not have — some sort of a patent sail we do not know about." This patent sail which had been developed with duPont "cordura" rayon, woven in the Wamsutta mills in New Bedford and cut, as they say, by an expert sail maker, was the first of that type of sail - lighter and stronger than canvas, woven so the air could not get through it. To decrease its skin friction, and thus increase the driving force of the wind it had been given a coat of lacquer, and after a puff of wind had done its work it could slip by and get out of the way for the next puff. That was one of the major contributing factors to the impressive victory of the Ranger. That same "cordura" rayon is being tried out extensively in place of cotton in truck tires and has given tires a very much greater mileage than those employing cords made of the cotton staple. So poor old cotton has another field in which we find a synthetic material giving it some real competition.

Dehydrated turpentine is just coming out now as a result of work down in the Department of Agriculture. Most turpentine contains some moisture, which ~~leads to the rustic~~ causes corrosion of metal containers and of course a loss of grade of the turpentine. So the simple thing has been to take out the water and make a dehydrated turpentine that does not corrode. This has resulted in increased production and is better, for example, than using the cracking process in it, for the use of cracking in any year means that we use about half the amount of crude oil to produce necessary gasoline that would be necessary without the cracking process, and that runs into something like over a billion barrels a year.

Synthetic dyes I have mentioned.

I dare say that synthetic rubber is something that has been of interest to you ~~here~~. It is one of the most interesting things in the world today, ~~from my point of view,~~ because we have Germany with her Buna rubber, starting with acetylene, and promising to make by another year one third of her requirements of rubber. We have Russia making a butadiene rubber from alcohol derived from potatoes and using potatoes from at least 750,000 acres of land, with the intent of becoming independent in that respect if they live up to their quota and plan for manufacture of rubber. We in this country are making the new ~~del~~neoprene from chlorine and acetylene, and thiakol from chlorine, natural gas, and sulphur. ~~In this country~~ Here, I am happy to say, our synthetic -like material rubber has been made because it is better for many purposes than the natural rubber and sells for a higher price, whereas on the other side it has been a question of the four year plan in Germany, the effort to

become self contained; and it is a strategic material in Russia.

Camphor is another case of breaking ~~the Japanese~~ a monopoly, in this case Japanese. We now make our synthetic camphor from American turpentine and ~~are~~ can produce as much as we really need in our domestic industry.

The problems involved in meeting market changes are always very interesting. For example, ~~we did make in the by~~ there was made by a chemical process an impregnated, coated cloth for the tops of automobiles. That was a very large business until somebody decided to make the metallic top and then that market disappeared over night and there was ~~we had~~ a plant without a market! A very good job has been done in making instead a very lightweight ~~silk~~ coated sheeting for hospital use, a ~~very~~ fine raincoat material, and other sorts of similar things that are now taking the place of the production formerly that went into the tops of the automobiles.

I have spoken of the way cellulose acetate has replaced cellulose nitrate and how other things are now threatening to replace the acetate in the manufacture of safety glass. There are many other examples of that sort of thing.

We have the problems of industry that have to do with what use to make of products concurrently produced with the principal product. The manufacture of chlorine by the decomposition of salt always gives one caustic soda. Sometimes we have had more caustic soda than we have wanted; sometimes and more recently we have had more chlorine than we have wanted. What should we do in a case of that sort? One of the companies, the Allied Chemical and Dye Corporation, is working on a method

whereby they do not have to make caustic at the same time they make chlorine - treating salt with nitric acid. They make nitric acid so cheaply from atmospheric nitrogen. What they have actually attempted is a much more difficult technical problem than sounds in statement. The whole balance of chlorine and caustic has been more or less upset because of new uses for chlorine - in sanitation, the production of new types of solvents that are chlorinated hydro-carbons, and similar new uses of chlorine - and has given us too much caustic for current needs.

