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SOME AMERICAN CONTRIBUTIONS TO TECHNICAL CHEMISTRY.*

THE inventive genius of the American people is universally conceded. The necessity of accomplishing things quickly, incidental to the growth of a new country, such as ours, has naturally led to the invention of many forms of labor-saving machinery, and so with improved appliances have come improved methods. The technical chemist is, however, less fortunate than his brother in the professorial chair whose merits are made known by his students, thus attracting an ever-increasing following to his laboratory, and perhaps he is also less fortunate than his associate who devotes himself to research work; for to him are given medals and honorary memberships which are properly the 'blue ribbons' of science; hence it is that the discoveries of the technical chemist, especially where they are commercially meritorious, remain too frequently unknown, and the profits of the improvement go to swell the dividends of the corporation to which he owes his allegiance while he receives no public recognition. It naturally follows, therefore, that any summary of the achievements in the development of technical chemistry must be very incomplete.

To say when chemistry begins is not generally possible, for its origin wanders back into alchemy and pharmacy on the one side and into physics on the other, and there are no sharp lines of separation among the

* An address delivered before the Congress of Arts and Science, St. Louis, September, 1904.

various branches of science, for they gradually merge one into the other. In this country, however, we have grown to accept the date of the arrival of Joseph Priestley, June 4, 1794, as a most excellent time at which to begin the modern history of chemistry.

The younger Silliman's masterly 'American Contributions to Chemistry'* gives me the right, therefore, to mention first Benjamin Thompson, Count Rumford (1751-1814),† whose studies in heat and fuel were as practical as they are important. His early knowledge of science was acquired from John Winthrop (1717-1779), who held the chair of mathematics and natural philosophy at Harvard from 1738 till his death. Of Count Rumford I have said elsewhere:‡ 'He investigated the properties and management of heat, and the amount of it that was produced by the combustion of different kinds of fuel, by means of a calorimeter of his own invention.' By reconstructing the fireplace he so improved the methods of warming apartments and cooking food that a saving of fuel of almost one half was effected. He improved the construction of stoves, cooking ranges, coal grates and chimneys, and showed that the non-conducting power of cloth is due to the air that is enclosed in its fibers. Silliman well says of him: 'No writer of his time has left a nobler record of original power in physical science than Rumford.' It will also be remembered that by will he provided funds 'to teach by regular courses of academical and public lectures, accompanied by proper experiments, the utility of the physical and

* *American Chemist*, V., 1874, p. 70.

† See 'Memoir of Sir Benjamin Thompson, Count Rumford, with Notices of his Daughter,' by George E. Ellis, also 'Complete Works of Count Rumford,' 4 Vols., published by the American Academy of Arts and Science (Boston, 1876).

‡ 'Cyclopædia of American Biography,' V., p. 345, article Rumford, Benjamin Thompson, Count.

mathematical sciences for the improvement of the useful arts, and for the extension of the industry, prosperity, happiness and well-being of society.* Let me also remind you that Wolcott Gibbs, the oldest and now the Nestor of American chemists, held the Rumford chair in the Lawrence Scientific School of Harvard from 1863 till 1888, during which time many of those who are now leaders in chemistry were students under him.

The last century was only a year old when Robert Hare (1781-1858) communicated his discovery of the oxyhydrogen blowpipe to the Chemical Society of Philadelphia. This instrument held a foremost place for the production of artificial heat until the recent introduction of the electric furnace. The application of the principle invented by Hare still finds extensive use for lighthouse illumination and similar purposes under the names of 'Drumond light' and 'calcium light.' It is interesting to recall in this connection that Hare was the first to receive the Rumford medals from the Academy of Arts and Sciences.

Hare was also the inventor in 1816 of a calorimotor, a form of battery by which a large amount of heat was generated, and four years later he modified this apparatus, with which, then known as Hare's deflagrator, in 1823 he first demonstrated the volatilization and fusion of carbon. His memoir on the 'Explosiveness of Niter,' which was published by the Smithsonian Institution in 1850, was one of the earliest contributions by an American to the literature of explosives.†

The original discovery of chloroform is clearly of American origin and must be

* *American Chemist*, V., 1874, p. 73.

† 'Smithsonian Miscellaneous Collections,' II., 1895. Also see the memoir of him by the elder Silliman in the *American Journal of Science* (2), XXVI., 1858, p. 100.

credited to Samuel Guthrie (1782-1848), of Sacketts Harbor, N. Y., whose researches anticipated those of Soubeiran, Liebig and Dumas by nearly a year.

