ADDRESSES

MINERAL WASTES: THE CHEMISTS' OPPORTUNITY.

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No part of the world's history is more entertaining to study than the development of uses for the minerals with which we are so abundantly favored, the finding of new applications and new uses for the products prepared, and the conservation of waste material whereby the products themselves are obtained in increased quantities and at a lower cost. Such development has been a constant record of the production of new material, the applications for which have been enlarged and the demand increased by the cheapening of product through increased efficiency of method and through the utilization of other substances found in greater quantity and substituted for those which may be threatened with exhaustion.

In the earliest history of civilization only some five of our eighty or more elements were intelligently used. The number has been slowly increasing, and within the last fifty years greater progress has been made in the utilization of the mineral matter of which the earth is composed than in all previous time. The results accomplished have been the work of the chemist, the physicist, the metallurgist and the engineer, all utilizing the broad principles of chemistry to assist them in their work. Some processes have already progressed to a point where wastes are reduced to a minimum and their efficiency is great, although in no single case has perfection been reached.

The twenty-nine million metric tons of petroleum which the United States now produces is for the main part utilized. Formerly kerosene was the chief product, sought and immense quantities of the lighter and heavier fractions were allowed to waste. With the introduction of the electric light, of the automobile and of the proper understanding of lubrication, almost the total output is now worked up into gas, gasolene, naphtha, kerosene, lubricating oils, asphaltic road material and carbon for electrical purposes. Indeed, kerosene has almost become a secondary product and within the last few years the demand for gasolene has become so great that the petroleum companies are anxious to increase the output of that fraction. Indeed, the natural gas wells have introduced methods for condensing, by means of cold and pressure, the gasolene and lighter fractions carried mechanically by the gas, and during the latter part of 1910 some 13,000 gallons were so produced daily. From the gas wells from two to six gallons per thousand cubic feet of gas may be obtained and the gas itself rendered better for illuminating purposes or for gas engine combustion, but, of course, considerably decreased in volume.

Every student of chemistry knows the advances which have taken place in the iron and steel industry. Many of us can remember the old campaign arguments of how a beneficent tariff brought about the reduction in price of steel from $145 per ton to somewhere in the neighborhood of $20, but it was only in the schools that we were taught that the Bessemer process, the Open-Hearth and Basic Bessemer processes and the utilization of waste gases were the chief cause. At the present time the production of iron has reached a perfection which would have been deemed impossible a few years ago. Besides the wonderful development already mentioned the utilization of the waste gases has been carried so far that by using them directly in gas engines driving electric generators a single modern blast furnace may produce as much as 7,000 kw. of electric power besides driving the engines necessary for its own air blast.

Until recently there have also been immense losses of iron ore in the flue dust which, according to Edward M. Hager, amounted to fully three per cent. of the total ore charged. In a most interesting article on "The Utilization of the Wastes of a Blast Furnace" he points out that by collecting this dust and heating in the oxidizing atmosphere of an ordinary Portland Cement rotary kiln, this three per cent. of the ore added to the blast furnace is recovered in a nodular form carrying over sixty per cent. iron, an amount aggregating over 1,250,000, tons of iron ore per annum. Also he calls attention to the increasing utilization of slag, which formerly went to waste, for the production of a slag cement which differs but little in chemical analysis, fineness, specific gravity, color or in its operation in practical work from that made by the ordinary methods. In 1910 over seven million barrels of this kind of cement were produced in the United States, making up nearly ten per cent. of the total output of that commodity. Also hundreds of thousands of tons of scrap iron are annually collected and remelted, and improved processes for covering iron with protective coatings other than cement are making rapid progress. The wonderful effect of the growth of the Portland Cement industry on the conservation of our natural resources cannot be overestimated. In fifteen years it has developed from less than one million to over seventy-six million barrels per year for this country alone and has supplied a cheap material which not only replaces iron in much structural work but also is used as a coating to iron itself, greatly increasing its life by protecting it from rust. It is also taking the place of millions of feet of lumber, the great demand for which in recent years has been depleting our forests so rapidly. It is interesting to know that it is the thousands of small users of cement who are supplying the market for a large part of the product, and its use around the farm and the village is increasing as much as in large engineering work, such as dams, bridges and buildings. Indeed, the small cement house is becoming more and more in vogue, and with its comparatively indestructible qualities from fire or weather, together with new methods of coloring and decorating, promises to supplant our ordinary wooden houses in future.

