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VARIOUS RESULTS OF BEING RESEARCHFUL[1]

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IN accepting the Chemical Industry Medal, I feel that I am doing so as the representative of Mellon Institute and its executive and research staffs. I think that this signal honor has come not to me as an individual but to the group of research specialists of whom I am the director, in recognition of their original contributions, and I wish to thank you for this expression in permanent form of your high opinion of the scientific and technical accomplishments of our organization. It will be pleasant to take this medal to the institute, to show it to all those who are entitled to share in the great honor conferred by it, and then to place it among our treasured possessions.

I will now describe as briefly and clearly as I can some of the productive work at the institute whose results have been accorded your recognition in the bestowal of this medal.

[1] A discourse delivered in acceptance of the Chemical Industry Medal at the meeting of the American Section of the Society of Chemical Industry, The Chemists' Club, New York, N. Y., November 8, 1935.

THE INDUSTRIAL FELLOWSHIP SYSTEM

Mellon Institute has four functions, namely: it is an industrial experiment station, a training school for industrial scientists, a center for investigation in pure as well as applied chemistry, and a clearing-house on specific scientific information for the public. Its services are seen in the numerous discoveries, the successful processes and products, achieved under its auspices, and in the regiment of keen research men who have here acquired specialized knowledge and experience that they are now applying usefully in other fields.

As an industrial experiment station—in its researches in applied chemistry and allied sciences—

Mellon Institute has for its investigational procedure the system conceived by Robert Kennedy Duncan in 1906. Duncan was then in Europe gathering material for several books on chemistry; and, through visits of inspection to factories, laboratories and universities, and through conversations with industrialists and scientists, he had become impressed at various places with the spirit of cooperation that existed between technology and science which made for the advancement of both. At the same time, he became aware, more than ever before, of the fact that much of American chemical industry, from the standpoint of manufacturing efficiency, was in a weak condition. The absence of the application of scientific research methods was one reason for this state of affairs, and Duncan was led to propose a remedy in a definite type of industrial fellowships. His plan was to assist manufacturers who desired to break away from traditional procedure and to make even more scientific that production already well on the road from tradition to science. He decided to dedicate his life to the application of this idea.

Upon his return from Europe to accept the chair of industrial chemistry in the University of Kansas, Duncan arranged for the establishment of the first industrial fellowship in January, 1907. By 1910, his great work at Kansas created a demand for his services in Pittsburgh, which, as a large industrial center, offered his special opportunities. He therefore accepted a call from the University of Pittsburgh to inaugurate his system in this institution's department of industrial research, and the operation of the fellowships was begun in a temporary building on March 1, 1911. Duncan served the University of Pittsburgh as professor of industrial chemistry as well as director of industrial research from 1910 until his death, on February 18, 1914. Andrew W. Mellon and Richard B. Mellon, citizens of Pittsburgh and sons of Judge Thomas Mellon of the class of 1837 at the University of Pittsburgh, noted the practical success of Dr. Duncan's educational experiment and saw in his system an apparently sound method of benefiting American industry by the study of manufacturing problems under suitable conditions and by training young men for technical service. In consequence of this interest, in March, 1913, they founded Mellon Institute of Industrial Research at the University of Pittsburgh, and later placed the industrial fellowship system on a permanent basis, as a memorial to their father (1813–1908) and also to Duncan. The institute was incorporated in 1927 and its affairs are managed by its own board of trustees. The continued financial support of the Mellon family has made it possible to develop the system to its strong position at this time. The present home of the institute was occupied in 1915. The new building, a beautiful edifice that has been under construction for several years, will be ready for occupancy within a few months.

The industrial research of Mellon Institute is organized on a contract basis, the problem being set by a person, firm or association interested in its solution, the scientific worker being found and engaged by the institute, and an industrial fellowship being assigned for a period of at least one year. Each holder (fellow) of an industrial fellowship is given for the time being the broadest facilities for accomplishing a definite piece of research, and all results obtained by him belong exclusively to the founder (donor) of the fellowship. Only one investigation is carried out on a particular subject at any one time, and hence there is no duplication of the research activities of the fellowships in operation. By the application of the industrial fellowship system, the institute has been successful in demonstrating to about 3,600 American companies, either as individuals or as members of industrial associations, that research, properly conducted, is profitable to them. Most of the problems accepted for study, 1911–1935, have been solved satisfactorily. The institute has also been active in stimulating research in other laboratories and in cooperating with other research establishments, both in the United States and abroad. It is best known, however, by the successful commercial processes which it has developed (582 U. S. patents) and by its voluminous contributions to the literature of chemistry and allied sciences (18 books, 122 bulletins and 1,727 papers). During the past twenty-four years the institute has received $10,029,944 from industrial fellowship donors to defray the cost of scientific investigations conducted for these companies and associations.

