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The place of chemistry in business

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In the mind of the average business man chemistry is something quite apart from business, an abstruse science that deals with things of evil smell and unpronounceable names, something for the laboratory or the underpaid professor, but with which the hard-headed man of affairs has little need to concern himself. Yet you business men, who deal in dollars, think it well worth your while to learn all you can about them. You want to know where they are plentiful and where they are scarce. You follow their purchasing power and the interest rate they carry. You sit up nights trying to devise new ways to putsalt on the eagle's tail. You employ bookkeepers and accountants and income tax specialists in order that you may trail these dollars through every portion of your establishment and persuade the Government that a few of them really belong to you. You study balance sheets and audits and inventories, and base your decision upon what they tell you about dollars.

But the dollar is merely a symbol, a generic symbol of the value of things. The values are in the things the dollars represent, not in the dollars themselves. The things behind the dollar are materials and labor, and labor creates values only as it works upon material. Obviously, therefore, the ways and properties of material or matter are of greater fundamental importance to you as business men than even the properties and ways of dollars.

Now chemistry is the science which deals with the properties of matter and the changes which they undergo. Whether you know it or not, chemistry is, therefore, a partner in your business in a far more real and vital sense than the Federal Trade Commission, the Interstate Commerce Commission, the Tariff Board, the labor unions, the Federal Reserve Bank, or any other of the man-made agencies with which you admittedly have to reckon. As wise business men you take carefully into, account. freight schedules, city ordinances, insurance regulations you observe the man-made laws of legislatures and of Congress. But chemistry has some laws of its own that are not man-made: laws beyond the power of any legislature or Congress to mpml. What do you know about them, or how far do you take them into account in the conduct of your business? The scimce of chemistry is simply a codification of these laws and an wderiy arrangement of the innumerable facts upon which t k y are based. The chemist is the counsellor-at-chemical-law, amd as such you need him in your business. I suggest that you make an early reservation, as there is only one chemist to each 70UD of our population. An ounce of whiskey in 55 gallons of wder is a pretty thin mixture.

Now what have these relatively few chemists with thir gradecessors and associates throughout the world been able ts aecomplish for business and the nations? What contributimn hame they made that bears upon your own affairs?

The service of chemistry in agriculture

We are still essentially an agricultural country. Our prosperity comes from the soil. Just now, in fact, it seems to be underground. Two Boston men were talking the other day when their conversation took a theological turn- Boston is the home of Unitarianism, you know. Finally one of them said: "I'm a Unitarian. I don't believe in Hell and all that nonsense." "You don't believe in Hell?" the other replied, "Where has your business gone to?" With the same friendly interest I would inquire of you, "Where would agriculture go without chemical fertilizers?" But the great potash deposits of Stassfurt were not available to the farmer until van't Hoff applied the principles of physical chemistry to the separation of the salts. Two hundred and fifty great plants in this country are engaged in converting phosphate rock to acid phosphate by chemical methods. Nitrogen is another essential plant food. The world has derived its chief supply from the Chilean nitrate beds, but the exhaustion of these deposits is perilously near. It is bad enough to be tied in this way to a single far-away deposit, but the situation became alarming to those who realized that unless a new source of supply were found the world must make up its mind to starve. Fortunately, the chemists recognized that on every acre of the earth's surface the nitrogen of the atmosphere is pressing down with a weight of 33,800 tons. They have boldly attacked the problem of rendering available such portion of this inexhaustible supply as the world may need. The methods employed have been brilliant and daring in the extreme and so successful that our supplies of nitrogen for agriculture or for war are now assured, provided only our Government stands behind the chemists.

If you were a farmer, what would you think of the business if you had to pick potato bugs by hand? Who would get the potatoes? My money is on the bugs. Meantime, what is the farmer to do with the other devouring hosts-the gypsy and brown tail moths, the inch worms, the boll weevil, the coddling moth, the cabbage worm, and all the innumerable multitude of insects, molds and fungi that would feed at his expense? Were it not for chemical sprays and insecticides, he would be as helpless before them as were the Egyptians before the plague of locusts.