There is a lot more that might be said about these problems of the industry. ~~I presume that our real problem is to try to keep the average consumer happy.~~ Mr. Kettering perhaps told you when he was here that one conception of a research man's job is to keep you reasonably dissatisfied with what you have so you will want the better things that come as a result of scientific effort. Of course it is that flow of new ideas that does underly all sorts of progress. That is particularly true in the chemical industry, and the men are on the lookout for ways to improve their processes, to make their products less expensive, because here again if you will examine the statician's curve you will find the chemical industry unique in that it has constantly striven for larger production at lower price. There is no price making in the chemical industry. The idea is that if you make the thing cheap enough there will be so many more uses for it that you will increase production and profit accordingly. Cellophane, I think, is an outstanding example of that. Cellophane was introduced in about 1923 and since that time there have been eighteen voluntary

price reductions. Every time they have been able to make the stuff for less they have passed on a part of that savings to the customer. That has meant a broadening market demanding a larger production with still greater savings and down would go the price again. Eighteen times that has happened and it has not only created much goodwill for the industry and increased the use of ~~rayon~~ cellophane but it has been most discouraging to competition. ~~and~~ I think is a far wiser sales policy than one frequently finds where an effort is made to keep the price up for all the traffic will bear, thereby inviting everybody to come and get in the business and when everybody is in you have so much ~~of it made~~ production that nobody can make any profit. That happens over and over again.

As long as new things are wanted, as long as there are imperfections in those things that are being made, and as long as there is just the natural curiosity concerning how things are made and why, I think you will find research being ~~followed~~ supported by the chemical industry and the industry itself along with ~~the~~ the public benefiting greatly from the results. Thank you.

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Discussion - Howe - 12/5/37

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Colonel Jordan: Gentlemen, does any one want to ask Dr. Howe any questions?

Q. I have three questions, Colonel. I would like to ask what the chemical industry is doing to overcome the difficulties imposed by tax legislation which affects the undivided surplus?

A. ~~That is a good one. I really do not know what any taxpayer could do these days but pay his taxes.~~ The chemical industry ~~I think~~ has joined with all industry in trying to make it clear that this general tax program, particularly that form of tax which makes unattractive new investment going into the industry and makes it unattractive for the industry to use its own earnings in expansion and development, is a real bar to progress. This is true particularly where so much has to go into process development, where you have to put in money in ~~a~~ large sum~~s at a continuous rate~~, sometimes over a period of years, before you get any real results. Perhaps you have seen the report of the National Resources Committee on trends, etc., where they say that on the average about thirty years elapses between the invention and its establishment commercially. I do not think that is quite the length of time in the chemical industry, but it is a long time. There have been various ways devised by other industries to ~~try to offset that so far as~~ get~~ting~~ new capital for ~~net investments is concerned~~ expansion, such as borrowing by issuance of new stock ~~and that sort of thing~~ in place of using surplus or earnings. But the tax situation is not any more satisfactory to the chemical industry than to the others.

Q. Is it tending to create mergers and form larger companies?

A. No, I do not think so. I think in our industry it is recognized that you can get too big to really move as fast as one must move. It is an industry where a man with a first rate idea can go out almost single-handed, alone, and get started. I know of a college professor ~~at Antioch College~~ who devised a new drying agent and ~~has~~ started a little business which is growing ~~as the result of something new that he has and knows about~~ rapidly his product. He can sell ~~it~~ on its merits although his is a very small unit. The only extensive mergers ~~that have been going on at all are those of~~ is the building up of the present American Cyanamid Company. There has not been such extensive ~~development~~ consolidation in any other recent case, so far as I know. The duPonts have at times bought up industries like the Grasselli and Roessler-, ~~the~~ Hasslacher, etc., but they have been in their own line of work. At the present time I do not know of any great tendency toward mergers of that sort.

Q. What benefit, if any, has accrued to the chemical industry from these recent reciprocal trade agreements?

A. For the most part, the reciprocal trade agreements have been, we think, detrimental to what we call in the chemical industry the real manufacture of chemicals, largely because of the way in which our foreign friends work and the extent to which they get into other countries. For example, the Swiss chemical industry is unquestionably dominated by German influence and on the favored nation clause whatever we do with one favored nation must be done for the others. ~~As you know, we have the favored nation clause so that it is difficult to see just where we are coming out.~~ At the present time in the negotiations with Czechoslovakia there are some items in ~~that~~ the list for which Czechoslovakia

is not noted and the products such industries problems of which have not been coming to us from Czechoslovakia, yet they are insisting on those items being in the treaty, which makes us suspicious. ~~We have our friends~~ Perhaps there are others trying to work into that door to get into our market.