But the facts are seldom so favorable as those already cited. Our fertilizer industry is the largest of all our chemical industries, producing some three million tons per annum, and it is probable that one-half of this output is not intelligently utilized. We produce sulfur cheaper than any other country in in the world, sell it at the highest price and discharge into the air from a single stack of the Washoe Smelter in the form of sulfur dioxide almost as much as is utilized throughout the whole country from sulfur and domestic pyrite put together. Indeed, the total amount of sulfur dioxide discharged into the air in this country would produce probably eight million tons of sulfuric acid, the basis of all chemical industry, could it be economically recovered. That the sulfur dioxide from smelter smoke can be recovered has been proved by the zinc smelters and by the copper smelters of Tennessee, but the question is so closely connected with the question of transportation and markets that at present the idea of converting the waste sulfur dioxide into sulfuric acid seems to be almost hopeless for our western smelters, although there can be no question that in time the problem will be solved, perhaps in this way. Already rapid progress has been made and of the three million tons of sulfuric acid now manufactured in the United States, probably two hundred thousand tons are recovered as a by-product in the roasting of zinc sulfide. More than 250,000 tons are reported to have been produced in like manner from the copper smelters in Tennessee and at the same time a terrible nuisance to the surrounding farms has been largely mitigated. The fertilizer industry more than any other requires this sulfuric acid for rendering the phosphoric acid of phosphate rock available to plants, and, as immense deposits of phosphate rock exist in Wyoming and Montana, it is probable that some market for sulfuric acid will be developed in that portion of our country.

Ages ago there were stored up, chiefly through the influence of plant life, immense deposits of carbon and of nitrogen which have made modern civilization possible. Although some of this nitrogen may have been brought into combination by means of electrical discharges through the atmosphere, it is highly probable that the larger portion of it was fixed through the same form of bacterial action that is now known to take place in the tubercles growing upon the roots of the leguminosae. Certainly it appears to be true that the five hundred million tons, more or less, of sodium nitrate which is known to have been deposited in the desert of Atacama, Chili, probably is of organic origin from plants through animals whose refuse under the peculiar conditions of heat and limited water supply was oxidized and collected in this unique locality. Besides these deposits, bituminous coal contains between one and two per cent. of nitrogen, a small fraction of which can be recovered by proper methods. From these deposits, together with the comparatively small amounts which we are able to conserve by saving animal and plant refuse and returning it to the soil, we have drawn until recently our total supply of this absolutely essential element for both plant and animal food. From these supplies also we have drawn all of the nitrogen, without which we would have no explosives upon which depends our whole mineral industry. Our wastes of nitrogen, worth in combined form about fifteen cents per pound, are almost inconceivable, and no calculation can give us a real idea of what these losses mean. Their immensity has so impressed the human mind that the daily press for years has contained article after article in regard to the approaching starvation of man through the inability of the earth to supply plant life on account of the future lack of nitrogen. 2,600,000 tons of sodium nitrate are being produced each year in Chili, which means that the time of depletion of these deposits is probably less than a century ahead.

Although we produced last year over 406,000,000 tons of bituminous coal, we recovered but $3,800,000 worth of the $160,000,000 of recoverable nitrogen which it contained. Of course, it is entirely impracticable under present conditions ever to recover all of the nitrogen which might be obtained as ammonia, but it does at least seem reasonable to bemoan the fact that of 63,000,000 tons of coal converted into coke in 1910, containing $22,000,000 worth of recoverable nitrogen, only about one-seventh was even treated in ovens or retorts which could make that recovery possible. The balance went off as free nitrogen in the air. It certainly is startling to realize that if we consider the total nitrogen content of bituminous coal, last year we saved less than $4,000,000 worth of combined nitrogen from this source while more than two billion dollars worth of that stored up for us ages ago was again dissipated into the atmosphere in the uncombined condition. Of course, the recovery even of ten per cent. of this amount with our present knowledge is impossible, but it is interesting to note that the public and manufacturers themselves are being aroused to the loss, that by-product coke ovens are being employed more and more, and that the question of producing combined nitrogen from the atmosphere in which we live is making a real beginning.