Chemistry puts new values on farm products by greatly extending their range of use. Kirchhoff discovered the inversion of starch to glucose by dilute acids, and as a result of that simple observation a single corn products plant treats 50,000 bushels of corn a day. Not many years ago cottonseed was a nuisance. Laws were passed forbidding the throwing of it into streams. The chemist converted it into a perennial source of Southern wealth and the raw material on which are based such great enterprises as the Southern Cotton Oil Co., and the American and Buckeye Companies. From it he derived edible oils, soap stock, and cattle feeds. Then Sabatier supplied more chemistry, and by his process of hydrogenation converted vegetable oils to solid fats, which provide an adequate and satisfactory substitute for lard and butter. Again the price of cottonseed oil went up. A single company in England treats by this process 2000 tons of coconut oil a week, and in more than one county in the South peanuts are worth more than the cotton crop. Few discoveries have been more far-reaching in their influence than the observation by Schonbein in 1845 that cotton on exposure to nitric acid was converted into a new and highly explosive product. For seventy years research has been focused on that observation. It led von Lenk and Abel to guncotton; Viele, Nobel, Abel, and Dewar to various forms of smokeless powder. It revolutionized warfare. It led Hyatt to celluloid, Goodwin to photographic films, du Chardonnet to artificial silk, and is the underlying fact on which is based the manufacture of patent leather, artificial leather, lacquers, and a bewildering variety of other products which are everywhere in daily use. Hundreds of millions of feet of nitrocellulose film, most of which comes from Rochester, carry their message of instruction or amusement to hundreds of millions of people in the tens of thousands of moving picture theatres throughout the world each year. Before we leave the farmer you will perhaps permit me to quote from an advertisement of the laboratory with which I am associated. It is headed, "Chemistry and the Astonished Cow, "and proceeds: "The cow made the milk for use in the family, her own family. She was indignant and surprised when the farmer ran it through a separator and extracted the cream, but she was astonished when the chemist took the skimmed milk, which the farmer threw away, and converted it into billiard balls and back combs, fountain pens, and a size for coated papers. Her astonishment was shared by the farmer." Years ago a manufacturer was making a water paint from glue and gypsum. He had found a German product which was better than glue for his purpose. It made the paint insoluble when it was dry. Its analysis showed a mixture of casein and lime for which the Germans wanted 30 cents a pound. That was more than his product would stand. It was pointed out to him that casein was easily prepared from skimmed milk. His factory was in a dairy country. He was shown how to make casein. A few months later he moved to New York, organized a large corporation, pulled down a salary of $50,000 a year, and took a house on Fifth Avenue.

The work of Louis Pasteur

There are few men to whom the world stands in greater debt than the French chemist, Pasteur. There is probably not a man in this room who is not under heavy obligation to him, and except for his discoveries some of you would not be here at all. His demonstration of the germ theory of disease and the development of the serum and antitoxin treatments have saved more lives than the recent awful war has cost all the belligerents combined. Such service is beyond estimate in monetary terms, but the direct financial value of Pasteur's discoveries was years ago appraised by Huxley as sufficient to cover the whole cost of the war indemnity paid by France to Germany in 1870. In 1865 a fatal epidemic among the silk worms had ruined the silk growers of France. In June of that year Pasteur was called to the south of France to study the disease. In September he announced the method which proved successful for its control. Other studies saved the French wine industry from the destructive ravages of phyloxera, stamped out chicken cholera and anthrax, and for the first time put brewing and wine making on a scientific basis. More recently they have reverted to the status of cottage industries, and the scientific control is less in evidence. Sufferers from gastritis who consult their physician are commonly greeted with the observation, "I see you make your own."

Relation of the chemist to the transportation problem

Perhaps the greatest domestic problem before the country today is that of transportation. I still guard, not as carefully as formerly, a few shares of the New York, New Haven & Hartford Railroad which I bought at 188. It was going to 200. I doubled up at 70. It is now about 16. And yet a New York banker had the nerve to tell the AMERICAN CHEMICAL SOCIETY at a dinner at the Waldorf that what he required of chemical investments was absolute security. We have lots of things at 30 Charles River Road, Cambridge, that are lead-pipe cinches in comparison with any bank-managed railroad that slides from 188 to 16. I know of one poor little chemical company which started with $20,000 capital and in a few years wrote off $750,000 in real estate and equipment.