Q. Does that have any effect on the production output in this country?

A. Only insofar as increased imports would show it. I do not know of any very material difference so far. I think it is a nip and tuck proposition up to the present time. (Later: For the first 10 mos. of 37 as compared with same period in 1936 the imports of chemicals and allied products increased 32% while the exports increased only 19%)

Q. What effect, if any, has Japan's expansion in the chemical field resulted in?

A. We do not know where Japan is going in the chemical field. It is perfectly obvious from the plans they have announced for the expansion of their sulphuric acid industry, the great expansion of their rayon industry, and now the synthesis of camphor and a number of other things, that they must be looking to a large export market for they simply do not have the absorption capacity at home for the volume of things they are planning to make. ~~[illegible]~~ Their extraordinarily low labor costs, the technical assistance they are known to be getting from the Germans, as well as their own ability to imitate, ~~to a certain extent~~ makes them a rather dangerous factor in this whole international trade situation so far as chemicals are concerned, as well as, of course, other products. Their limitation is one of natural resources. If they are able to buy what they need in the way of various raw materials, I think we will find them a very serious factor in world trade. It will then depend upon treaties, and the extent to which they may be observed, to what extent they embarrass

us here so far as our own industry is concerned.

Q. How does the amount of synthetic rubber produced in this country compare with the amount of buna that is produced at the present time?

A. At the present time Germany claims to be making buna at the rate of 20,000 metric tons a year, which is about one-third her requirements. In this country we are making, I think, on the order of not more than 1,500,000 pounds a year of neoprene. ~~I spoke of 20,000 metric tons, English measure. We produce probably 1,500,000 pounds of neoprene.~~ I do not know the output of thiakol but it is probably on the order of 2,000,000 pounds a year. So you have 3,500,000 pounds. Somebody divide that quickly by 2,400 pounds and you will ~~be able to get~~ have metric tons ~~against~~ to compare with metric tons. ~~It is difficult I do not mean it is difficult, but you have to remember other things.~~ Germany is producing buna rubber because she has not sufficient funds and foreign exchange to buy natural rubber. The cost of producing buna must be many times the cost of crude rubber, but how are you going to figure cost when they use their own raw materials in their own equipment built from their own resources, their own labor, paid in paper marks, and then utilize their own product? Buna is not for sale for export. ~~Then you pay your workmen with paper marks.~~ How are you going to figure cost? All we can do is to say what it would cost to produce the same compound here, because we know how it is made, and from the standpoint of economy it is entirely unattractive. We have produced synthetic rubber-like materials in this country for certain ~~things which~~ uses where they are

superior to crude rubber and our price is about three ~~or four~~ to five times the retail price of crude rubber. But the objective is entirely different.

Q. I understand that their production of buna is used by the Army at a high price. I wondered if that put them in a position to make it much more easily than this country where it has to be sold commercially?

A. Well, of course it is a very great help to have a dictator say "You must use this." That really establishes the industry, you see. But ~~consequently~~ if there were a demand in this country for 20,000 tons of neoprene of course the price of production could be very substantially lowered but our point of view, you see, is so different from theirs. We can go out and buy our crude rubber. We are not worrying about war so much as they are - I hope we are not. ~~We do think differently and for different purposes~~. While it is ~~true~~ said that last year they only made about ~~25~~ 10 tons of buna per day and put that away in their stores for military purposes, they now propose ~~on this~~ a much larger scale, and next year a still larger scale, to make enough for industry as well. In the Ai~~x~~ch ema exhibit which I visited last July in Frankfort a great effort was being made to convince every one that buna rubber for commercial uses, like insulation on electrical equipment and all down the line, ~~was~~ is actually superior to crude rubber. I do not know the actual facts but I am pretty sure that if they are told in Germany it is better, why, by George, it is better. That is all there is to it.

