lain crucible was found to be unaffected, the change in weight not exceeding 0.0001 to 0.0002 gram. The fact that the loss on ignition in limestone can be determined in a porcelain crucible with accuracy and without the crucible being attacked renders it possible to make an accurate technical analysis of limestone without the use of platinum, the silica recovered of

course not being corrected by volatilization with hydrofluoric acid. If, however, the analysis is made on the residue after the determination of the loss on ignition and the total silica does not exceed 6 or 8 per cent. the uncorrected silica recovered will be found to carry very little alumina or ferric oxide.

CHEMICAL LABORATORY
UNIVERSITY OF MICHIGAN

ADDRESSES

EFFICIENCY IN CHEMICAL INDUSTRIES¹

The Corn Products Industry

By T. B. WAGNER

During the Eighth International Congress of Applied Chemistry, held in New York in 1912, a number of general lectures were delivered, among them one by Dr. Carl Duisberg, of Germany, entitled "The Latest Achievements and Problems of the Chemical Industry." With others, I was profoundly impressed with this recital of achievements—a splendid record indeed, bearing testimony to the distinguished services rendered by the Chemist and the Chemical Engineer. It is but fair that we give the latter full credit, for while the "pure" chemist takes the initiative by developing ingenious theories and syntheses, it is the chemical engineer who follows up the former's work and transforms it into commercial success, by which is judged, in no small degree, the value to mankind of scientific effort and accomplishments. Dr. Duisberg's essay surely brought to many of us the thrill of romance, but below it all lay a deeper meaning, for it spelled the "Triumph of Efficiency." We heard, among other things, what has been done in the way of producing cheaper power with engines driven by blast furnace gas, or Mond, or even peat gas; we were told of refrigeration, where, through the means of liquid air machines, temperatures were obtained as low as minus 190° C.; of rare metals and new alloys; of electrolytic iron and refined steel; of new methods of detinning waste tin; of the production of nitrogen compounds from atmospheric nitrogen; of ammonia obtained direct from its constituent elements; of advancements in the manufacture of soda, chlorine and sulfuric acid; of the distillation of tar and of new coal tar products; of lake and coal tar colors; of synthetic perfumes and artificial silk; of pharmaceutical products and of chemotherapy; and lastly, of the brilliant results obtained in synthetical chemistry, especially in the syntheses of adrenalin and rubber.

Gentlemen, would not one have to be void of all sentiment not to be stirred when learning of such work, and not to take pride in being a member of so useful and illustrious a profession as that of Chemists and Chemical Engineers? We need not go abroad, however, to learn of the magnificent results accomplished by them, for we have abundant evidence in this country of the marvelous changes which their efficiency has brought about, with the result that this country occupies to-day a commanding position among nations in the field of applied chemistry.

"Efficiency in Chemical Industries," the subject I have chosen for this occasion, leads one, as you have seen, into such vast fields of accomplishment and possibilities, that I fear my fate to-night might be that of the parson who arose before his congregation and said: "My dear Brethren, I shall divide my sermon this morning into three parts—firstly, I shall announce my text; secondly, I shall depart from it; and thirdly, I shall never get back to it." To avoid such a calamity, the calamity of going astray, I shall speak to-day only on what efficiency has

done for the industry with which I am identified—that of Corn Products. I trust I have walked in the highways and byways of that particular domain long enough not to get lost. A further reason why I have elected to speak on this subject is that experience tells me that we rather welcome an account of accomplishments in industries other than our own, for the precedent of another's difficulties encountered and overcome, acts as a tonic to cheer us over the stumbling blocks in our own paths but they are only stumbling blocks after we have passed them and left them well behind; when they loom before us, they seem to have the proportions of mountains!