However deeply your sympathies may be aroused, you must not let my ownership of a hand car or a water tank on the New Haven blind you to the fact that your business cannot go on without the railroads. You will admit that without argument, but what I want you to realize is that the railroads cannot go on without chemistry. They operate on steel rails, and those rails are cheap because of the Bessemer process of making steel. Few even among railroad men realize how greatly the whole community is in the debt of Dr. Dudley, whose laboratory work went far to standardize the railroad practice of the country. His specifications covered rails, soaps, disinfectants, oils for signals and for lubricating, paints, steel in special forms for every use, car wheels, cement, signal cord, and every detail of equipment. He made the transportation of life and property cheaper, safer, and more expeditious by reason of his application of chemistry to the problems of railroad management.

I would ask you to consider what chance you would have of securing cheap transportation without the Bessemer process, or that of Thomas and Gilchrist which followed for phosphatic ores. What without them would be the value of iron ore lands in this country or that of coking coal? What inducement would Germany have had to go to war if she could not smelt the phosphatic minette ores of Lorraine? Picture, if you will, the opportunities for labor which these processes have created in the mining of coal and iron ore, in the coking of coal, in the making of rails and structural steel and plates for ships. Shopkeepers who never heard his name owe their prosperity to Bessemer, and cheap Bessemer steel is the foundation of countless industries.

But modern civilization makes demands which cannot be satisfied by Bessemer steel. So the chemist has developed nickel steel for armor and for guns, and tungsten steel for army helmets and for tools whose cutting power is four times that of ordinary good tool steel. You regard the automobile and the motor truck as among the highest expressions of mechanical engineering. They are revolutionizing transportation. Because of them the road before your door which formerly seemed to lead only to the village or the town is now the opening to the highway upon which you may travel north or south or east or west upon the continent, as you choose. But the automobile is as truly a chemical creation as it is a mechanical product. Chemistry enters into its every part. It supplies the alloy steel, the aluminium, the artificial leather, plates the nickel, vulcanizes the rubber, provides lacquers and pigments and paints. It furnishes the gasoline and promises to develop new types of motor fuel. Good roads of cement or bonded with asphaltic compounds are replacing the stretches of dust on which we used to travel.

Artificial Abrasives

A chance remark of Dr. George F. Kunz in 1880 on the industrial value of abrasives turned the thoughts of Acheson to the problem of their artificial production, and led to the discovery in 1891 of carborundum and its subsequent manufacture on a small scale at Monongahela City, Pennsylvania. In 1894 Acheson laid before his directors a scheme for moving to Niagara Falls-to quote his own words:

To build a plant for one thousand horse power, in view of the fact that we were selling only one-half of the output from a one hundred and thirty-four horse-power plant, was a trifle too much for my conservative directors, and they one and all resigned. Fortunately, I was in control of the destiny of the Carborundum Company. I organized a new board, proceeded with my plans, and in the year 1904, the thirteenth from the date of the discovery, had a plant equipped with five-thousand electrical horse power, and produced over 7,000,000 pounds of those specks I had picked off the end of the electric light carbon in the spring of 1891.

The sulfur industry

Especially notable and picturesque among the triumphs of American industrial research is that by means of which Frasch gave to this country control of the sulfur industry of the world. There is in Calcasieu Parish, Louisiana, a great deposit of sulfur 1000 feet below the surface, under a layer of quicksand 500 feet in thickness. An Austrian company, a French company, and numerous American companies had tried in many ingenious ways to work this deposit, but had invariably failed. Misfortune and disaster to all connected with it had been the record of the deposit to the time when Frasch approached its problem in 1890. He conceived the idea of melting the sulfur in place by superheated water forced down a boring, and pumping the sulfur up through an inner tube. In his first trial he made use of twenty 150 h.-p. boilers grouped around the well, and the titanic experiment was successful. The pumps are now discarded, and the sulfur brought to the surface by compressed air. A single well produces about 450 tons a day, and their combined capacity exceeds the sulfur consumption of the world.