Q. I would like to ask if this transparent synthetic resin that is being put out by the Dow Company can be utilized to replace optical glass?

A. That resin and also all the ~~acrylic~~ acrylic resins of Rohm and Haas and the " lucite " of duPont are all sufficiently colorless and transparent to take the place of optical glass, but unfortunately we have not yet learned how to make such a resin hard enough to withstand the abrasion which glass receives. For example, there is a concern in Los Angeles now making eyeglasses and spectacles out of these resins but you can not wipe them. You have to wash them and let them dry because if you wipe them off with your handkerchief or cloth the dust on the surface might scratch the resin. Those resins are also being used in the place of glass in some airplanes, but they have to be replaced because of the abrasion of the surface. Some of these days we will learn how to make them hard enough, ~~cast~~ case harden them or put on a hard transparent lacquer or something of that sort. While they can be used, the length of life is limited because of the ease with which the surface may be abraded.

Q. Dr., can you tell us anything about the cost of the production of nitro starch and what relation it is going to bear, or you think it will bear, to nitro-toluene?

A. I can not tell you about that because I do not know.

Q. Have you any idea how expensive it is?

A. It is my understanding that it is much more expensive than nitro-toluene. However, I do not know.

Q. That is my understanding also. I wonder if you could tell why it is so expensive since it is capable of being produced from so many sources?

A. Of course, toluene can be produced from sources other than coal tar. The science in handling petroleum production has advanced to the point where the aromatic hydrocarbons can be made over into aliphatic hydrocarbons, of which toluene is a member, so that if necessary petroleum could become a source of toluene. I can not give you the exact cost figures. I can help you look them up but I can not give them to you from memory.

Q. Can you give us a division of costs as to labor, material and overhead in the industry as a whole?

A. The nearest I could come to that now would be those figures I gave you a while ago, which have to do with the salaries, wages, materials, and the final product. Shall I read those again?

Q. We have those, but we have been able to get nothing particularly in the heavy chemicals which we are studying. The direct labor, as we have it, was 20% of the total cost, and the other figures are very contradictory.

A. These figures I have here are not confined to the heavy chemical industry. I think those can be found. The nearest I could come to it this morning would be the figures I gave you, and as I say they go beyond the heavy chemical industry. That perhaps does not answer your question but I will try to find those for you if you would like them.

Q. Doctor, does the ~~Western~~ Mistvaco Chlorine Company use a patented process?

A. They use the same process that other people use, namely an electr~~o~~-lytic cell. It so happens that the Vorcecell which they use is one of the most efficient cells we know ~~about~~. Any one can buy the Vorcecell who wants ~~to buy~~ it. It is not a patented process in the usual sense of that term. There are many other plants in the country also making chlorine, if not using that cell then some other ~~cell~~. It so happens that Mistvaco has become the world's largest producer, largely because they have ~~it~~ at hand a ready market for the chlorine, being next door to the Carbide and Carbon Chemical Corporation.

Q. I was tempted to bring up a general subject by asking a specific question. What I would like to know is to what extent patented processes exist in the chemical industry. ~~especially the hydrocy process in the product.~~

A. I am trying to think of examples of processes in the heavy chemical industry that are so patented as to be unavailable to others. That is not true of the contact process for the manufacture of sulphuric acid. There are at least two different schools of thought, some like the platinum catalyst and some like the vanadium catalyst. If you want a sulphuric acid plant there are suppliers of either process and you could proceed on either of those lines by paying suitable royalties. There are patents on most of these processes but they are not held exclusively in most cases. There are some patents that are very far-reaching and do form the basis of operations. Several of the

patents of the Dow Chemical Company are very important to them. I expect that is very probably true of most of the companies. They do own a group of patents that are exclusive with them. I think they are mostly in the organic field. In the inorganic field you get into patented equipment of various sorts, such as roasting furnaces and things of that kind. There is a nice question in the industry: whether to buy a piece of equipment or make it. That would indicate that there are nevertheless ways of getting what is needed without going into patents. The patent literature is so extensive that I suppose we would have to say that the industry, very much like others, depends considerably upon patents.