A committee of the Medico-chirurgical Society of Edinburgh gave him the credit for having first published an account of the therapeutic effects of chloroform as a diffusive stimulant. Dr. Guthrie was likewise the inventor of a process for the rapid conversion of potato starch into sugar. He also experimented with considerable boldness in the domain of explosives, inventing various fulminating compounds, which he developed commercially.*

It would be an ungracious task to discuss in this paper the much-controverted 'ether discussion,' but I may say, without fear of doing injustice to any of the several claimants for the honor of the discovery of this important anesthetic, that Charles Thomas Jackson (1805-1880), said to be one of the foremost chemists of his time in this country, claimed from experiments made by himself during the winter of 1841-2 in his own laboratory, that he obtained results showing 'that a surgical operation could be performed on the patient under the full influence of sulphuric ether without giving him any pain.' Four years later (in 1846) this was successfully accomplished by Dr. William T. G. Morton, who had studied chemistry in Dr. Jackson's laboratory. The French Academy of Sciences decreed one of the Montyon prizes to Jackson for his discovery of etherization, and one to Morton for his application of that discovery to surgical operations.†

* An account of his career has been published in pamphlet form by his descendant, Ossian Guthrie.

† Dr. Jackson published a 'Manual of Etherization with the History of this Discovery' (Boston, 1861) and much interesting information is to be had from a 'Report of the House of Representatives of the United States of America, vindicating

Metallurgy is little more than the application of chemical knowledge to the extraction of metals from their ores, and I, therefore, beg to claim for the United States the first commercial production of steel. Zerah Colburn, the well-known engineer, gives William Kelly (1811-1888), an iron master of the Suwannee furnaces of Lyon County, Ky., the credit for the 'first experiments in the conversion of melted cast iron into malleable steel by blowing air in jets through the mass in fusion.' Later, when Sir Henry Bessemer made efforts to secure the patent of the process that bears his name, it was decided by the U. S. Patent Office that William Kelly was the first inventor and entitled to the patent, which was promptly issued to him. In 1871, when application was made for a renewal of the patents originally issued to Bessemer, Mushet and Kelly, the last was successful, while the claims of the first were rejected.*

The successful electro-deposition of nickel and its commercial development are chiefly due to the energy of Isaac Adams (1836-), a resident of Cambridge, Mass. He carefully studied the subject and found that the failure to obtain satisfactory results was caused by the presence of nitrates in the nickel solutions previously used. His invention gave rise to prolonged litigation, but in the end he was victorious. Dr. Chandler thus describes it in the fol-

the rights of Charles T. Jackson on the Discovery of the Anesthetic Effect of Ether Vapor.' The other side of the controversy is given in 'The Discovery of Modern Anesthetics: By whom it was made?' by Laird W. Nevius, New York, 1894.

* Much has been written of the claims of Kelly and nearly all of the leading American metallurgists agree in conceding his priority. Swank and various writers in the *Transactions of the American Institute of Mining Engineers* may be consulted. Kelly's own story, as he gave it to the present writer, appears in the *Iron Age*, February 23, 1888, p. 339.

lowing words: "The novel proposition was presented to the court, of a patent for not doing something, namely, for not permitting nitrates to find their way into the nickel solutions employed in nickel plating, and the court held that the exclusion of nitrates was an essential condition of successful nickel plating, and that a process involving this condition was just as patentable as a process involving any other special condition necessary for successful execution, and the patent was sustained."*

In passing I may mention the name of Joseph Wharton (1826-), whose experiments in producing nickel in a pure and malleable condition so that it could be worked like iron culminated in the first production in 1865 of malleable nickel.

Chemistry owes a great debt of gratitude to the genius of Thomas Sterry Hunt (1826-1892) and one of his most notable contributions to technology is the permanent green ink which he invented in 1859 and which is used in the printing of our national bank notes and from the appearance of which the well-known term of 'greenback' was derived. The Hunt and Douglas process for the precipitation of copper by iron, for a time so extensively used for the extraction of copper from low-grade ores, is an invention the credit of which he shares with the well-known metallurgist, James Douglas.