DUNCAN'S BASIC WORK

My contact with Duncan began in 1907 at the University of Kansas. Subsequently as an industrial fellow at Kansas, during 1909–12, and at the University of Pittsburgh, 1912–14, I had the privilege of his direction and friendship. Duncan was a model of the advocate for scientific research, the advocate through love of science and through confidence in the realizable value of his industrial fellowship system. He was also a model of the laboratory manager, the ingeniously helpful research supervisor and the inspiring leader through love of his organization. "Whoever will be chief among you, let him be your servant," was the principle that he tried to live out. In the days when industrial research was practically unknown, company officers whom he met were entranced by his sincerity and tact and also by his literary works which he would always send them if they desired to learn more about science and its utility than he could describe in conference. It was in this

way that he succeeded in creating a new mental attitude among American manufacturers with respect to the importance of science in industry.

Leading a research organization is difficult work. It means bearing the brunt of responsibility, being forever focused seriously on the purpose in hand, and trying to influence others that they will want to take their own share of responsibility and enjoy their part of the load. In all activities and particularly in research laboratories a fine respect is accorded to the man who knows. And Duncan was so familiar with the technics of his procedure and its applicability that he had the full confidence of his donors, fellows and university associates.

As the application of the industrial fellowship system became more and more extensive, it was necessary to broaden purposes and to adopt plans of action to attain these objectives certainly and satisfactorily to all concerned. It was at this stage that coordination was essential, which meant that policies had to be prepared, transmitted, interpreted and worked out with donors and fellows as well as university officers.

Industrial Fellowship Researches at the University of Kansas

There was a group of deeply interested young chemists at the University of Kansas under Duncan's direction. Duncan made a team out of these workers and generated and fostered the spirit of cooperation that has characterized his system ever since. He once remarked: "It is simply extraordinary the way in which these fellows are able to help one another, as they are taught to do to a discreet extent." As the number of fellowships gradually increased, this power of discreet, mutual helpfulness increased in what might be called "geometrical progression." It is understood, of course, that personal integrity is the sine qua non to appointment to our fellowships, and that, in consequence, the institute is in a certain sense a fraternity.

Let us now view the results of some of this pioneer work in industrial research at Kansas. W. F. Faragher's investigation of laundering was the first American research in that field and uncovered much new information on detergency; upon the completion of this work he entered the employ of his donor. The most interesting outcome of H. A. Kohman's studies on the chemistry of bread was the preparation of the bacillus for making salt-rising bread; later Kohman engaged in the commercial production thereof, in which enterprise he has been successful. F. W. Bushong isolated naphthenic acids from petroleum and investigated their use in soap-making. E. W. Tillotson conducted his classical research on the relation between the physical properties of glass and its chemical constituents.

New Industries from Fellowship Researches

From 1910 until 1913, L. V. Redman was engaged at the University of Kansas, during the latter part of this time with two assistants, on an investigation of the combination of phenolic substances with hexamethylene tetramine. This work was completed at Kansas after the foundation of Mellon Institute and resulted in the commercial manufacture of "Redmanol." At the same time the analogous product called "Bakelite" had been developed by L. H. Baekeland. Later these two processes were united, and the institute carried on investigations of interest to this strong union, relating to the synthesis of formaldehyde and phenol.

Not long after the institute had been organized, an industrial fellowship was founded by the Prest-O-Lite Company to study acetylene. It must be remembered that acetylene lighting was an important industry at that time; electricity had not yet displaced it from the automobile. During the course of the investigation it was found that ethylene could be made cheaply by a new process, and the question of how to utilize this gas was an interesting economic problem. The world war solved this difficulty temporarily in the preparation of mustard gas, but the end of the war rendered it a comparatively useless product. Yet it seemed probable that some commercial uses for compounds from ethylene might be found, and the Carbide and Carbon Chemicals Corporation was organized to carry out these ideas. The success of this endeavor is well known, and the utilization of these ethylene derivatives, the processes of manufacture of which have been developed at the institute, has spread throughout the chemical industries.

The history of this rapid commercial development of organic compounds which but a few years ago were chemical rarities or unknown has been told by George O. Curme when he was awarded the Perkin Medal. Curme was the first incumbent of the fellowship, and for its accomplishments the interested specialist is referred to his account of this romance of chemistry. The wide uses that the materials have found have been in large measure due to work on the fellowship in describing accurately the physical properties, such as the solubility relations, of these various compounds. This basically essential activity has indicated the procedures to follow in the subsequent merchandising research in the instance of each product.