Q. I would like to ask first of all the status of the development of plastics for use in heavy vehicles, for use in fuselage for airplanes - to what extent that shows promise?

A. I think that the use of plastics in structures of that kind and even heavier areas may be still considered something for the future, but I am inclined to think in the rather immediate future, probably not the plastics as such, but frequently as a binder for other light materials such as canvas, laminated bakelite, which of course you are familiar with, and the like. I do not know of any plastic which will find wide application at the present time which would have the necessary mechanical strength for really heavy duty but, as a binder with other strong fillers, such as the various fibers, I rather think the immediate future is promising.

Captain Burgess: I would like to hand you this list of the 22 materials we carry as being strategic. I have indicated four which

your discussion this morning indicates ~~there is a~~ as possibility ~~x~~ is that we may be able to produce in sufficient quantity to meet our war requirements and become self-sufficient. If you care to comment on any others than those I have indicated I would appreciate it a great deal.

A. The first we find here is aluminum. I suppose, in the words of Shakespeare, "we have the world by the tail" when it comes to aluminum - at least the manufacturing process. The only point ~~there~~ is the question of raw material. We have a great deal of bauxite in this country but we also draw ~~of course~~ heavily on other sources of bauxite for our raw material for the manufacture of aluminum ~~manufacturer~~.

Antimony - I am not so sure where we stand on antimony at the present time. Dr. Walker, do you know?

Dr. Walker: I do not think that any part of the world produces antimony to any extent except China.

Dr. Howe: That is my understanding too. Certainly the richest chromium still comes from outside the country. That is a question of minerals. So far as how to use them and all that sort of thing is concerned, we certainly have all the information we need and all the equipment to do it if we can get the raw materials.

Cocoanut shells - On account of the great density of the material, cocoanut shells are still, I think, preferred for the source of carbon which you have in mind here. So far I do not know of any really acceptable substitute although some of the most recent activated carbons do give some promise. But I would say we still have to depend ~~somewhat~~ on cocoanut to a considerable extent.

Coffee - Coffee always has been produced elsewhere.

Hides - I expect we could get into a lot of arguments about how extensive hides still are in a strategic position. We do know that some of the fabrics that are impregnated and coated with combinations of viscose, which is a solution of cellulose, and ~~with those various~~ latex~~es~~, either the natural rubber latex or some of the suspensions of the synthetic materials, do have many properties that are superior to ~~hides~~ leather. I am not ~~[illegible]~~ familiar enough with the fine points in the use of leather in military equipment to say whether ~~they~~ the synthetics would be satisfactory. I have seen much of that material that is better than leather for many, many purposes. But sometimes you get into peculiar physical qualities. Maybe it is ~~porosity~~ or elasticity or something of that sort that makes a difference.

I think we are all set on jute. I should imagine that some substitutes for of these newly developed synthetic fibers would help out in an emergency.

Manganese - I am told that the Bureau of Mines has just recently developed a brand new process which makes possible the use of the lower grade manganese ores in this country that have heretofore been ~~out~~ unavailable.

Manila fiber - There again is the question of fibers. I do not know whether some of the physical characteristics are such as to make manila very essential. So it is with mica.

Nickel - With nickel we are no better off than we ever were before. I have been told that a large deposit has been found in

Brazil but I can not be sure of that. I do not know.

Opium - I presume that is listed because of its use in medicine as a source of narcotics. I would expect that some of the newer synthetics would make opium far less strategical than when this list was made up. Is this a revised list?

Q. Yes.

A. How recently revised?

Q. September, 1937. The date is on the list.

A. I did not know if that was the date of the memorandum or the date of the revision. Evidently somebody thinks that as of September 16 this year opium is still necessary. If it is, certainly there is none of it here. I would like to know the basis of this because there has been so much done recently in various types of hypnotics and the like that I should think we would need less of it.

Optical glass - We are in a good position there.

Quicksilver - We are no better off than before. We do not know what to do about quicksilver. I believe the largest mines are in Spain. The quicksilver, copper, and iron of Spain are some of the underlying causes of this present fracas.