The vulcanization of india rubber by sulphur is the invention of Charles Goodyear (1800-60), who was so persistent in his efforts as to become an object of ridicule. Indeed, he was called an india rubber maniac and was described as a 'man with an india rubber coat on, india rubber shoes, and in his pocket an india rubber purse, and not a cent in it.' His invention consisted in mixing with the rubber a small quantity of sulphur, fashioning the

articles from the plastic material and curing or vulcanizing the mixture by exposure to the temperature of 265-270° F.*

Of almost equal importance was the invention of hard rubber or vulcanite, for which Nelson Goodyear (1811-57), a brother of Charles Goodyear, obtained a patent in 1851, claiming that the hard, stiff, inflexible compound could be best obtained by heating a mixture of rubber, sulphur, magnesia, etc., but this never became an article of commerce. In 1858 Austin Goodyear Day (1824-89) patented a mixture of two parts of rubber and one of sulphur, which, when heated to 275-300° F., yielded the flexible and elastic product now generally known as hard rubber.†

Dr. Leander Bishop has said: 'In the art of modifying the curious native properties of caoutchouc and gutta percha, and of molding their plastic elements into a thousand forms of beauty and utility, whether hard or soft, smooth or corrugated, rigid or elastic, American ingenuity and patient experiment have never been excelled.‡

Exceedingly valuable to the industries of this country was the influence of James Curtis Booth (1810-88), who from 1849 till his death was melter and refiner in the U. S. Mint. In 1836 he established a laboratory in Philadelphia for instruction in chemical analysis and chemistry applied to the arts, and in the course of a few years gathered around him nearly forty students, among whom were Martin H. Boyé, John F. Frazer, Thomas H. Garrett, Richard C. McCulloh and Campbell and Clarence Morfit, all of whom have achieved eminence as chemists. It was said of him, 'that Mr.

* His life has been published by Bradford K. Peirce with the title, 'Trials of the Inventor,' New York, 1860.

† *American Chemist*, II., 1872, p. 330.

‡ 'A History of American Manufactures,' by J. Leander Bishop (Philadelphia, 1860).

* *Journal of the Society of Chemical Industry*, XIX., 1900, p. 611.

Booth had few, if any, superiors as a teacher of practical chemistry.' From 1836 till 1845 he held the chair of chemistry applied to the arts in the Franklin Institute, delivering three courses of lectures extending over three years each. He was the author of an 'Encyclopædia of Chemistry' (Philadelphia, 1850) and with Campbell Morfit of a report 'On Recent Improvements in the Chemical Arts,' published by the Smithsonian Institution in 1852. His appointment to the mint was coincident with the discovery of gold in California, and the new processes required to prepare the bullion for coinage were largely of his own invention and many of them, to use his own words, 'were not known outside the mint.'*

It is well known that prior to 1850 and for some time thereafter Philadelphia was the acknowledged center for the manufacture of chemicals for medicinal use. To collect the details of the many improved methods for the production of these chemicals would be a long and difficult task, and would require more space than I have at my command in this article. The names of such firms as Powers, Weightman and Rosengarten and Sons are readily recognized as those of manufacturers of standard chemicals. M. I. Wilbert has recently published a paper, entitled 'Early Chemical Manufacturers: A Contribution to the History and Rise of the Development of Chemical Industries in America,' to which I must refer you for further information concerning their growth and progress.†

I am reminded in this connection that the name of Edward Robinson Squibb

(1819–1900) is one well worthy of deserved recognition among manufacturers of chemicals. The ether prepared by him by processes of his own invention has long been accepted as standard. For a brief period during the early fifties of the last century Dr. Squibb was associated with J. Lawrence Smith (1818–83) in Louisville, Ky., in the commercial production of chemical reagents and of the rarer pharmaceutical preparations.* It is also proper to add the name of the Baker and Adamson Chemical Company of Easton, Pa., as that of a corporation which has established a reputation for the manufacture of pure chemicals by processes, many of which are of their own devising. The success of this young firm is generally admitted to be due to Edward Hart (1854–), who fills the chair of chemistry in Lafayette College.

Eben Norton Horsford (1818–93) made distinct contributions to technical chemistry and among these may be mentioned his invention of condensed milk. According to Charles L. Jackson, he originally prepared this most valuable article of food for use in Dr. Kane's Arctic expedition and afterwards presented the process to one of his assistants, who then sold it to Gail Borden. His name, however, is more commonly associated with his invention of a phosphatic yeast powder, the object of which is to return to the bread the phosphates lost in bolting the flour, and which, as is well known, form such an essential constituent of the food of animals. He also devised 'a marvelously compact and light marching ration of compressed beef and parched wheat grits,' which found some use at the time of the Civil War, and his name is also attached to the preparation

* A sketch of his career by Patterson Du Bois was presented before the American Philosophical Society on October 5, 1888, and has since been issued as a separate of eight pages.