The background of the work that led to the use of acetylene as a starting point for the synthesis of organic compounds is somewhat similar to the history of the Carbide and Carbon Chemicals Corporation. Acetylene was available in quantity; research was necessary to point the way to successful commercial utilization. The growth of the Niacet Chemicals Corporation is a proof of the soundness of the investiga-

tional program. Acetaldehyde and its derivatives prepared synthetically have become available in large quantities as a result of this work. Acetaldehyde has achieved importance because of its usefulness in syntheses and its solvent properties. It serves as an intermediate for the preparation of the substances mentioned below as well as of acetic acid, lactic acid, quinaldine, chloral, chloroform, acetyl chloride, acetic anhydride and certain synthetic resins. Acetic acid is commercially the most important development of this work. Acetaldol, or "aldol," has valuable synthetic applications. Crotonaldehyde is a good solvent for many purposes and is used in many syntheses. Paraldehyde has found considerable use in the production of rubber accelerators and synthetic resins. It is also a good solvent for varnishes, fats, waxes, rosins, natural and synthetic resins and vegetable oils.

The Niacet Chemicals Corporation is now making and marketing certain of the cane sugar derivatives, and especially sucrose octa-acetate and calcium levulinate, whose processes of preparation, properties and uses were determined by G. J. Cox and his associates on the multiple industrial fellowship sustained by The Sugar Institute, Inc. Mellon Institute effected these commercial arrangements with the hearty approval of The Sugar Institute, when that organization of producers of sucrose decided it did not wish to embark in the manufacture of chemicals. This is a good example of cooperation between two fellowship donors.

In the early days we observed that, as the number of fellowships increased, a mutual helpfulness of the donors, one to another, appeared with striking results in numerous cases. These corporations did not know one another in all instances, because they mostly desired no publicity on the establishment of their fellowships; but as the business of all of them passed through the executive staff of the institute, many opportunities to aid appeared and were taken advantage of. Furthermore, quite outside the actual direct business of the fellowships, opportunities for general assistance to the donors frequently became evident and were followed. This practice has been cultivated throughout the development of the fellowship system, so that today the relations with the donors and the interrelations of these donors are extensive.

We have a saying in the institute that "once a fellow, always a fellow." By it is meant that we do not lose interest in the former incumbents of fellowships when they enter their donors' or other companies' organizations, nor do we lose interest in former donors. The former fellows and donors of the institute have proved to be our friends.

A lesson in the patience that is sometimes necessary to reap the reward of research comes from the history of the industrial fellowship that "put cotton shirts on wieners." Ten years passed between the first experimental work and commercial production, but the faith of the donor, E. O. Freund, in the ultimate success of a carefully planned research program did not succumb to the early disappointments.

The steps in the progress of this investigation are in many respects typical of the paths of industrial research. First of all, a thorough literature survey of the field of edible food containers was made. The possible raw materials were examined critically, and cellulose was finally chosen. It was then necessary to determine which process of using cellulose was most promising. The viscose process was finally shown to be most adaptable to the work, and the study was then directed to the modification of this method to the production of seamless tubing. The method of preparing the cellulose solution, the aging and the technic of making the film all required detailed study. The noncontinuous pilot plant was the next step, and then the continuous semi-plant scale manufacture. The solution of difficulties in adapting the finished product to actual use as a sausage casing required a long time. Finally, in 1926, the process was under way in the factory of the Visking Corporation, in Chicago. The production, measured in length of frankfurter tubing, has now attained 500 miles per day. The cellulose casings are, of course, edible. The fact that they do not stick to the sausage, however, is made use of in preparing skinless wieners.

When the Koppers Company was organized, the Koppers byproduct oven developed in Germany was taken over. Much applied research and engineering ingenuity were required to adapt it to American conditions, and, in addition, many improvements in plant design, new uses for products and betterment of the quality of coke were worked out. Prior to the entry of the United States into the world war, the Koppers Company conducted an energetic campaign for the installation of new byproduct coke ovens and benzol-recovery plants. It is probable that the greatest service of the institute to national defense was rendered in research on the recovery of toluene from carbureted water gas. The solution of this problem was reached in a short time, and toluene was soon available at a rate of 1,000,000 gallons per year. When the special demand for this hydrocarbon ceased at the close of the war, the fellowship developed a new method of gas purification in which much of the toluene-recovery equipment is employed. The same process is now in use for natural gas. Additional liquid purification procedures have been developed which permit the recovery of finely divided sulfur and other salable products.

The fellowship of the Koppers Company led to the formation of the Koppers Research Corporation,

which was active from 1930 to 1934. I will now point to an especially notable illustration of the conversion of a fellowship into a research corporation with extensive facilities.