As an offset to this great waste of nitrogen there are at present two essentially different commercial methods for bringing this element into combination and a third appears to be imminent. Two of these processes have already reached commercial success, but the tremendous amount of energy at present required for their prosecution raises an effective barrier against ever really offsetting the wastes which are taking place.

It is scarcely necessary before this audience to enter into detail of the processes for obtaining nitrogen in the form of cyanamide as practised at Niagara Falls and abroad or to describe again the processes of Birkeland and Eyde, of Pauling and of the Badische Company for obtaining nitric acid by means of the high temperature of the electric arc and absorbing it in lime to be sold as calcium nitrate. It may be well to state, however, that the cyanamide is obtained by the action of nitrogen on calcium carbide heated to 1200° C., at which temperature it rapidly absorbs the gas forming cyanamide. It is necessary, however, first to produce calcium carbide and to obtain pure, dry nitrogen free from oxygen, which is done by means of liquefying air, and the cost of these operations forms the chief limitation of the process. Of the three processes for the actual burning of nitrogen and oxygen at the elevated temperature of the electric arc the Birkeland and Eyde process at Notodden, Norway, has been so far the most successful, perhaps because it was the first in the field and has cheap electric power. This last year they utilized some 50,000 kw. of electricity throughout the year which is to be increased to 100,000 kw. Their output approximates 70 grams of HNO_3 per kw. hour and their furnace has the great advantage of being capable of use in large units, some of which are of 4,000 horse power. They report net earnings for this last year of some $350,000 and produce nitric acid as calcium nitrate, which commands a ready market. The Pauling process is being used near Briancon, France, and also appears to be in successful operation. The Badische process is to be installed in new works in Norway together with the Birkeland and Eyde process and it is estimated that the two processes will shortly be using 250,000 horse power in that country.

Even this tremendous expenditure of energy can, however, supply but a fraction of the world's requirements for combined nitrogen, as it requires one kw. year to produce one ton of 13 per cent. calcium nitrate. The success of these processes at the present time is dependent almost solely on the question of cheap energy. The principle of all is the same; namely, the utilization of the intense heat of the electric arc to bring about a reaction between nitrogen and oxygen and the quick cooling of the gases in order that the reaction may not reverse itself. In the Birkeland and Eyde process the electric arc is branched out by means of an electric field; in the Badische process a similar active surface is obtained by producing long arcs even up to twenty-two feet in length in tubes, and in the Pauling process the arc is enlarged by means of a blast of hot air under pressure. Patents recently issued to the Badische Company indicate that an entirely new method may soon be used, depending upon the reaction between nitrogen and hydrogen under pressure with the reaction hastened by uranium or some catalytic agent, the ammonia being absorbed as fast as produced. It will certainly be of inestimable advantage to procure some method by which nitrogen can be fixed without the tremendous loss of energy required when it is heated to the 3500° required in the electric processes. It would certainly seem that if bacteria can bring about the fixation of nitrogen in the small laboratory they utilize on the roots of the legumes, man must sooner or later also succeed in bringing about this reaction at moderately low temperatures, and I confidently believe that we may in some measure hope in time to imitate this process through the use of catalytic agents.