Oil refining

An equally notable solution of a technical problem which had long baffled other investigators is the Frasch process for refining the crude, sulfur-bearing Canadian and Ohio oils. The essence of the invention consists in distilling the different products of the fractional distillation of the crude oil with metallic oxides, especially oxide of copper, by which the sulfur is completely removed, while the oils distil over as odorless and sweet as from the best Pennsylvania oil. The copper sulfide is roasted to regenerate the copper. The invention had immense pecuniary value. It sent the production of the Ohio fields to 90,000 barrels a day, and the price of crude Ohio oil from 14 cents a barrel to $1.00.

The electric dynamo

The dynamo supplies the current which lights our streets and homes and factories, drives our machinery, fires electric furnaces, creates new products in electrolytic cells, and is our ready and ever-willing servant responding in countless ways to our demands. It so serves us only because Faraday, by refined research, stimulated and directed by the scientific imagination at its best, developed the underlying principles on which its operation depends. Faraday was first of all a chemist. When he needed the science of electricity he created it as he went along.

Chemical industries at Niagara Falls

At no place in the world are the results Of industrial research more strikingly evident than at Niagara Falls. The electrical energy derived from a small fraction of that stupendous flow produces, in its passage through electric furnaces and decomposing cells, aluminium, metallic sodium, carborundum, artificial graphite, chlorine and caustic soda, peroxides, carbide, cyanamide, chlorates, and alundum. The story of the electrochemical development behind these products is an epic of applied science. It starts with the wonderful story of aluminium. Discovered in Germany in 1828 by Wohler, it cost in 1855, $90 a pound. In 1886 it had fallen to $12. The American Castner process brought the price in 1889 to $4. Even at this figure, it was obviously still a metal of luxury with few industrial applications. Simultaneously Hall in America and Heroult in Europe discovered that cryolite, a double fluoride of sodium and aluminium, fused readily at a moderate temperature, and, when so fused, dissolved alumina as boiling water dissolves sugar or salt, and to the extent of more than 25 per cent. By electrolyzing the fused solution, aluminium is obtained.

On August 26, 1895, the Niagara works of the Pittsburgh Reduction Company started at Niagara Falls the manufacture of aluminium under the Hall patents. In 1911 the market price of the metal was 22 cents, and the total annual production 40,000,000 pounds.

Extraction of gold from ores

As business men you are directly interested in gold as the standard of values. It is not a fixed standard, and any increase in the available supply reacts at once upon other values. Two chemical processes, cyanide and chlorination, have had a profound effect upon the volume of the world's supply of gold, and so influence the price of everything you buy and sell. They permit the profitable extraction of gold from low-grade ores like those so abundant in the gold fields of South Africa.

Explosives

Mining, the building of railroads, the great construction projects for which America is famous, like the Panama Canal and the vast works of the Reclamation Service, are possible only through the agency of explosives which make instantly and locally available enormous stores of chemical energy. To supply this energy chemistry has developed various types of black powder, nitroglycerin, dynamite, guncotton, and other compounds and mixtures so numerous as to require a "Dictionary of Explosives." Nowhere has their manufacture been so highly developed or conducted upon so vast a scale as in this country. The war, from which we are now slowly recovering, was in a very real sense a chemists' war, and if we have another, which God forbid, chemistry will make it inconceivably more terrible than the last. Fortunately for our country, the Chemical Warfare Service, which functioned with such magnificent resource, energy, and effect throughout the war, has had its continued existence assured as an independent though skeletonized branch of the military service.