In 1927 the Gulf Production and Pipe Line Companies, a subsidiary of the Gulf Oil Corporation, of Pittsburgh, founded a multiple fellowship in the institute for the purpose of investigating major problems in the winning, storage and transportation of crude petroleum. Paul D. Foote, a pure scientist who had distinguished himself by his researches in physics at the Bureau of Standards in Washington, D. C., was selected for the senior incumbency of this fellowship. After surrounding himself with competent assistants it did not take long for Foote to demonstrate many ways in which science and particularly chemistry and physics could be applied in the business of his donor. A number of researches relating principally to metallurgical and corrosion problems and to drilling practice were begun and carried through to successful conclusion. In 1929 this fellowship had increased its personnel to such an extent that it was decided to erect a laboratory building near the institute in Pittsburgh. This step was taken and the building was occupied early in 1930. Shortly thereafter the Gulf Research and Development Corporation was organized, with Foote as the executive vice-president. Throughout the past five years Foote's team has continued its creative work and last year it was found to be necessary to construct a group of three new laboratory buildings at Harmarville, Pa., near Pittsburgh, to house this staff and its equipment. These buildings, which were occupied last April, contain over four times as much floor space as the first building. In January, 1930, the Gulf Laboratory had ninety scientists and engineers. In April, 1935, the staff numbered 450 (including 200 specialists at work in the field). This is an impressive instance of industrial research progress during the depression.

Processing Research—New Processes

The institute's researches on new processes of manufacture have been in effect basic production investigations; they have embraced the development of more economical chemical and physical processes and the evolution of more efficient apparatus and special mechanical appliances. The researches on the improvement of present processes have included the application of the fundamental sciences associated with the industries, aiming at the prevention of industrial wastes, the elimination of difficulties in practice, the standardization of methods and the lessening of costs of operation.

Among the broadest investigations conducted at the institute have been the researches on improving flotation processes, especially for low-grade copper ores and for solid fuels. Some of these researches eventuated in the discovery of a number of new organic flotation agents. The experimental work in hydrometallurgy was scopeful, particularly during the period 1912–1915. New processes in the domain of metallurgy have related to the dealuminization of iron ore and to iron casting. A type of permanent molds for making iron castings was developed to the commercial stage. A fellowship worked out a method of chrome-plating aluminum that is in successful use.

For many years there was a multiple fellowship on fertilizer technology that had numerous accomplishments to its credit—a new contact process of making sulfuric acid, the preparation of available phosphates from phosphate rock, and the removal of fluorine from that mineral being its outstanding achievements. Recently the institute has begun research on another phosphate—sodium metaphosphate—and has devised uses for it as a water-conditioner or calcalyst (alkaline-earth soap solvent) and soap-saver in laundering ("Calgonizing"), textile processing and other operations. The novel "Hommelaya" enameling process is another late development, which is a reminder that a few years ago another fellowship invented a new sanitary enameling process that is employed to a large extent and still another fellowship discovered a method of pretreating steel to minimize hydrogen-occlusion in pickling. This latter work was done before the days of inhibitors, which we have likewise studied quite thoroughly. Wood-preserving has been investigated with commercially important results in research on zinc salts, several new processes coming from this fellowship.

The institute's fellowship on natural gas was founded in 1914 and has been active ever since. Perhaps its chief creations are processes of separating gasoline and of recovering butane and propane from natural gas. Another old fellowship—the multiple fellowship on petroleum—established in 1911 has a record that is impressive; it has had a number of prominent chemists at its helm—R. F. Bacon, B. T. Brooks, Harry Essex, W. F. Faragher and W. A. Gruse—and has contributed importantly to most of the chapters of petroleum technology. Its processes of pyrolysis and distillation are mentioned here in passing. Other organo-chemical processes evolved by fellows working at the institute pertain to beet-sugar waste recovery and utilization, paper finishing, vegetable adhesive manufacture and the production of liquid glue and keratin.

Unit Plants

Mention will be made here of the institute's "large-scale equipment." When a process, developed during

the course of a fellowship, demands apparatus of special type, which is not available in the donor's factory, a unit plant is built. This plant is of such a size and is constructed in such a way that, when it is running smoothly, the donor will feel justified in adopting its plan and investing sufficient money to put in a very much larger unit or, it may be, several units. Since 1912 many donors have authorized us to build unit plants to develop processes worked out in the laboratories of their fellowships. In no case has money for unit plants been provided in the original foundation of these fellowships; but in every instance, after discussing the subject, the donor has felt that the progress of the work and the results obtained appeared sufficiently promising to justify the expenditure of money for further development. In the case of a number of these small plants in which processes have been developed, and where the processes have gone into the commercial scale of operation, the plants are still available, being located in small, temporary buildings near the institute; and such unit plants can often be adapted to the study of other new processes. The institute has thus been gradually acquiring "large-scale equipment" that will be placed in fully adequate quarters in the new building.

A Few New Products

Many fellowships have had for their problems the creation and/or development of new products, including the working out of methods of preparation, the devising of satisfactory processes of manufacture, the discovery of commercial uses and helping to introduce the products to the professions, trades and public. I will give here some examples of this type of research.