† *Journal of the Franklin Institute*, CLVII., 1904, p. 365.

* See 'Original Researches in Mineralogy and Chemistry,' by J. Lawrence Smith (Louisville, Ky., 1884), p. xxxviii.

of 'acid phosphate,' so commonly used with summer beverages.*

The development of the mineral resources of our country has been due largely to those who from their knowledge of chemistry were able to recognize the commercial value of the natural deposits in the vicinity of their homes. This has been conspicuously the case with the great fertilizer industry of the south, and especially so in South Carolina, where the names of Charles Upham Shepard (1804-86) and St. Julien Ravenel (1819-82) are recognized as those of pioneers in that important branch of chemical industry.

To quote from Silliman again, and he is always an acceptable authority, "No observation or original research of Dr. Shepard has been fruitful of so much good in its consequences as his discovery of the deposits of phosphate of lime in the Eocene marl of South Carolina, and the distinct recognition of its great value for agriculture."† It was Dr. Ravenel, however, whose experiments made it possible to transform these phosphate rocks into commercial fertilizers, and of him the younger Shepard wrote in 1882: "Well might this community erect a public monument in honor of the man to whom preeminently is due the inauguration of that phosphate industry which has proven of such incalculable value to ourselves and others. As the statue of Berzelius adorns beautiful Stockholm, let us commemorate [similarly] the founder of Charleston's greatest industry." It may be added that Dr. Ravenel differed from the agricultural chemists of his time in devoting greater attention to the physiological phases of the application of fertilizers to plants than to the mere

chemistry of the subject; this was naturally due to his early training in medicine.*

It would lead me too far from chemistry, perhaps, to discuss the work of the younger Shepard (1842-) in successfully introducing tea culture into the United States, but his farm in Summerville, S. C., is a monument to the application of his chemical knowledge to a new industry, and well may his fellow-countrymen be proud of the results.

It is desirable to mention at this place the remarkable successes achieved by a small band of chemists who spent the four years of our Civil War in their southland. George Washington Raines (1817-98), John Le Conte (1818-91), Joseph Le Conte (1823-91) and John William Mallett (1832-) are among the more conspicuous names that occur to me. It was Raines who erected at Augusta, Ga., the Confederate powder works, which at the close of the war were regarded 'as among the best in the world.'†

The Confederate government appointed John Le Conte to the superintendency of the extensive niter works established in Columbia, S. C., which place he retained during the war.‡ Joseph Le Conte, a younger brother, served as chemist to the Confederate laboratory for the manufacture of medicines in 1862-3, and also in a similar capacity to the niter and mining bureau in 1864-5. Professor Mallett was

* Two memorial pamphlets of Dr. Ravenel have been published. One, entitled 'In Memoriam, St. Julien Ravenel, M.D.' (9 pp.), is a reprint of an editorial from the *Charleston News and Courier* of March 18, 1882. The other, entitled 'Dr. St. Julien Ravenel,' is a memorial published by the Agricultural Society of South Carolina, Charleston, S. C. (54 pp.).

† He published in pamphlet form a 'History of the Confederate Powder Works' (Augusta, 1882).

‡ 'Biographical Memoirs,' National Academy of Sciences, III., p. 369.

* A sketch of his career prepared by Charles L. Jackson appeared in the *Proceedings of the American Academy of Arts and Sciences*, XXVIII., 1903, p. 34.

† *American Chemist*, V., 1874, p. 96.

in charge of the ordnance bureau of the Confederate states, serving with the rank of colonel. He has described his experience under the title 'Applied Chemistry in the South during the Civil War,'* which he has delivered as a lecture before various chemical societies.

A history of the manufacture of explosives in this country would carry us far into the past, for the oldest of the still existing powder mills was established in 1802 by Eleuthere Irene Du Pont and the name of Du Pont is still honorably associated with the industry, for so recently as 1893 two of that name received a patent for a smokeless powder which is now largely made at works near Wilmington, Del.