The waste of our fuel supplies is almost inconceivable. In the mining of coal in this country it is probable that scarcely 50 per cent. of the coal in the ground is taken out and brought into a form where it can be economically utilized. That portion which is left behind is undoubtedly lost forever, for the mines are allowed to cave in and probably can never be opened again. Of the energy in the coal mined probably not over 11 per cent. is effectively utilized. The remainder of the energy is lost through the inefficiency of the steam boiler, the steam engine and the electric dynamo. It is estimated that the boiler scale alone on the locomotives of the country means a loss of over fifteen million tons of coal. It has been shown that $^1/_{16}$ of an inch of boiler scale means a loss of 13 per cent. of efficiency and that $^1/_8$ inch, which occurs in many boilers, means a loss of 25 per cent. Not only does this boiler scale mean a loss of energy, but its removal means much longer life for the boilers themselves.

The whole question of the conservation of these losses of energy is becoming almost as much the province of the chemist as of the engineer. In spite of present conditions, great advancement has been made and greater advances are yet to come, although the time when we shall be able to directly utilize the full energy of carbon through some direct chemical process may not be reached before the millenium is here.

Our supplies of coal are being more and more conserved directly through the utilization of water power, of which, according to M. T. Bogert, there are 150,000,000 horse power possible of economical development in this country, of which 37,000,000 horse power, equivalent to 800,000,000 tons of coal, are readily available and of which 5,500,000 horse power are now actually used. Also the development of the gas engine, by means of which power can be obtained without the intermediary loss through steam, is rapid and has the distinct advantage that much coal, too poor in carbon content to be economically transported, can be readily used in gas producers and its energy utilized and transmitted to a distance through the gas engine and dynamo. The covering of pipes with asbestos and magnesia coatings and the scientific control of the combustion of coal under boilers is adding greatly to the amount of energy actually utilized. Also, as already stated, the recovery of waste products through by-products coke ovens is not limited to the nitrogen alone. Mr. E. L. Parker, of the United States Geological Survey, states that the value of the recoverable contents of the coal made into coke in beehive ovens which went to waste in 1910 would have been worth between $35,000,000 and $40,000,000. If all the coke made in the United States was produced in retort ovens, these would yield (from the carbon now wastefully consumed) without reference to the other by-products obtained approximately 1,000,000 horse power for every day in the year.

Without entering at all into the detail of the wonderful coal tar industry, which has not as yet been developed in this country, but is probably the greatest example of chemical industrial progress, it is interesting to note the indirect bearing upon our conservation which this coal tar develops when we think of the alizarin, indigo and other colors which were formerly produced on land now devoted to other purposes. It has been stated that the synthetic indigo now prepared from coal tar is equivalent to over 300,000 acres of indigo plants. Development of one industry like this always has a striking influence upon another. When the cyanide process for the extraction of gold was first proposed potassium cyanide cost over one dollar per pound. By the utilization of waste products and the perfection of methods the price of cyanide, now chiefly used in the form of sodium cyanide, has been reduced in the chief producing countries to something like fifteen cents per pound and since a difference of one cent per pound of cyanide means a saving of something like $150,000 a year to the gold industry, the cheapening of this product alone means a saving of some $12,000,000 a year.

In spite of the losses through waste already mentioned and many others that might be cited, there is really a silver lining to the cloud. When we look at the question from the standpoint of the progress that we have made and the problems which may perhaps be easily solved, we feel proud of the work which the chemist has accomplished and glad that we belong to a profession which offers so much in the way of accomplishment. The president of our largest chemical corporation recently stated that progress in chemical industry is taking place so rapidly through new processes, new machinery and new methods that his company has very little in the way of plant to-day which was in existence ten years ago. Only three years ago one of our leading scientists stated: "The crest of our known resources of high-grade copper ores is clearly past and we are using lower and lower grades with increased cost of production. The inadequacy of our copper supply is a matter of deep concern." This, of course, is largely true, but the situation has developed in a different way from that indicated by the quotation given. The fact is that the low-grade ores are proving the more profitable to work and have not brought an increased cost as might have been anticipated. Indeed, although our production of copper has increased about one thousand per cent. in the last twenty-five years, the annual output as well as consumption is still increasing and prices are lower than they were three years ago, owing to the greater efficiency of method and the utilization of deposits formerly supposed to be worthless. Immense mountains of ore yielding less than 2 per cent. of metal are worked with steam shovels, concentrated in mills capable of handling some 30,000 tons per day, with a recovery three years ago deemed impossible, smelted by methods far more efficient than those then in use, and bessemerized in basic-lined converters capable of handling three times the charge of the old acid form, using some ore direct for its fluxing constituents and having a life many hundred per cent. greater than their forerunners. These low-grade deposits, instead of causing an increase in the price of copper, are really forcing some of the high-grade mines to struggle for a continued existence. In spite of all this, it is doubtful if there is any branch of our metallurgy that would respond more quickly to scientific research by well trained men, who were not forced always to keep the immediate output in mind, than the metallurgy of copper.