"Arkady" yeast food, well known to American and British baking technologists, was among the first products of this class. Another creation of H. A. Kohman and his coworkers was a new shortening composition. About the same time other fellowships invented a novel composition flooring and a new dental cement. In April, 1915, J. B. Garner, a fellow of the institute, devised a gas mask, utilizing the adsorbent property of especially activated carbon, that was adopted by the U. S. Army after endorsement in Great Britain. The institute has had a fellowship on insecticides for about twenty years, and a dry lime-sulfur product, new forms of calcium arsenate and lead arsenate and the special pyrethrum extract known as "Fly-Tox" have resulted from its activities. From the researches of other fellowships of a decade ago came new detergents, perfumes and artificial waxes. Fatty acid salts of cinchona alkaloids were demonstrated to be mothproofing agents; a new branch of manufacture was founded on the successful production of silk racquet strings; a series of organic rubber accelerators was originated; formulas for a number of emulsion flavors were developed. Subsequently Heinz rice flakes and Heinz breakfast wheat, two breakfast foods, and more recently Heinz strained vegetables were created. And another late food contribution is flaked coffee.

New paper toys, specialty papers, envelope adhesives; "Alumino Hi-Temp," a heat-insulation; "Plaskon," an aminoplastic now in wide use; a new iodine antiseptic; Robertson "Keystone-Beam" steel flooring, Robertson bonded metal and "Tile-Faced" Robertson protected metal, which have recently been described in the literature; "Vici Special," a leather possessing high scuff-resisting properties; a new safety-fuse; slag products for constructional purposes; and "Thor" core binder for foundry use, have also resulted from fellowship investigations.

Advancement of Industrial Operations

A large number of fellowships have added usefully to chemical and physical technology by contributing solutions to production problems and particularly by improving manufacturing practices. Such widely different industrial fields as food packing, yeast, cosmetics, dry cleaning, mercerization, roofings, galvanizing, silverware, steel products and glassware have been quite thoroughly explored. The results of investigations of the vitrified sewer pipe fellowship led to important economies in fuel consumption in that industry. Special refractories for the zinc industry and other metallurgical purposes and for the manufacture of glass have been developed. The production of safety razor blades has been improved. New heating devices have been worked out. The manufacture of fiber containers has been studied with beneficial results.

The best known series of researches of this type related to laundering. The Laundryowners National Association supported fellowships in Mellon Institute during the period 1917–1931, and the incumbents aided importantly in applying science in laundry technology and in otherwise helping the laundry industry. One of the most useful results of this work was the system of standard practice for the power-laundry washroom, which, after thorough trial and demonstration of its practical value, was published in book form. A treatise on "Textile Fabrics," by George H. Johnson, was also written on the basis of some of the studies of the fellowships; and numerous papers descriptive of other phases of the activities were published in periodicals. The Department of Research and Tests of the Laundryowners National Association, which is located at the American Institute of Laundering, Joliet, Ill., is the outgrowth of these fellowships.

On the fur fellowship, which was sustained during the period 1926–1932 by the American Hatters Fur Cutters Association, the purpose was to develop a

method of preparing fur for felting that would avoid health hazards in hat-making by the elimination of mercury from the process and furnish light fur of a better color by the substitution of other reagents for nitric acid. Both of these objectives were achieved and the new methods of carroting gradually found their way into production in the plants of the association members. An equally important accomplishment of the fellowship was the formulation of a rational explanation of the carroting process.

NEW USES FOR OLD INDUSTRIAL PRODUCTS

One of the objectives of many fellowships has been to gain new knowledge respecting the properties and commercial utility of various commodities. In these activities laboratory investigation has collaborated with market research in finding new ways to increase sales. In studies in this field results of value have occasionally come directly from and have always been hastened by the advisory assistance of specialists on other fellowships of the institute.

Many donors of fellowships are constantly investigating the fitness of their products to the uses to which they are being put. These companies have raised mass production to a quality stage. Technical service studies of how such products as refractories, alloys, lacquers, plastics, insulating materials, gasoline and lubricants are satisfying the requirements of users have resulted in many improvements in these products. A recent instance in the institute has been the development of a new form of carbon black lacquer base ("Coblac"), produced as a result of several years of fundamental research work. The basic investigation of the dispersion properties of carbon blacks led to the development of a method for colloidally dispersing carbon black pigments in lacquer vehicles; this colloidal dispersion resulted in markedly improved properties for the black lacquer. The use of this new lacquer base enables the manufacturer to prepare superior black lacquers by simply dissolving it and formulating this solution with stock solutions to give the desired product. It also eliminates the troublesome and unsatisfactory pebblemill grinding of carbon blacks, because the carbon black is dispersed in the new base and retains this colloidal dispersion during subsequent solution and formulation. The superiority of such black lacquer is amply demonstrated. The pigmented lacquers prepared with this new material show remarkable improvement in color (blackness), color tone (black instead of the usual brown or gray cast), stability of pigment dispersion, remarkably increased resistance to ultraviolet exposure and weathering and surprisingly superior gloss properties. This specific improvement is an illustration of the desire of the manufacturer to put into an old product all the properties most wanted by the user of the material.