During the years 1862-4 Robert Ogden Doremus (1824-) developed the use of compressed granulated gunpowder, which was adopted by the French government. It was concerning this inventor that Sir Frederick A. Abel in 1890 in his retiring address before the British Association said that Doremus 'had proposed the employment in heavy guns of charges consisting of large pellets in prismatic form.' Charles Edward Munroe (1848-) must be recognized as the first in the world to prepare a 'smokeless powder that consisted of a single substance in a state of chemical purity.' This explosive, which he invented while chemist at the U. S. Torpedo Station, Rhode Island, and which became known as the 'naval smokeless powder,' was referred to by Secretary of War Tracy in 1892 as presenting 'results considerably in advance of those hitherto obtained in foreign countries.'†

* An abstract of this paper with the title 'Industrial Chemistry in the South during the Civil War' is contained in the *Scientific American* for July 25, 1903.

† The history of the 'Development of Smokeless Powders' was the subject of Dr. Munroe's presidential address before the Washington Sec-

Of later development is the Bernadou powder invented by John Baptiste Bernadou (1858-), of the U. S. Navy, and which it is claimed has been adopted for use in the naval branch of the service.

No contribution to the history of technical chemistry in the United States would be complete without some reference to the development of coal oil and petroleum. It seems almost impossible to realize that scarcely half a century ago the only use of petroleum was as a cure for rheumatism under the name of Seneca oil. The commercial exploitation of this important illuminant is, of course, largely due to the Standard Oil Company and to the expert chemists in their employ credit should be given for the production of the many beautiful by-products that are now made. A full description of these with proper reference to the chemist to whom we are indebted for them would, indeed, be valuable, but even for a simple enumeration of the products in tabular form giving their immediate origin I must refer you to the text-books on industrial chemistry.*

One of the most interesting of these many compounds is vaseline, whose use in pharmacy is so prevalent. It was invented in 1870 by Robert Augustus Chesborough (1837-). Charles Frederick Mabery (1850-) has been an indefatigable worker in the theoretical branch of the subject, especially on the composition of petroleum, in the study of which he has been aided with grants from the C. M. Warren Fund for Chemical Research of the American Academy of Arts and Sciences. Stephen Farnam Peckham (1839-) has been a prolific contributor to the literature of the technology of the subject,

tion of the American Chemical Society in 1896. See *Journal of the American Chemical Society*, XVIII., 1896, p. 819.

* See 'A Handbook of Industrial Chemistry,' by Samuel P. Sadtler (Philadelphia, 1900), p. 21.

and his report on petroleum, prepared for the tenth census (Washington, 1880) is standard authority. Another chemist who has studied petroleum both in the laboratory and also from a commercial point of view as well, is Samuel Philip Sadtler (1847-). His 'Industrial Organic Chemistry' (Philadelphia, 1900) gives a very satisfactory survey of the subject with an admirable bibliography. Among the younger men I learn that William Cathcart Day (1857-) has succeeded by carrying out operations of distillation at the ordinary atmospheric pressure upon animal and vegetable matter, both separately and mixed, in obtaining three different materials, all of which present in different degrees the properties characteristic of asphalts.*

An early worker in the scientific part of this subject was Cyrus More Warren (1824-91), whose original researches on the volatile hydrocarbons and similar bodies resulted in many practical applications in the use of coal tar and asphalt, especially for roofing and paving purposes. Clifford Richardson (1856-) has in recent years devoted much attention to the study of asphalt and is a recognized authority on its value for commercial purposes.

I can not claim for the United States the invention of illuminating gas, although as early as 1823, its manufacture was begun in New York city, but the development of the production of a luminous water gas was largely accomplished in this country. According to excellent authority,† Thad-

deus S. C. Lowe (1832-) built and successfully conducted gas works in Phoenixville, Pa., in 1874, producing a water gas 'far superior to that made from coal.' According to Dr. Chandler 'there are forty or fifty differing forms of apparatus for manufacturing [water gas], but they are almost without exception applications of the invention of Thaddeus Lowe.*

Those of us whose memories extend back for a quarter of a century may recall Tessie de Motay (1819-80), whose agreeable personality charmed all of those who were so fortunate as to meet him, and to him is due the production of water gas in the late seventies of the last century by a process of his own invention in New York city.‡

A much-needed substitute for ivory and horn that could be produced economically was invented in 1869 by John Wesley Hyatt (1837-) and called by him celluloid. It is so seldom that foreign recognition is unqualifiedly given to our American inventors that I am glad of the opportunity to quote Thorpe,‡ who says, concerning celluloid, that it 'is an intimate mixture of pyroxlin (guncotton or collodion) with camphor, first made by Hyatt of Newark, U. S., and obtained by adding the pyroxlin to melted camphor * * * and evaporating to dryness.' Its many applications in various industries are so well known as to need no further mention here.