The manufacture of corn products in this country is not an infant industry, and much has been written about it, its history and evolution. The first product manufactured from corn was starch, and the first manufacturer was Thomas Kingsford, his plant being located at Oswego, N. Y. He commenced operations about 70 years ago, at a time when the raw material—Indian corn—was a low-priced commercial commodity, for in those years the population of this country was much smaller than to-day, home consumption was limited correspondingly, and a demand had not, as yet, been developed abroad. The raw material was cheap and the price of the finished product was high. The margin of profit, therefore, was considerable, and an attempt at efficiency did not appear imperative, particularly not since competitors were "few and far between." Thus the principal stimulus for efficiency was lacking. The almost exclusive aim—a commendable one—was to produce starch of the highest quality. The matter of yield and of cost was of secondary consideration. With good quality and rather handsome profits, why talk about economy or efficiency in the boiler house, in the engine room, in the transmission of power, or with respect to labor? Labor too was cheap in those days and labor unions were unknown. If the efficiency were to have been gauged, as it should among other things, by the recovery of products from a given unit, that is to say, by the yield, it cannot be denied that a manufacturer could have taken but little pride in revealing his degree of efficiency. This should not be taken as a reflection upon the industry at that time, for to be fair, we must not judge conditions retrospectively. It was the status of the industry in those days, but that the future had many and far-reaching changes in store soon became evident.

The price of corn gradually rose, and, due to growing competition, the price of the finished product declined, narrowing the margin of profit. The manufacturer, therefore, had to begin to pay attention to the subject of yield and to an increase of revenue possibly by recovering some of those products which were allowed to run to waste. First among these were the nitrogenous ingredients of corn, the "Gluten," but the method of recovery was very crude. It was collected while in a wet condition and its sale was in the nature of a local business, that is to say, it was sold to the farmers located in the neighborhood of the factory, and used by them in feeding cattle. It was not known as a commercial commodity, yet the proceeds from its sale added materially to the reduction in the cost of starch. With an increased output, the local markets eventually proved

¹ President's address before the American Institute of Chemical Engineers at the Boston meeting, June, 1913.

too small, and it became necessary to recover the gluten in a condition which would permit of shipping it to distant points. This led to the drying of the gluten, and while the recovery of this product in itself was a step in the direction of efficiency, the methods and appliances resorted to in drying were primitive. It did not take long, however, for efficiency to make its entrance: the apparatus first in use were capable of evaporating about 1000 pounds of water per hour; each unit of the apparatus employed to-day has an efficiency, expressed in terms of evaporation, equivalent to 9000 pounds of water per hour. The amount of dry gluten recovered in one of the larger factories is 250,000 pounds per day.

The hull of the corn, the "bran," underwent the same transformation, and was changed from a waste product, or offal, to a valuable staple product, the amount recovered per bushel being approximately the same as that of the gluten.

In the course of time, the manufacture of glucose was started, and the enterprise flourished. The introduction of this new product from corn furnished a splendid opportunity for the display of efficiency. In a measure, the industry was an imported one, for glucose had been made from potatoes in Germany many years prior to the establishment of the first factory in this country. In those early days it was necessary not only to import the machinery, but skilled labor as well. Among the most important were the men in charge of the vacuum pans. They were brought here at the expense of the manufacturer and engaged at extravagant salaries. They were quick to realize their advantage and soon became the "bosses" of the plant. They ruled absolutely. Their work was surrounded with great mystery, but it had to give way to efficiency, and to-day the position of a pan man is no more important than that of any other workman, in fact, unskilled men are often selected for this work and soon become experts at their posts. The problems which arose in the manufacture of glucose taxed the ingenuity and efficiency of the chemical engineer. To illustrate, I will cite the history of the Chicago Sugar Refining Company, which was organized by Chicago business men with a paid in capital of $1\frac{1}{4}$ million dollars—a large amount of money even in present-day enterprises, but particularly so in 1880, when this factory was constructed. Its purpose was the manufacture of anhydrous grape sugar (pure dextrose), the production of which, on a commercial scale, had been made possible by Dr. Arno Behr. His method differed from all previous ones in that alcohol was not required in the process of crystallization. The price of sugar was high in those days; I believe it sold at 8 cents a pound. Anhydrous dextrose, or grape sugar as it was called then, could be manufactured quite cheaply, as corn was still sold at a relatively low price. The scheme was to blend the soft cane sugar from Louisiana with this anhydrous dextrose, and sell the product to the confectioners, for whose purposes it was suited most admirably. The factory started off a great success. The product turned out was of the highest purity and called forth the commendation of every one who tried it. Thousands of barrels were sent out in the course of a few months, but in the course of another few months, the shipments commenced to be returned to the factory, because it was found that the anhydrous sugar had absorbed the moisture contained in the soft sugars, with the result that the contents of the barrels had solidified into a hard mass. It was impossible for the confectioner to use this product, and the company stood face to face with the failure of an enterprise in which, by this time, approximately $1\frac{1}{2}$ million dollars had been invested. There was no alternative but to shut down the factory. The question now arose what to do next.