A number of years ago a fellowship had for its problem the creation of new uses for carbon dioxide and secured new information regarding the carbonation of beverages, the employment of carbon dioxide in fire extinction and the production of solid carbon dioxide. Edible gelatin was also studied broadly for the purpose of extending its uses, and this comprehensive research threw new light on the nutritional value of gelatin and its utility in the confectionery and food industries. New uses for carborundum are being sought by a fellowship now in operation and from this investigation has come the utilization of carborundum in novel types of refractories. In exploring the field of likely uses for magnesia, a fellowship found markets therefor in the rubber and pharmaceutical industries. Another fellowship has been active for a long time in effecting improvements in magnesia heat-insulation. Nickel and nickel alloys were studied by a fellowship for the purpose of securing detailed information regarding their properties, for the guidance of market research specialists.

Other industrial products for which fellowship investigations have found new uses are wood chemicals, naval stores, rosin oil, stearic acid and oleic acid (the development of triethanolamine oleate and the application of oleic acid in the textile industry). New applications have also been found for sodium bicarbonate and sodium chloride. Quite recently our multiple fellowship on sulfur learned that acid-resistant cements, made by combining sulfur with an aggregate, could be improved by the addition of certain olefine polysulfides. With the aid of these sulfides, sulfur cements can be made resistant to deterioration by fluctuating temperatures and can also be produced in varying degrees of plasticity. Such cements can be applied as bonding agents or as protective coatings in structures subjected to acids or corrosive solutions. The production of such modified sulfur cements has been undertaken by a company, according to arrangements made by the fellowship donor.

RESEARCHES ON STANDARDIZATION

Various fellowships have been active in the field of standardization. Standardization is generally regarded as one of the easiest approaches to greater technologic efficiency, and in our work we have had opportunities to aid certain industries to set up standards for production as well as for products. Much of this work has involved the development of analytical methods, physical testing procedures and factual information for use in the preparation of specifications. Years ago asbestos products were given thorough

attention by one of our fellowships, and later other fellowships investigated floorings, vitrified tile and writing inks from the standpoint of standardization. But the best known and most useful activities in this field have been on the fellowships relating to heat insulation, petroleum products, plastics and refractories. The incumbents of these fellowships have served on various organizational committees concerned with standardization and particularly on committees of the American Society for Testing Materials.

In illustration of such investigations, I will describe briefly some of the results of the work of the multiple fellowship of the American Refractories Institute, which has a productive history of about twenty years. The staff of this fellowship, headed by S. M. Phelps, has studied methods of measuring brick and has investigated the tolerance that should be used in preparing specifications. These scientists have devised an accurate portable instrument for the measurement of 9-inch brick that has the advantage of not being subject to the personal factor of ordinary measuring. From the data obtained in measuring a very large quantity of brick as manufactured throughout the United States, size tolerances for 9-inch brick and special shapes have been computed. This fellowship has also contrived precise and speedy methods for the estimation of alumina, iron and alkalies in refractories. Other research has led to the development of what is known as the panel spalling test, the principle of which is to expose for treatment a section of the furnace wall rather than individual brick. This test has been accepted by the industry and is now a part of the A. S. T. M. methods; the rather extensive testing equipment necessary for the procedure has also been adopted.

Some Researches for Public Good

The institute has conducted a number of researches for the benefit of the professions and of the public—investigations not usually suggested by companies, but comprehensive studies in the realm of pure science—by the financial support of the institution and through grants made by other organizations and science-minded persons. All the results of such researches are published and the literature so produced is given wide distribution.

The first of these investigations, on smoke abatement, was started in 1911 and lasted for three years. A strong staff of scientists and advisory specialists studied all phases of the urban smoke problem, and their findings were reported in nine bulletins and many journal articles. This research was recognized as of such great importance, not only to the city of Pittsburgh but to every industrial city, that the work was resumed in 1923–24 and reestablished in 1928. Since then this fellowship or air pollution investigation has become a helpful information bureau for organizations that need advice and other assistance in smoke and dust control movements and has carried out useful research on capnometry, or smoke measurement, the estimation of natural ultraviolet light, the determination of the light-screening effects of smoke and dust particles and the occurrence of carbon monoxide and sulfur dioxide in city air. Three sootfall studies have been made in Pittsburgh since 1911, the last and most extensive in 1929–30. The outstanding result of the work thus far is to show plainly that the present smoke abatement methods are utterly inadequate to cope with the problem. The great proportion of combustible and ash in the solids at low levels demonstrates the necessity for elimination at the source. H. B. Meller, the head of this investigation, has been collaborating with specialists of other organizations in evolving plans to solve this problem.