It should not be forgotten that saccharin, a coal tar compound with a sweetening Value of Water Gas Processes' (New York, 1864) by John Torrey and Carl Schultz which gives a brief summary of some sixty patents on the subject.

* *Journal of the Society of Chemical Industry*, XIX., 1900, p. 613, where also excellent descriptions of both the Lowe and the Motay processes are to be found.

† See sketch of Cyprien M. Tessie de Motay by A. J. Rossi in the *Journal of American Chemical Society*, II., 1880, p. 305.

‡ 'Dictionary of Applied Chemistry,' I., 1891, p. 449.

* *Journal of the Franklin Institute*, September, 1899, p. 205.

† See a 'Communication on the Lowe Gas Process,' New York (May, 1876) and 'A Communication on the Lowe and Strong Gas Processes' of later date (probably 1878) and also 'The Chemistry of Gas Lighting,' by C. F. Chandler (Philadelphia, 1876), a reprint from the *American Chemist* for January and February, 1876. There is also a pamphlet report on the 'History and

power of about five hundred times that of cane sugar, although now manufactured chiefly in Germany, was discovered in 1879 in the laboratory of the John Hopkins University by Constantin Fahlberg, a student under Ira Remsen (1846-) and the Society of Chemical Industry in 1904 crowned Remsen's work by conferring upon him the medal of the society, recognizing thus for the first time in its history the discoveries of an American chemist.

In the domain of technical chemistry no American has ever achieved greater results than Hamilton Young Castner (1858-99), and the opportunity of presenting a brief summary of his brilliant inventions is a pleasure that I gladly welcome.

His first invention was a continuous process for the manufacture of bone charcoal, but this failed of commercial success, although scientifically of much interest, and he then turned his attention to the study of an improved method for the production of aluminum. To accomplish this it was necessary to produce sodium economically, and this he succeeded in doing by using carbide of iron as a reducing agent. When he began this now historic research the market price of aluminum was \$10 a pound, and when his process was completed he was able to manufacture aluminum at about one dollar a pound. "This," says Dr. Chandler, "revolutionized the whole industry and aluminum could be now used for a hundred different purposes." In his retiring address before the British Association in 1890 Sir Frederick A. Abel said: "The success which has culminated in the admirable Castner process constitutes one of the most interesting of recent illustrations of the progress made in technical chemistry."

But there were other uses for which sodium could be employed, and so he invented a process for converting metallic sodium

into sodium peroxide. Then came the suggestion that with cheap sodium pure cyanides could be produced, and so he modified his process so as to manufacture pure cyanides, especially the potassium and sodium cyanides, enormous quantities of which were used for the extraction of gold from low-grade ores. His active mind was ever busy with new solutions of chemical problems, and subsequent to the invention of electrolytic processes for the reduction of aluminum, Castner concentrated his attention on the original methods used by Sir Humphry Davy and overcoming the difficulties encountered by that great chemist he soon devised an electric process of remarkable simplicity for obtaining metallic sodium from caustic soda by electrolysis. His ambition was not yet satisfied and he added to his triumphs a beautiful method for the electrolysis of common salt with the production of caustic soda and bleaching powder. Thus Castner invented 'the first process which could be said to be a complete success; for accomplishing what French, German, English and American chemists had been working at for a hundred years.' Again to quote Chandler:* 'He never worked on a chemical process that he did not invent a better one to accomplish the same result.'

The silver metal and the white crystals, pure and beautiful, the results of his many hours of study and research, will always preserve in the literature of chemistry the memory of him of whom it is surely not too much to say that he was the most eminent of American inventors in chemical technology in recent times.