But our industrial chemical problems are not all connected with the larger industries of which I have so far spoken. Many new elements, many new minerals and mineral products, are coming into daily use and have also their minor problems in the question of the utilization of waste. In the manufacture of thorium for the Welsbach mantle the larger part of the raw material present in the original monazite now goes to waste. About 50 per cent. of this is cerium and the balance lanthanum, neodymium, praseodymium and other rarer elements of the rare earths. There is every prospect that the cerium will soon be utilized and bring a fair price. Its separation from the other earths is no longer difficult and once in solution can be brought about in a single operation. Its properties in alloys, some of which have most remarkable pyrophoric properties, are now well known and the metal can be readily reduced by the electric current. The oxide of cerium as well as the oxides of the other elements that occur with it are highly refractory and may find special uses where this property comes into play.

In the production of gold telluride ores and in the refining of copper, large amounts of tellurium are annually going to waste and offer a splendid opportunity for research. No promising application is yet in view.

Our output of bromine might also be greatly increased could uses be found. The application to the formation of bromides is apparently not increasing, but there seems to be a real opportunity for its use in the form of bromates and it would appear that potassium bromate, the wonderful oxidizing properties of which are not yet appreciated, may have a real use in metallurgy and possibly in other industries when it is more clearly understood that if a real demand arises the material can be furnished at a surprisingly low cost. Indeed, many of our rarer elements are being passed by in the industries chiefly because the cost of production on a small scale is much greater than would be the case if an extensive contract could be entered into. Also manufacturers themselves frequently prefer to let large quantities actually go to waste rather than reduce their prices in order that the wastes may be utilized.

Chlorine, like bromine, is produced in the electrolytic manufacture of caustic soda and potash in amounts which make its utilization a problem. It is being worked up more and more into the form of by-products such as carbon tetrachloride, sulphur chloride and acetylene chloride, is being liquefied and transported in liquid form for the direct production of sodium hypochlorite for use in laundries, and is utilized in recovering the tin from tin scrap in the form of tin tetrachloride used chiefly for weighting silk. It can now be obtained in cylinders which are so cheaply made that their return is not necessary, or it can even be procured, if desired, in tank cars.

Bleaching-powder also, by being mixed with a little copper sulphate and cobalt oxide to act as a catalytic agent, is now on the market as a cheap source of oxygen under the name of Lavoirsite.

Calcium also can be readily obtained cheaply and in quantity as soon as a use therefore is found.

Silicon, which has some wonderful properties of resistance to chemical agents, is now easily made and except for its brittleness would probably find extensive use. Even as it is, uses are gradually developing, one of the most interesting of which is for the shoes of the plows used in certain acid or pyrite furnaces where iron rapidly goes to pieces. Many tons of this element are used in alloy with iron, especially in electrical transformers. It reduces hysteresis losses and increases resistance.

Among the comparatively rare elements and minerals which are becoming more and more prominent in industry may be mentioned tungsten, the ores of which to the extent of some 6,000 tons per annum are now worked up, to be used chiefly in the production of tungsten steel but also in the filaments of electric lamps; vanadium, for the preparation of vanadium steel; titanium, for the preparation of ferro-titanium, with which more than half of the Bessemer steel now produced is treated in order to deoxidize and denitrogenize the product; and selenium, obtained as a by-product in copper refining, which has the unique property of changing its conductivity under the influence of light and which is now used to the extent of some twenty tons per annum to color glass or enamel a beautiful ruby-red, and also by use in small amounts to decolorize glass or enamel by neutralizing the greenish tint from ferrous iron.