The need for knowledge relative to the pertinent factors in the cause and prevention of dental caries brought about the foundation of a multiple fellowship in 1923. The studies of this fellowship, which were continuous for nine years, were conducted with the cooperation of specialists in the School of Dentistry of the University of Pittsburgh. It was found by J. J. Enright and his associates that local environmental conditions are the main factors in the active causation of decay of fully erupted enamel and that deficient diet and defective nutrition are the important factors during the developmental period of the teeth in that these are responsible for the construction of teeth more susceptible to the action of the acids of fermentation. These studies also indicate that improper diet and defective nutrition are of some though minor importance as a predisposing factor in caries of enamel, being responsible for an environment of saliva low in calcium phosphate content. It was determined that *Lactobacillus acidophilus,* Y type, is the micro-organism commonly found in the food debris in direct contact with areas of progressive caries of the enamel. This fundamental research has received the highest commendation of dental authorities.

During 1934 G. J. Cox and Mary L. Dodds conducted some studies of the basic causes of tooth decay. In consequence of their investigational findings they pointed out that there is thereby suggested the existence of a factor which, if present in the diet during a critical period of tooth formation, will aid in the construction of teeth resistant to decay. This research is being continued along broad lines, as a pure science investigation, through a grant from The Buhl Foundation of Pittsburgh.

During the period 1924–1932 the institute carried out a comprehensive investigation of sleep, headed by

H. M. Johnson, under a grant from the Simmons Company, of New York, N. Y. Perhaps the most important experiments embraced the kind of bodily positions in which healthy persons sleep, the time that each position is held, the order in which they are taken, and the modifications of postural habits that may be effected by substituting one typical combination of bed springs and mattress for another. A greatly improved photographic recorder was invented, developed and used in these studies. The results show that a given individual may have a repertoire of a dozen or more sleeping postures that differ grossly from each other. On a typical night he resorts to nearly every one of them one or more times, unless he is physically restrained. Some of these poses are favored by nearly all sleepers; but most of the others may be divided into two groups, one of which is favored by one class of sleepers and avoided by a second class, and vice versa. It is normal for an adult to make from twenty to forty or more gross changes of posture on a typical night while children shift more often. Each pose appears to be well chosen, if considered with reference to the irritation that was set up by tenure of other poses recently taken. Poorly designed bedding equipment may limit the variety of postural changes without decreasing the number. This effect is far more important for some sleepers than for others. In many instances no important effect was found. If the sleeper was provided with a good upright coil bed spring and a good interior-spring mattress, no restful poses appeared to be discriminated against.

Throughout the period 1926–1931 there was in operation a fellowship that investigated searchingly the effects of aluminum on foods. An extensive study of pasteurizing or boiling milk in aluminum showed the metal to be entirely without specific effect in the destruction of vitamin C. Another research was concerned with the absorption of aluminum from the alimentary tract. Analysis of the tissues of animals that had consumed foods containing as much as a hundred times the amount of aluminum which would come from utensils by corrosion revealed the naturally present aluminum to be only very slightly increased. Many of the animals subsisted on the aluminum-containing diets continuously for 18 months. The results of the entire investigation proved that aluminum is not a poisonous metal and does not give rise to any disease, that aluminum utensils are very resistant to corrosion by foodstuffs cooked therein, and that aluminum does not accelerate the destruction of vitamins or other food accessory substances during cooking.

Training for Industrial Service

The institute has lately been giving more and more attention to the important branch of industrial research that treats of the personal and official duties of the investigatory staff, in distinction from the better developed subject of systematic research, which deals with literature studies, planning and experimental methods.

This branch has a valuable place in training young scientists for industrial and public service, principally because it imparts a large amount of useful information, largely gleaned from the experience of the institute's executive staff, that is not acquired in scientific courses in the universities. All fellows of the institute are instructed in business correspondence and in commercial procedures in general, in technical reporting, in the minutiae of professional ethics, and, most important of all, in the psychology of the industrial mind. The relative prominence accorded to this subject makes it gradually easy for a young scientist of correct attitude to appreciate the industrial point of view. It teaches him to convey to the industrial executive the ideas of science and the results of research in a manner and language that can be easily comprehended. In industrial research, particularly in the practical connections with the companies sustaining their fellowship work, the art of making and keeping contact and of promoting cordial relations is of constant utility to the fellows. It is of great aid in securing essential cooperation and in gaining the confidence that results, of course, primarily from research accomplishment and technical merit. All successful industrial research is built upon trust.

Department of Research in Pure Chemistry

The institute has funds that enable it to sustain a Department of Research in Pure Chemistry, which was established in 1927 and has since been headed by L. H. Cretcher. This department is concerned with the investigation of important chemical problems of strictly scientific interest. Its aim is to contribute to the advancement of the science and profession of chemistry and to aid advisorily industrial fellowships of the institute. This attitude is the result of altruistic motives and of the realization that fundamental chemical studies are essential as a background and stimulus for industrial research. So far the researches have been entirely in the province of organic chemistry, but in the institute's new building the scope of this department's activities will be widened to embrace other branches of pure chemistry.