While Castner was studying the problem of preparing aluminum by chemical methods Charles Martin Hall (1863-),

* See the 'Unveiling of a Bronze Tablet in Havemeyer Hall to the Memory of Hamilton Young Castner, December 16, 1902,' *School of Mines Quarterly*, XXV., January, 1904, p. 204.

a student in Oberlin College, conceived the plan of extracting aluminum by electrolysis and he found that a melted bath of the double fluorides of aluminum and metals more electro-positive than aluminum, such as sodium or calcium, was a perfect solvent for alumina, and from such a solution he was able to separate the aluminum by means of the electric current. It is by this process that all of the aluminum of commerce is produced to-day.

Moissan, whose extended researches with the electric furnace have made his name justly famous, writes: 'The discovery of crystalline carbon silicide belongs to Acheson.'* This remarkable abrasive, prepared by heating a mixture of silica, coke, alumina and sodium chloride in an electric furnace, was invented in 1890 by Edward Goodrich Acheson (1856-) while experimenting for the artificial production of diamonds, and is one of the many beautiful products obtained at Niagara Falls, where quite a number of chemical manufacturers have established their plants in order to take advantage of the power obtained from the great waterfall. Mr. Acheson has also succeeded in preparing artificial graphite as a by-product in the manufacture of the carborundum, and he claims that it is the result of the decomposition of the carbide formed in that process.†

Although the existence of calcium carbide has been recognized ever since its original production in 1857 by Edmund Davy, Wöhler and Berthelot, it was not until May, 1892, that its commercial production became known in consequence of its chance discovery by Thomas Leopold Willson (1860-) while experimenting in Spray, N. C. He obtained it by the fusion and reduction in an electric furnace of a mixture of finely powdered and intimately

mixed lime and coke. When it comes in contact with water decomposition ensues with the production of acetylene gas, an illuminant of remarkable power. This valuable compound is also manufactured at Niagara Falls.

Another valuable application of the high temperatures obtained by the electric furnace to substances from which the extraction of the metal was formerly considered impossible is the method patented in November, 1903, by Frank Jerome Tone (1868-), of Niagara Falls, N. Y., for obtaining metallic silicon by reducing silica with carbon in an electric furnace of his own construction.

Of great value is the elaborate bulletin* on 'Chemicals and Allied Products' prepared for the twelfth census by Charles Edward Munroe, already mentioned, and Thomas Mareau Chatard (1848-). The industries discussed are grouped into nineteen classes and with each the discussion is introduced by a history of the development of the manufacture in the United States, and at the close is a brief bibliography. The volume includes a digest of United States patents relating to the chemical industries.

Worthy of the most distinguished consideration is the career of Charles Frederick Chandler (1836-). This eminent chemist has since 1864 taught the technical chemistry in the Schools of Science in Columbia University and no record of the development of chemistry applied to the arts in the United States would be complete without mention of his work. It is true that no great invention bears his name, but he has achieved results greater than inventions, for he has educated chemists, and yet even more than that as we shall see. Go where you will and you will find busy workers in science who have learned from

* 'The Electric Furnace' (Easton, 1904), p. 273.

† *Journal of the Society of Chemical Industry*, XIX., 1900, p. 609.

* Census Bulletin, No. 210. Quarto, 306 pp. Washington, June 25, 1902.

Chandler something of that splendid power of applying chemical methods to the subject at hand which has long since gained for him the reputation of being the foremost authority on technical chemistry in the United States. Wherever gold or silver is determined, the little assay ton weights—their conception was a stroke of genius—claim him as their inventor. The brilliant series of articles on technical chemistry—the best in the English language—that appeared in Johnson's *Cyclopedia* were written by him. The first museum of applied chemistry in the United States where the crude material may be studied in its course of development to a finished product was established by him. Masterly, indeed, are the practical contributions to chemistry which marked the years during which he had charge of the public health in New York city. It resulted in enormous benefits to the community, and in 1883 it was well said: 'There is no other city in the world which has so complete a sanitary organization as New York'; for all of which credit is due to Chandler.* In 1889 he was chosen president of the Society of Chemical Industry, the first American upon whom that honor was conferred, and a year later, on June 18, 1900, in the lecture theatre of the Royal Institution founded by Count Rumford, to whom reference has already been made, he delivered his presidential address on 'Chemistry in America,' in the course of which he elaborated most fully the achievements of those who have distinguished themselves in that branch of science in the United States.†

* See the sketch of Charles Frederick Chandler by the present writer in the *Scientific American*, LVII., July 16, 1887, p. 39, and 'President Chandler and the New York City Health Department, 1866-1883,' in the *Sanitary Engineer*, May 17, 1883.