Many suggestions were submitted, among them very worthy ones, but they were discarded until the chemical engineer stepped into the breach and suggested that this anhydrous sugar plant be converted into a glucose factory. I shall not go into

details, but simply recite the fact that after untold efforts and untold moments of anxiety, the new venture succeeded, and in the course of time it prospered. It may be properly said that it was principally responsible for the development of the American Industry of Corn Products, as we know it to-day.

Even though it prospered, there were many problems. Every step in the manufacture of glucose requires the most careful attention, and chemical control is needed incessantly. The aim is first to obtain the raw material—starch—in as nearly chemically pure a state as possible; this means the elimination of all nitrogenous and fatty matter, a task which offers the greatest difficulties, because of the enormous scale on which the business is conducted, because of the condition of the raw material—whether fully matured or not, whether entirely sound or slightly deficient, and even because of atmospheric conditions which exercise a certain influence. The ambition of the manufacturer is water white, crystal clear glucose, which will retain its color in all seasons, in all climates, and even if kept in transit or storage for a long period of time. Such quality depends upon a thousand and one factors, some of which it is very difficult to control. The refining of the glucose and the treatment of the refining agents are important problems, which, however, have been worked out most successfully, as the result of applied efficiency on the part of the chemical engineer.

The recovery of the gluten and the bran was an important step forward, but one of the most valuable parts of the corn was still allowed to go to waste, *viz.*, the germ, which yields the oil. There was no incentive to recover it, since no one seemed to want the oil. Had it been produced on a large scale, there would not have been a market for it, although it was realized, even in those early days, that a vegetable oil of the character of that obtained from corn must eventually become a valuable article of commerce; so it did, but it took many years of hard work to bring about this condition. Shortly before I entered the business, less than 15 years ago, they had just started producing corn oil on a large scale, but had no market for it—the oil went begging; that was a serious condition. The Chicago factory produced at that time about 15,000 pounds of oil per day, and selling as it did for less than 15 cents a gallon, the revenue from this production was but two hundred and fifty dollars. To-day the value of a gallon of corn oil is nearly 50 cents, and the amount of oil recovered from the same number of bushels as in the Chicago factory is worth \$2,700. This is not due altogether to the increased selling price, but also to the greater efficiency prevailing in the separation of the germ, and the extraction of the oil resulting in a yield 3 times larger than in the days of the Chicago factory. To-day the gross value of the oil recovered from one bushel of corn, together with that of the oil cake obtained as a by-product, is equivalent to 25 per cent of the purchase price of the corn.

The ingenuity of the chemical engineer did not stop there. The price of glycerine was rising steadily, hence the proposition suggested itself of separating the glycerine from the fatty acids. What this meant is evidenced when I recite that glycerine to-day sells at 18 cents per pound and corn oil at about $6\frac{1}{2}$ cents, and that 100 pounds of corn oil yield twelve pounds of glycerine; the price of crude oil and fatty acid is substantially the same.

To the list of by-products recovered, gluten, bran, oil cake, oil and derivatives such as glycerine and fatty acids, another was soon to be added. We still had a waste product, which, if recovered, seemed likely to be convertible into a revenue producer of the first magnitude. I am referring to the solids contained in the so-called "steep water," the water in which the corn is immersed and softened prior to grinding. It contains the most valuable ingredients of the grain, *viz.*, the organic phosphorus compounds, magnesium and potash salts, nitrogenous bodies and sugars. Many efforts had been made to recover