In 1931 the department started researches in the field of the cinchona alkaloids, which, it was hoped, might eventuate in the discovery of compounds possessing therapeutic usefulness. During 1932–3 many new cinchona derivatives were evaluated therapeutically, in cooperation with internists, especially in the

treatment of pneumonia. This work was continued during 1933–4 and a large number of preparations were tested for toxicity, protection against lethal doses of pneumococci in animals and pneumococcocidal power in vitro. Throughout the period 1933–35 many biological and clinical data were accumulated by the medical collaborators, Dr. W. W. G. Maclachlan and his associates, Drs. H. H. Permar, John M. Johnston, Joseph R. Kenny and H. B. Burchell. To date the most interesting compounds studied, from the medical point of view, have been hydroxyethylhydrocupreine, apoquinine, ethylapoquinine and hydroxyethylapoquinine. C. L. Butler, Alice G. Renfrew and B. L. Souther, assisted by Mary Hostler, are conducting these chemical studies of cinchona derivatives under Cretcher's direction.

For six years Mellon Institute has been supporting broad investigational work in the Institute of Pathology of the Western Pennsylvania Hospital in Pittsburgh, through arrangements made by Dr. C. B. Schildecker. These studies, which are being carried on by a group of scientists under the direction of Dr. R. R. Mellon, relate mainly to the treatment of pneumonia and allied pulmonary diseases and have resulted in the production of an apparently effectual antipneumococcic serum. Considerable advancement has also been made in an anti-streptococcic serum.

A Word of Appreciation

As the director of an industrial research institution, it has been my pleasant task to assist in infusing science in technology and particularly in the chemical industry. My problem has been twofold—to convince manufacturing organizations of the functions of scientific research and research management in the industries, and to aid in educating the public to a greater appreciation of the value of science. This problem is only partially solved; I can merely report progress. But the fellows of the institute have made themselves felt as an integral group in the industrial body; and their accomplishments are not only inspiring, they are facilitating greatly my own work. Thanks to these fellows, Mellon Institute is regarded generally as a strong link between the world of science and the industries. What about the future? I believe that all of us at the institute will have much greater encouragement and opportunities and that we shall be able to do many more useful things when we have the advantage of working in our new building with its splendid facilities for research in pure as well as applied science.

OBITUARY

HARRY SCHELWALDT SWARTH

By the death at his home in Berkeley, California, on October 22, of Harry Schelwaldt Swarth, at the age of fifty-seven, ornithology has been deprived of one of its most devoted and able workers.

Mr. Swarth was born in Chicago, Illinois, on January 26, 1878, and was educated in the schools of that city and Los Angeles, where his parents moved in 1891. His interest in natural history manifested itself early, and under the guidance of G. Frean Morcom every opportunity was afforded for its development.

In 1896 he made a field trip to Arizona, by which he initiated the work in that state which he carried on intermittently until his death, and which resulted in his "Birds of the Huachuca Mountains," "Distributional List of the Birds of Arizona" and "Faunal Areas of Southern Arizona."

The Klondike gold rush drew him to the north in 1898, and then there was awakened his interest in this region that took him back again and again to Vancouver Island, to the Sitkan region, to the Stikine and Skeena valleys and to Atlin, where he had planned to end his days. These trips were very productive, and gave him material for many papers, notably his "Birds and Mammals of the Stikine River Region of Northern British Columbia and Southeastern Alaska," "Birds and Mammals of the Skeena River Region of Northern British Columbia," "Report on a Collection of Birds and Mammals from the Atlin Region" and (in conjunction with Major Allan Brooks) "Distributional List of the Birds of British Columbia."

During the years in which this work was being carried on, Mr. Swarth had served as assistant in the department of zoology, Field Museum (1905–08); curator of birds, Museum of Vertebrate Zoology, University of California (1908–12; 1915–27); and assistant director, Museum of History, Science and Arts, Los Angeles (1913–15).

His years at the Museum of Vertebrate Zoology were very productive ones. In addition to the many papers on northern faunal areas, he published independently and in collaboration with Dr. Joseph Grinnell many papers on the birds and mammals of California and Lower California, and revised several groups. Among the more important of them was his "Revision of the Avian Genus Passerella."

The Cooper Ornithological Club was, from its inception, one of Mr. Swarth's strongest interests and, whether in Berkeley or in Los Angeles, he participated in its activities. He was treasurer of the Southern Division from 1898–1903, vice-president of the Northern Division in 1921 and president in 1922. In 1910 he became associate editor of *The Condor*, and this office he continued to fill until 1927. His "C. O. C., 1893–1928," is indispensable to one desiring a proper understanding of this organization and its activities.