The place of chemistry in reconstruction

The war, which has changed everything, has given a new aspect to chemistry and a fresh impetus to research. Hereafter the nation which would live must know. Through the wreck and peril of other peoples, Americans have learned with them that research has something more to offer than intellectual satisfactions or material prosperity. It has become a destructive, as well as a creative agency, and in its sinister phase the only weapon with which it may be fought is more research. The organization and intensive prosecution of research has thus become a fundamental and patriotic duty which can neither be ignored nor set aside without imperiling our national existence. Now we are carrying as cheerfully and hopefully as we may the stupendous burden of the war. Chemistry, with the sympathetic and understanding cooperation of business and financial men like yourselves, can do more to lighten that burden by the creation of new wealth in vast amounts than all the law makers in Congress and state legislatures. And the first step is to stop the stupid, wicked, childish waste of our basic natural resources. The time has passed for quoting figures. They are of astronomical proportions anyhow and make no more impression on the mind than the distances of the fixed stars in light years. The time has come to demand action, to the end that we may pay our bills with what we waste. Let us develop our estate. It has potentialities vastly beyond anything we have accomplished. A very large proportion of industrial problems are problems in applied chemistry. Many of these so-called problems have already been solved somewhere. The present need of industry is not so urgent for new research and for new facts as for the immediate and proper utilization of facts already known and demonstrated.

A few of you may remember that in pre-prohibition days beer commonly became cloudy when placed on the ice. It was an objectionable tendency which the best skill of the brewers was unable to overcome. A little research by a clever chemist proved that the cloudiness resulted from the deposition of albuminoids previously in solution. He remembered that pepsin digested albumin, added a trace of pepsin to the beer, and the thing was done. The beer remained bright at any temperature.

Not long ago a Jewish manufacturer was using a leather stain for which he was paying eighty-five cents a gallon. It proved to be water containing a little gum tragacanth and still less aniline dye. He was shown how to make it at a cost of less than ten cents a gallon. He said he began to realize where the Gentiles get the money the Jews get from the Gentiles.

In a plant near Boston using two tons a week of special steel, rolled very thin, their chemist was able in about two years to reduce the cost of this material from eighty to forty cents a pound, at the same time standardizing and greatly improving the quality of the steel. Broken rails are more expensive than analyses, and there are no dividends in broken trolley wires, defective castings, spotted or tendered piece goods, or rejections in any line of manufacture. Competition is difficult when your wastes are your competitor's profit.

Ways in which chemistry can aid the manufacturer

By way of suggestion, let me point out a few of the more obvious ways in which chemistry can serve the manufacturer. There is, first, the control of quality of raw materials, as in case of steel, alloys, bearing metals, lubricants, coal, paints, paper, cement, and practically everything else you buy. Second, perhaps, is the problem of finding suitable substitutes for such supplies as are unobtainable or unduly high in price. For example, there is the use of selenium in place of gold in the production of ruby glass, the substitution of tungsten points for platinum in spark plugs, o1 silica ware for platinum dishes for the concentration of sulfuric acid, of casein for glue, of chlorate of soda for chlorate of potash in dyeing, of zein (derived from corn) for the prohibited shellac for varnishing confectionery, of specification oils for oils whose value is largely in brand names, and of the specifically indicated chemicals in place of high-priced boiler compounds.

Of even greater importance is the scientific control of processes of production, control of formulas, temperatures, pressures, time and spacing, fineness of material, moisture content. and all the other factors which influence the quality and amount of your daily output. Correlative with such control are the studies having for their object the standardization of your product and the elimination of seconds and rejections.

Wastes can be minimized and often turned into profit by well-directed research. The waste liquor of the sulfite mills is now a source of alcohol and of adhesives. Barker waste is an excellent raw material for certain low-grade papers. The Cottrell process of electrical precipitation effects the recovery of values of smelter fumes, cement dust, and many other chimney products. In some industries, as lumbering, the potential values in the wastes are greater than the realized values in the product.

The wholly abnormal conditions under which business everywhere is now conducted lend particular interest to another function of industrial research, namely, that of finding new outlets for present products and new products for existing plants. Bankers and capitalists should realize, as they doubtless do, that the basis of credit for industrial enterprises has shifted. Past earnings have lost their significance. Audits and inventories and balance sheets tell the story of past performance. What is now required is the assurance of future earning power. That assurance can be safely based only on technical studies covering raw material supply, the adequacy of equipment, the relation of processes and methods to the best modern practice, the

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efficiency with which energy and material are utilized, and the status of the product in the market under the new industrial and economic conditions. Now is the time to put our house in order, to sweep out wastes and inefficiencies, to study and solve our problems, to make ourselves worthy of and ready for a sounder and broader prosperity than our country has yet known. Let us go to it.

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