Quinine - Quinine still comes from outside the country.

Rubber - I think that with our synthetic rubber-like plastics, and what we know about how to use reclaimed rubber and what might be produced from the guayule plant, we could get on better than ever before in the case of an emergency. We still use a lot of rubber where we do not need to use ~~rubber~~ it. Restricting the uses to the places

where we can not get along without rubber would change that picture somewhat.

Silk - I suppose that still goes back to the use of silk in powder bags, doesn't it?

Q. Yes.

A. Whether the newer types of the chemical fibers could be used in emergency some powder expert would have to say. There have been continual improvements in these fibers, particularly in strength when wet. One thing that still appears to be lacking is sufficient elasticity in the chemical fibers. That is being considerably improved.

Sisal - Sisal goes back to the other fibers again.

Tin[redacted] - Tin[redacted] comes from the same old places, as does tungsten.

Wool - If our German friends are correct when they say their present synthetic wool will wear as long and be as good an insulator as natural, then we too could produce it from cellulose derived from cotton or wood, if we had to do that. I am not convinced that they are correct in their statement. I brought some of that wool back with me. I could not get a piece of cloth - it was not yet commercial. I could not buy it. Although I asked for it politely they would not give it to me and I was watched so closely I could not steal it. What I brought back was a sample of the fiber, that I believe you have already seen. This wool is made by a modification of the rayon process. Some of the best of it is spun or drawn as a cylinder in which the dead air space on the inside of the tube helps to provide the

insulation which we get as a result of scales on a natural wool fiber. But I have not seen any authoritative data either on the insulation or on the wearing qualities.

Q. How about camphor?

A. We do not have to have any camphor. We make our camphor now. While the camphor that has been made thus far has been largely for technical purposes, the refinement of the process is such that I am confident that much of it could be used for many of the medicinal uses to which high-grade camphor is being put. The new synthetic camphor is really a remarkable product. I am sorry I could not give more definite answers on some of ~~those things~~ items in the list.

Q. In going over your list just now you spoke of optical glass not being a strategic material at the present time. Is that a recent development?

A. That is a post-war development.

Q. Some two and a half years ago the Ordnance Department had occasion to go into the market to buy lenses, rather large lenses for camera obscure work. We let the contract to the Bausch & Lomb Company and they stated they could not get a hunk of glass in this country that was of the proper quality and we would have to wait some six or seven months until they got it from Germany. They finally did make the lens for us but they imported the glass from Germany.

A. Isn't that another one of those cases where in peace times it does not pay to make a small quantity of a special thing? We have that same situation in the dye industry. We are making about 96% of

the dyes needed in this country, and it does not pay to make the other 4% because they belong in a specialty class. You gentlemen, particularly those who are married, know that a group of people get together in Paris of some other seaport town and decide what the shade is going to be for the year and give it a fancy name. A few years ago we had one called "Elephant's Breath". Everybody who was selling fabrics worked overtime to match that shade. It may not be practical - it may not be in vogue more than six weeks. So you get dyes wherever you can to do what the stylists say. But meanwhile we plod along with about 60% of all our dyeing being blues and blacks, another 20% reds and browns, etc. That makes up the steady flow of business and those specialties do not pay. The "know how" has been developed since the war and we have the raw materials necessary to make, I think, all the optical glass we need. There is a nice controversy about why we do not have more. I can say, among us fellow Elks here, that if the Government had not felt it necessary to experiment so extensively on optical glass and supply so much of its own needs that there would have been more encouragement to the industry to develop some of these specialties to have them ready for the Government. There are some things that the Government alone takes in any quantity worthwhile and many of those have been made experimentally by the Government for its own use. I do not know from experience; I am merely repeating what I have heard some people say.

Colonel Jordan: As a Chemical Warfare Officer, would you move Edgewood Arsenal down to Charleston, West Virginia?

A. I think Charleston, West Virginia, is probably densely populated enough at the present time with worthwhile plants for war emergency. I think a part of the work of manufacture might conceivably be carried out at Charleston, but certainly not necessarily all centered there. I feel that perhaps in an emergency Edgewood would have to continue some types of work but with manufacture somewhat scattered, ~~no doubt~~ for obvious reasons.