Bismuth, so valuable in medicine and alloys, is now obtained as a by-product in the electrolytic refining of lead in this country alone to the extent of some 90,000 pounds per year. Palladium even is finding new uses, so that the accumulated supplies of many years appear to have been exhausted and it is being recovered to the extent of 2500 oz. per year from copper anode slimes. Zirconium oxide is being eagerly sought for and new patents issued almost daily for its use and production, chiefly on account of its refractory properties and its power to replace tin oxide as an opacifier in enamels. Magnesium even appears to have a future in certain very light alloys of high tensile strength for use in the constructions of aeroplanes. It is stated that the alloy with 4 per cent. of zinc is extremely light and extremely strong. Also magnesite is greatly in demand for the preparation of refractory brick, but unfortunately no deposits are known in this country east of California. On our Atlantic coast at least, most of it must be imported, although immense quantities exist, together with calcium carbonate, in dolomite.

Barium in the form of barite, with the products therefrom, is finding an increased use in paints and in the production of barium sulfide for the manufacture of lithopone. Barium dioxide is imported for use in the manufacture of hydrogen peroxide, since America has no deposits of witherite.

Lithium carbonate is also now a comparatively cheap substance that could be produced in much greater quantities if more extended uses could be found.

Asbestos is eagerly sought and its technology has become so extensive and its uses so diversified that an article could be written on this subject alone. The application to fire-proof asbestos lumber, which can be sawed and milled, and to asbestos slate, which is replacing shingles, is having the advantage of utilizing the cheaper grades which were formerly largely a waste product. The same may be said of mica, and the old mica scrap heaps at the exits of old mines have been all carefully reworked on account of the excellent insulating material they contain as well as for the production of other products in which scrap mica has been utilized. New methods are also rendering available much material that formerly went to waste and are also cheapening and thereby increasing the application of much other material long used.

Immense deposits of graphite have not been available on account of the impossibility of separating them from the gangue that they contained, but it has been found that in many cases simple pulverizing and sifting through sieves will separate the fine granular gangue from the more flaky graphite.

Immense deposits of molybdenum occur in Maine and in the West which have been useless for the same reason. They could not be worked unless they could be separated from the gangue and no good method of separation was known. Molybdenum has not been used extensively in steel chiefly for the reason that tungsten, which served the same purpose, was cheaper, and also molybdenum has the disadvantage of volatilizing out of the steel quite easily. On the other hand, a much smaller amount will bring about much the same result that tungsten produces. Manufacturers have been willing to pay as high as $600 per ton for limited amounts of good molybdenite, practically all of which had to be imported. By a new flotation method it now seems possible to separate molybdenum as well as other sulfide ores from the inert material with which they occur, and it is hoped that our American resources of this mineral may now be utilized.

Considerable deposits of carnotite and some uraninite are found in Colorado, and the material is now being exploited for the extraction of radium abroad. In view of the immense value of radium for scientific and medical purposes, it would certainly seem that this wonderful substance should be produced in our own country, and it would at least seem possible that some more rapid method for its separation might perhaps be found. The production in France for 1910 was something less than two grams, which sold for $150,000, and the material is so rare that in Paris one hundred milligrams is rented out at the rate of one hundred to two hundred dollars per day for scientific or medical use.

The new method of following the wastes of zinc concentration in New Jersey by means of ultra-violet light is also of extreme interest, and it is stated that the wastes, which formerly amounted to some 5 per cent., have been reduced to less than 2 per cent. with the assistance of this method.

Much might be added on the question of alloys, artificial stone, refractories, nickel and cobalt, arsenic, antimony, tantalum, boron and beryllium, but I do not wish to try your patience too far.