these solids in dry form, but owing to the hygroscopic condition of the residue, such methods were found to be impracticable. In some localities, serious consequences were the result. I have in mind the experience we had at an Iowa factory, grinding about 10,000 bushels of corn per day. The steep water was not recovered, but together with the wash waters from starch and gluten was run into a creek, which, in turn, discharged into a river of fair size. This method of disposing of the steep water soon became a menace to the plant, for proceedings were instituted in the courts with a view to having the factory shut down and declared a public nuisance because the steep water contaminated the river, killing the fish and contributing in many ways to the discomfort of the residents. The owner of the factory being unable to satisfactorily dispose of this waste, as a last resort constructed a pipe line to a farm located about 3 miles from the factory and entered into an agreement with the owner of the farm whereby he was permitted to conduct the steep water through the pipe line from the factory to the farm and discharge it there. For that privilege, besides furnishing a most excellent fertilizing material, he had to pay the farmer three thousand dollars annually. To-day we recover this former waste, by collecting it, concentrating it *in vacuo*, and adding it to the gluten feed in the form of a syrup, with which it is subsequently dried—the feed acting as an absorbent. Instead of investing in pipe lines and paying for dumping rights, the waste of a 10,000 bushel plant was thereby converted into a revenue of almost \$100,000 per year. Applied to the industry as a whole, this former waste furnishes to-day an annual gross income of approximately $1\frac{1}{2}$ million dollars.

Very little is now running to waste. Whatever small loss there is, is caused by the soluble solids carried off in the water used in the washing of starch and gluten. However, these solutions of solubles being very dilute, it is doubtful whether an efficient method will ever be devised for their recovery at a profit. It will probably be a question of economical evaporation, therefore, largely an engineering problem. Nor will the recovery of these solids add materially to the efficiency record in point of yield.

Efficiency has manifested itself in our industry in many ways. As production increased and finally exceeded the demand, ways and means had to be found for diverting the surplus into new channels. This meant partly new products and partly new markets. The latter were secured by entering our starches, for instance, into competition with products mostly foreign, such as rice, wheat, potato and cassava starch; and by studying closely the needs of the respective industries requiring starchy materials, we have succeeded, in a large measure, in replacing rice, etc., with products of corn.

The development of our products occurred simultaneously, and to the series of bulk products were added, in the course of time, a large number of special products, such as thin boiling and modified starches, suitable for every conceivable technical purpose, dextrines and gums, special varieties of glucose, mixed table syrups, so-called "70" and "80" sugars, and refined, hydrogenated and vulcanized corn oils. There is every prospect of further additions to the present number. Products of corn, in one form or another, are consumed to-day in almost every industry, and they reach every corner of the civilized world. Figuratively speaking, this branch of efficiency was raised from 1 to 100—that is to say, where originally the industry was based upon the manufacture of only one product, to wit, corn starch, to-day the number of separate articles obtained from corn presents the formidable array of 100 products and more.

Hardly anything, however, contributes so much to the general efficiency of an industry as the individual plant capacity. This is the part of our business which requires the special attention and skill of the engineer. It has been only ten years since we stopped operating those plants having a unit of only 500 bushels of corn per day. Those plants could not compete with modern

conditions for the simple reason that they did not keep pace with the demands of efficiency. How can a plant grinding 500 bushels of corn a day enter into competition with a plant converting into commercial commodities 30,000 bushels or even 50,000 bushels of corn, which is the daily capacity of the latest addition to our chain of factories, *viz.*, the mammoth plant at Argo, Illinois. It is the concentration of operations that makes it possible for this plant to carry off highest honors in point of efficiency, and this concentration is carried through every department of the plant, each department being organized as a manufacturing unit of its own. The boiler house is our steam factory. It is the business of the man in charge to manufacture and deliver steam at the lowest possible cost and if you could go through this boiler house you would be surprised, perhaps, to find to what an extent chemical control is observed, and to what extent it contributes towards the low cost of steam. The efficiency of the boiler house depends, of course, not only upon its operation, but equally as much upon the equipment; hence the old tubular boilers had to give way to modern high efficiency water tube boilers. Where formerly the standard unit was 100 H. P., it is now 600 H. P. per boiler. We now have only mechanical stokers in place of hand-fired furnaces. Great savings have been brought about in coal and ash handling machinery, so that the operation of a boiler plant to-day requires but a fraction of the labor formerly employed.