† *Journal of Society of Chemical Industry*, XIX., 1900, p. 591.

It is worth while, I think, to mention very briefly three branches of our national government that have had much to do with the development of chemical technology in this country. The first of these and also the oldest, for it celebrated its centenary in 1891, is the patent office,* where inventors receive the protection of the government for their discoveries. By thus recognizing worthy inventions a valuable stimulus is given to invention which has not been without value to the community. Of exceptional interest to chemists is the system of indexing chemical literature now in use in the classification division of the patent office.†

I will also call your attention to the excellent work done in the Division of Mineral Resources in the U. S. Geological Survey, where under the efficient direction of David Talbot Day (1859-) valuable information and statistics are gathered concerning native minerals and ores from which are obtained the products of so many of the leading chemical processes.‡

Finally the bureau of chemistry of the Department of Agriculture has been a potent factor in the development of chemical industries. It was this bureau that first called the attention of the public to the possibility of establishing the beet sugar industry in the United States. As a result of the investigations carried on by chemists in this branch of the government service the average yield of cane sugar to

* 'Patent Centennial Celebration, 1891: Proceedings and Addresses,' 554 pp. (Washington, 1892).

† See 'On a System of Indexing Chemical Literature; Adopted by the Classification Division of the United States Patent Office,' by E. C. Hill, *Journal of the American Chemical Society*, XXII., 1900, pp. 478-498; also *Scientific American*, LXXXVI., June 14, 1902, p. 411.

‡ Beginning with the year 1882, annual volumes of the Mineral Resources of the United States have been published.

the ton in the state of Louisiana has been increased from 130 pounds to 170 pounds. In the examination of road materials important contributions to technical chemistry have been made by this bureau. The valuable studies on the dietetic value of foods and on their adulterations, conducted under the direction of Dr. Harvey Washington Wiley (1847-) have not only done much towards creating a demand for the enactment of national legislation for pure food, but they have also been praiseworthy contributions to the application of chemistry to sanitation. This bureau also should receive recognition for its fostering influence over the Association of Official Agricultural Chemists, an organization which has done so much to secure uniform methods of analysis of fertilizers and of foods.*

To Henry Carrington Bolton (1843-1903) is due the credit for the series of bibliographies of the literature of the chemical elements that have been published by the Smithsonian Institution. His own memory will always be worthily preserved by the splendid 'Bibliography of Chemistry' in four octavo volumes, an important section of each of which is devoted to technical chemistry.

The records of the past give abundant hope for the future.

MARCUS BENJAMIN.

U. S. NATIONAL MUSEUM.

THE PHYSIOLOGICAL SECTION OF THE
CENTRAL BRANCH OF THE AMERICAN
SOCIETY OF NATURALISTS.

A PHYSIOLOGICAL section of the Central Branch of the American Society of Naturalists was organized and held enthusiastic meetings on March 31 and April 1

* The literature issued by the Bureau of Chemistry is large and includes nearly one hundred important bulletins and many minor circulars and leaflets.

during the recent meeting at Chicago. The sectional meeting was called to order in the Hull Physiological Laboratory and Professor G. N. Stewart was chosen chairman.

The following papers were presented:

Changes in the Percentage of Water in the Central Nervous System of the White Rat between Birth and Maturity: H. H. DONALDSON.

Between birth and one year of age the percentage of water in the brain of the white rat falls from approximately 89 per cent. to 77 per cent., and in the spinal cord from 86 per cent. to 69 per cent.

In the brain the rapid decrease occurs during the first seventy days of life, while in the cord this period is somewhat more prolonged.

Taking the converse change of increase in solids, it is found that in both the brain and the cord the solids increase more rapidly than does the weight of the organ, a relation probably dependent on the process of medullation.

In general, the percentage of water in the central nervous system is very closely correlated with the age of the animal, and almost independent of its absolute body weight.

On the Presence of a Sulphur Compound in Nerve Tissues: WALDEMAR KOCH.

Kossel first called attention to the fact, later confirmed by Cramer, that all preparations of protagon contained sulphur. Thudichum isolated an impure barium salt containing four per cent. of sulphur, which he classed as a cerebrosulphatid.

A comparison of the organically combined sulphur (not proteid sulphur) present in various tissues gives the following result expressed in parts per million: Spinal cord, 1,029; liver, 470; striated muscle, 310; testicle, 209; submaxillary gland, 135. These figures point very