In order properly to cultivate our natural resources, experience has taught our progressive manufacturers that two kinds of trained chemists are essential if they expect to keep ahead or even abreast of the world's progress. They must have the works laboratory where careful control is kept of the actual carrying out of the process in hand, and they must have a research laboratory where new processes, applications and ideas are developed and the efficiency of old methods studied with a view to greater economy of production and value of output. The importance of the works chemist has long been realized, and his usefulness is continually augmented by the fact that customers are becoming more and more exacting in their requirements for purity of product and more and more insistent that standard specifications be accepted and fulfilled. The research chemist has until recently been appreciated only in Germany, but America is fast awakening to the real basis of Germany's industrial progress and research laboratories are now installed by large numbers of our most progressive producers.

It is probable that the first American commercial laboratory where the real spirit of research was fostered by the company itself was established less than ten years ago. To-day there are over fifty in active operation with a steadily increasing corps of investigators, and one at least has passed the hundred mark for the number of chemists employed. These laboratories have justified their existence and in every instance where properly trained men have been secured have returned the investment many fold. Better still, they have kept their respective firms far ahead of their competitors. Other corporations, less wise in their understanding of the requirements of the situation, have thought they were establishing laboratories when they employed some recent graduate at one-tenth the salary they would pay their engineer and one-fiftieth of that they would allow their lawyer and have expected him to revolutionize the business within a twelvemonth and act as foreman and analyst meanwhile. Sometimes even then *they* have drawn a prize. Research laboratories are also being fostered by the government and by educational institutions. Even a few of our more progressive consulting laboratories are supporting research departments. This can have but one result, which is that American industry is not to depend alone upon unlimited natural resources, but also upon new and increasingly efficient methods for their development. Indeed, specific instances of wonderful accomplishment are not rare, although secrecy as to results is too often insisted upon and maintained.

A few instances may prove of interest. A chemist of my acquaintance had been employed for years by a large textile company that saw no need for chemical research and kept him confined almost wholly to passing upon the quality of the supplies they bought. It happened that this company's engineers installed an open pipe line through which raw cotton was blown from mill to mill and which proved a great saving over the previously used mode of transportation. Their plan worked beautifully until the cold days of the late fall arrived, when moisture on the cotton from the warm mills condensed and freezing to the large galvanized pipes soon caused a stoppage. This was removed, to be immediately repeated, and it was evident that something must be done or the plan abandoned for at least five months of the year. By chance, this chemist was standing by when advice was given by the local engineers to box in the pipes and heat with other pipes carrying steam. Knowing some of the principles of elementary physics, he modestly suggested that instead they open the window that happened to be near and blow with cold air inside as well as outside the pipes. Of course, there was then no condensation of moisture, the pipes worked equally well the year round and some $14,000 of construction was rendered unnecessary. A little later a specially fine grade of cloth appeared to demand a treatment which the foreman stated could be done only by hand, and plans were drawn for a new building to accommodate seventy additional laborers for the purpose. Profiting by experience, the general manager, for perhaps the first time, called his chemist into conference, with the result that the plans were temporarily held up and after a few weeks finally abandoned, for a chemical treatment was accomplishing easily, cheaply and rapidly the work of seventy men. It is useless to follow the case further except to say that in at least one other instance since he has to my knowledge saved in a single year's operation of a new process more than the company will pay him in his lifetime. He is now appreciated by his employers and recompensed in some measure of his value to them, and his work is now of a research character with helpers for the routine.

In another instance the vice-president of one of our large corporations told me that in the first year their research laboratory was established one thing accomplished alone netted the company $80,000. Furthermore, he added that this was only one of a dozen improvements, each one of which more than paid for the total running expenses of their research work.

In another case of which I know, a young and well trained chemist was sent by his company to Amsterdam to make a special study of the phase rule under Roozeboom. They were manufacturers of soap, and a special brand they made was subject to great fluctuation in cost through the varying price of one of its constituents. On his return to the laboratory he was able to apply the new knowledge he had gained in such a manner that he shortly drew a chart, intelligible even to the foreman, by which certain substitutions were made as the market varied without altering, in any way, the physical character of the product, a result which had before been impossible. In the first year something over $90,000 was saved thereby.