Coincident with the increased efficiency of the boiler house was the rational, the scientific use of steam. Evaporation in driers and vacuum pans is done through exhaust rather than live steam, and one may well point with pride to the fact that in spite of the large amount of exhaust steam produced, our plants are operated without the discharge into the air of a single pound of unused exhaust steam.

The engine room is another such manufacturing unit, and a high degree of efficiency is required to produce and transmit motive power at a low cost. Here the slide valve engines had to yield to the Corliss type, and more latterly to the steam turbine. The costly transmission of power by belts, rope drives and transmission shafts had to give way to electrical power. Efficiency is carried into the minutest detail; even an item apparently so small as lubricating oil did not escape the general policy of efficiency; while such items do not represent an imposing saving *per se*, the aggregate foots up a substantial amount.

The milling department is another unit of its own, and so is the refinery, the feed house, the oil plant, the dry starch house, the dextrine department, etc. Each one of these departments is in charge of a chief, responsible for the output, its quality and cost. This general efficiency is carried further in that we operate our own box and carton factories, our printing shops, barrel factories and tin can plants, which latter have a record of efficiency second to none in this country.

You will have noticed that we distinguish between two domains of efficiency: *first*, that of the Manufacturing Department; *second*, that of the Engineering Department. In the latter may be included plant construction, for efficiency not only reigns on the inside, but makes itself felt on the outside as well. Improved plant construction leads to reduction of maintenance charges, to a lowering if not elimination of fire risks, accompanied by a corresponding lowering of insurance rates, to a better safeguarding of the employees, to a reduction of accidents and to an improved sanitary condition. The last-named features, in turn, lead to increased efficiency of the workmen, without which any attempt at a high degree of general efficiency must come to naught.

Another link in the chain of general efficiency is furnished by labor-saving devices, the result of which is that less men are employed to-day in a factory grinding 30,000 bushels than were formerly required to operate a plant with a capacity of only 10,000 bushels.

Gentlemen, I have singled out the industry of Corn Products because it furnishes one of the most striking examples of what efficiency has done for the development of a chemical industry within a comparatively brief space of time. Unlike other industries, such as steel or sugar, our industry is a conglomerate of a number of others. *Per se*, the manufacture of starch has nothing to do with that of oil; the manufacture of corn syrup nothing in common with the production of concentrated feedingstuffs; the manufacture of dextrines nothing with that of dextrose, etc., yet these various departments are so related to the whole as to form inseparable parts of it, and the efficiency of the whole depends, therefore, upon the efficiency of each branch.

The net result of our efforts with respect to efficiency is perhaps best illustrated by the fact that we pay to-day for our raw material—corn—three times as much as did our predecessors, and yet we sell our products in the markets of the world at one-third of their price.

To continue the increase of this efficiency, it is necessary that we have young men with the proper training—not only men with a scientific schooling, but men who have received thorough training in engineering, who know the parts and functions of machinery and apparatus, who have a fair knowledge of factory operations, and who have a general understanding of the principles of manufacturing. It is gratifying to note that the number of colleges and universities is increasing from year to year, where a course of chemical engineering is added to the curriculum of the chemical student. The chemical industries of this country have grown from a small beginning into a position of great importance. A large share of the credit is due to the schools which furnished the men. They must give us men of ideas, men with initiative, men with mental and physical equipment to carry their creations of mind through into creations of fact. No matter how small a cog the individual may be in the big wheel of industry, he may well be proud of his share in the building up and development of the chemical industries, which contribute materially toward the prosperity of this country. If his work goes unnoticed by the public-at-large, he can find comfort in the fact that "The greatest joy of those who are steeped in work, and who have succeeded in finding new virtues and understanding the relations of things to each other, lies in work itself."

Such work cannot result other than in efficiency. Efficiency stands for all that is great and potential. Efficiency is the making of a man. Efficiency is the making of an industry. Efficiency is the making of a nation.