Colonel Jordan: Can any chemical industry or any chemical firm get those patents from the Chemical Foundation?

A. Yes.

Q. There is no limit to that?

A. It is non-exclusive and most of these patents have now expired. Recently the income of the Chemical Foundation has been derived more largely from stainless steel and hydrogenation patents that were brought out by ~~Burgess, and not~~ Bergius than on dye patents ~~any longer~~.

Colonel Jordan: I want to ask one gentleman to please stand up and let the class see him and say something about this problem that we have been listening to, and that is Dr. Walker. Dr. Walker has just retired from the Bureau of Standards where he was Chief of the Chemical Division there. I would like you to stand up and let the class see you, sir, and we want to hear something from you, please.

Dr. Walker: Colonel Jordan and gentlemen - I really haven't anything to say. Dr. Howe has said so much on this subject that I do not want to get up here and make a goat of myself by saying a lot of foolishness. I have enjoyed very much hearing what he has had to say.

There is one point that I think I might add a little to in answer to one of the questions about optical glass. I believe the Navy makes all its optical glass. I do not know about the Army. I think it is made by the Bureau of Standards. You can get an immense amount of information about optical glass from Finn, who has the glass laboratory factory at the Bureau of Standards. They have made there large lenses, I think up to 24-inch casting, for telescopes. Of course they do not make many. It is a war time operation still carried on in time of peace. I can add nothing to what Dr. Howe has said, and I thank you very much for the privilege of coming here and listening to him.

Q. Concerning this particular lens that I was referring to, we went to the Bureau of Standards for it first and they told us at the Bureau of Standards that they were not in a position to make it and that the only people in the country who could grind this lens for us was Bausch & Lomb and that the Bausch & Lomb Company would have to import the glass, that the quality of this particular lens we were looking for was so finely drawn that they would have to get the glass from Germany. We went to the Bureau of Standards first and they were the people who guided us along our lines of research in order to find out where we might get it.

Colonel Jordan: I might say that from this platform Mr. Bausch said that was one of the things they were still dependent upon Germany for. We did not pursue the subject any further. He said that other than that the supply in this country was sufficient.

Q. I just wanted to bring out that there has been some question as to where the Army gets its optical glass. All of its optical glass is purchased from Bausch & Lomb. They have large supplies of glass which were made during the war but this glass is not very good quality. Practically all new instruments are made from new glass rather than from the war reserve glass. It is all purchased from Bausch & Lomb.

Colonel Jordan: If there is anything that any representative of the Chemical Warfare Service would like to say we would be delighted to hear from them.

Q. I wonder if the Doctor could tell me what the Houdry process is?

A. The Houdry process is a cracking process that is being developed, ~~I think,~~ conservatively and slowly under the auspices of the ~~Southern~~ Sun Oil Company and its subsidiary the Houdry Process Corp. While not very much has been said about it they have what I suppose they would call a semi-commercial unit operating now and they are gradually working out the details of the process. As to how it differs from other cracking processes I am not competent to say. That is what it is and where it is.

Q. Doctor, you spoke of the research done by General Motors and one or two other plants on flame propagation in gasoline engines which led to tetraethyl lead or something like that. Do you know of any firm in this country or in the world doing any work on powders along the same line, propellant powders?

A. No sir, I do not. Here was a question as to what caused the knock in the engine and they had to get that worked out before they knew where to begin. Various people had various theories as to what actually caused it. Under Dr. Kettering's direction a cylinder was made with a quartz window and motion picture cameras and other devices were used to watch the flame propagation under various conditions of knock, its mechanization, that led to a conception of what it was all about and how it might be controlled. From that point on it was largely the Edisonian method of trying different things to see what would work and following your hunches accordingly. The result was tetraethyl lead - after considerable research. I do not know about any one doing the same thing on powders.

Colonel Jordan: Dr. Howe, I want to express to you the appreciation of the College for your talk. It was a very illuminating one and right down our alley. Thank you very much.