While these are only a few of the cases of which I have personal knowledge, one has only to read the exceedingly interesting address of Dr. W. R. Whitney on "Research as a Financial Asset" to be immediately convinced that no other asset is more promising for investment. He casually mentions the fact that although the expense of the research laboratory of the General Electric Company is now considerably in excess of $100,000 a year, it has been a good expenditure of money. As the result of the work on improvement in incandescent lamps alone, very largely brought about in his laboratory, some $240,000,000 a year are saved to the consumers of electricity by the greater efficiency of operation. He mentions also another case where a corporation had saved by the results of its research men over $800,000 a year and cites many other instances minor only by comparison.

In closing, I want again to call attention to history and sound a warning to all young chemists here to-night. It has often been said that the reason that Germany has forged so far ahead of England in her industrial development is that German manufacturers have always appreciated brains and that pure scientific research has been encouraged to go hand in hand with the industry. England, on the other hand, has believed in the "practical man" and their manufacturers have had little sympathy with the theoretically inclined. In America we have both kinds, not only among our manufacturers but among the chemists they employ. Many are coming nearer to the German idea and they are the ones that are succeeding.

As Secretary of the American Chemical Society, I have many queer experiences, but none have proved more enlightening than letters received and conversations held with certain industrial chemists on the one hand who laugh at the phase rule, the mass law and the general application of advanced theory and who openly state that they believe the *Journal of the American Chemical Society* is a waste of good paper, while on the other hand certain so-called pure scientists, too often speaking from a pedestal raised by themselves and their admirers, sneer at the application of their own science and consider them and the journal in which they find place quite unworthy of their time and notice. Fortunately the number of each is small and is decreasing. I am sure there are none such in this audience, but I am sure that in so far as your knowledge of the theory of our science is complete and your ability to apply your knowledge develops, just so far will you measure up as a successful man.

Our science has progressed so far that each one of us must specialize to cover, even passably, our particular field, but this can never excuse us for a lack of sympathy with our honest co-workers. It is only arrogance and ignorance that assume omniscience.

PERKIN MEDAL AWARD.

The Perkin Medal was conferred, December 19th, in Rumford Hall, Chemists' Club, New York, on Mr. Herman Frasch for distinguished services in the fields of Applied Chemistry.

Mr. Frasch's inventions in connection with the purification of sulphur oils of Canada and the Ohio field, and also his invention of a method and the development of the mining operations in the sulphur fields of Louisiana, are fully discussed in the Presentation Address by Professor Chandler, and the acknowledgment by Mr. Frasch. An additional feature of the program was an address on the "Geology of the Sulphur and Sulphur Oil Deposits of the Coastal Plain," by Captain A. F. Lucas, and an address by Mr. F. H. Pough, of the Union Sulphur Company, on the operations of their mines in Louisiana. Mr. Pough's address was illustrated by lantern slides and moving pictures taken at the sulphur mines as late as Saturday, January 13th.—[EDITOR.]

INTRODUCTION.

By M. C. WHITAKER, Chairman.

The Perkin Medal, established to perpetuate the memory of the founder of a great chemical industry, is again to be awarded for distinguished service in the field of applied chemistry. Sir William Perkin expressed deep appreciation to his fellow workers in America for the honor paid him on the occasion of its establishment. The full wisdom of the plan is slowly unfolding to us as we see, year after year, our chemists gather in these halls to single out and honor a distinguished member of our profession.

A committee representing the chemical organizations of America, a body of men selected for their wide knowledge and experience in chemical and industrial development, deliberate and select. Merit and achievement alone determine their choice.

Dr. Chandler, we present to you, as the Past President of the Society of Chemical Industry, and as the officer wisely designated in the rules of the Society to make the presentation address, the unanimous choice of the committee. You, better than any other member of our profession, can speak with knowledge and with admiration of the scientific achievements of our distinguished guest of this occasion, Mr. Herman Frasch.