UTILIZING WOOD WASTE¹

By JOHN E. TEEPLE

I. INTRODUCTORY

I have been asked to give a general survey of the field of chemical wood waste utilization: what has been accomplished, what is being done, what are the prospects. In such an address many interesting details must be omitted, many subjects passed over lightly or merely mentioned; much of the material presented will be familiar to many of you, and a part to all of you.

Man has been utilizing wood from the beginning. Wherever we find him in history, even as a barbarian, he has known how to make charcoal and probably tar from wood, if he had the wood; and there was abundance of wood. Central and Northern Europe were almost entirely forest or swamp. The larger part of our own country, excluding the middle western prairies, was covered with trees. Nearly this whole state of New York, this spot on which we stand to-night, was a forest. There was no waste wood, or it was all waste, just as you choose to con-

sider it. The whole forest was a huge storehouse from which man drew indiscriminately whatever was best suited or most accessible for timber, for lumber, for charcoal, for tar. The settlers cleared millions of acres for agriculture by simply chopping down the trees and burning them where they lay.

It has remained for our own time, our own generation, the last few years in fact, to develop a *problem* of wood waste utilization and to make some progress toward its solution in a chemical way. In our day, ideas of conservation are prevalent and directing. The tar or charcoal burner of two or three hundred years ago in Russia or Sweden, and more recently in the Carolinas, centered his interest in the tar for his ropes or the charcoal for gunpowder or metallurgical purposes. To-day we approach the same manufacture with a view to utilizing waste materials. Here are certain residues unsuited for lumber, lath, railroad ties or box shooks, good only for fuel and unsalable at fair prices as fuel. What shall we do with them? Shall we or can we make tar or rosin, or alcohol or paper, or anything else that is marketable, and can we also secure a profit in doing so? The profit side is important because no matter how remarkable transformations are accomplished, or how interesting the process may be from a chemist's view point, still the law holds: no profit, no industry.

In this discussion we shall restrict ourselves mainly to this continent, mentioning only incidentally the work in Russia, Sweden, Austria Hungary, and other European countries. Our subject of wood waste naturally excludes most of the manufacture of paper pulp from spruce, poplar and hemlock, and some of the hardwood distillation, the extraction of tanning materials, dyestuffs, etc. In these excluded cases we are not specifically utilizing waste materials but are competing for the purchase of raw materials which are in some demand for other industries.

2. RAW MATERIALS

A list of the important woods of this Continent, which from their use for lumber would be a source of wood waste, would extend to more than a hundred names. For our purpose we may classify such as are of present interest as follows: *First*, the Longleaf Pine (*Pinus palustris*) in all the states touching the Atlantic Ocean or the Gulf of Mexico from North Carolina to Eastern Texas. This wood is exceedingly rich in resins and terpenes, and this tree makes the United States the largest producer of turpentine and rosin in the world. *Second*, the Shortleaf Pine (*Pinus echinata*) of the same distribution but extending farther inland, especially in Arkansas and Missouri, contains comparatively a small amount of resins and terpenes. The Loblolly (*Pinus taeda*) and the Cuban Pine (*Pinus Cubensis*) are intermediate between these two in their characteristics. These are the most important Southern pines. In the North, the Norway Pine (*Pinus resinosa*) occurs in Minnesota, Wisconsin, Michigan and the Province of Ontario. It does not occur in forests, but is scattered among other timber and in groves. A large portion of this has already been cut, and the waste for our purpose is in the form of stumps on uncleared lands. Like the Longleaf pine and other resinous trees these stumps do not rot. The bark soon falls away, the layer of sap wood decays, but the remainder apparently becomes more resinous with the years.

On the Pacific coast the Douglas fir (*Pseudotsuga Douglasii*) is especially abundant in British Columbia, Washington and Oregon. Individual trees vary considerably in character; some are rich in resins, particularly where it has collected in pockets or wind shakes; others contain very little. The amount being cut by lumber mills is very large, and any method of utilizing the waste either from mills or from stumps must recognize the variation and select the material suited for its purpose.

We next have the class of wood suitable for what is called hardwood distillation and including white pine, maple, oak, beech, birch, chestnut, ash and some other broad leaved woods.

¹ Paper presented before the New York Section of the Society of Chemical Industry, Chemists' Club, April 25, 1913.