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GEORGE AUGUSTUS HULETT

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A Biographical Memoir by

E. C. SULLIVAN

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COMPILED BY E. C. SULLIVAN

GEORGE HULETT was an outstanding experimental scientist. He was blessed with rare ability for handling both people and things. His outlook on life was broad and generous. Although in the laboratory no detail was too minute for his attention, there was nothing small in his view of the world. He was scornful of subterfuge, pretext, or show and could be devastating in his comments about, or directly to, any one who seemed to be putting on "side" or talking for effect.

Hulett was always interested in his family history. When he inquired at the College of Arms in London whether his name should be spelled Hulett or Hewlett he was told that both were correct because no two brothers would ever agree on one or the other spelling.

About 1894, while George was still an assistant at Princeton, he was invited by Dr. Thomas Hulett to spend a Thanksgiving vacation in Wallingford, Vermont, where many members of his father's family still lived. The group visited the cemetery, where they found the gravestone of Lieutenant Mason Hulett, George's great-great grandfather. The story is told of Mason Hulett's son Amos, who at the age of ninety drove alone from Westfield, Vermont, to Kingsville, Ohio. Amos Hulett reached his son's house early in the morning after being delayed by a night's heavy rain. The gentleman pounded on the son's door, shouting, "Erastus, Erastus, why aren't you out here hoeing your corn? The weeds in your garden are terrible."

George remembered his grandfather Erastus very well. He was a well-known fur trader and was proud that the Indians liked him and would hold their furs for him if he or his representatives were delayed. He built up a simple organization patterned after the British-Canadian Hudson's Bay Company, and became known as the richest man in the Western Reserve. He later owned a large tract of timber land.

George Augustus's father, Erastus Frank Hulett (who later dropped the "Erastus"), married a young Englishwoman, Lois Holmes, whose father had come to this country and bought a farm at Kingsville, Ohio, a few years before. The young couple set out from the Hulett's colonial homestead on Euclid Avenue in Cleveland for the west, hoping to find a suitable farm to begin a life of their own. Their travels took them into several states. They bought a tract of land which George later described as a ranch for raising horses and cattle in the township of DuPage, Will County, about twenty-five miles west of Chicago, and soon built a good frame, colonial farmhouse painted white. The hired man and his family lived in the log house the Huletts had first occupied. Here George Augustus was born July 15, 1867. He had a sister four years older. George learned to ride horseback before he learned to walk, his mother always said. His parents selected a small Western pony for him, and the two were inseparable. He attended the nearest district school when he was about five years old but his chief interest was the farm. He was given a low bench in the tool shop (a farm machinery repair shop) and later, but while still a young boy, he had entire responsibility for the shop. Under his father's direction he ordered the machinery needed and made the repairs for the most part himself.

Meeting the teacher, a student who had taken the school to help meet his college expenses, one day when George was in his teens, George's father asked how his son was getting on and was told, "Fine, he has a better mathematical mind than I have." Whereupon George found himself sent off to his Uncle George in Cleveland. He finished out the year in the Cleveland High School but the fall term found him on the Oberlin campus enrolled in the Preparatory School there.

George liked his studies—Greek more than Latin—and he was especially fond of mathematics. He enjoyed sports too, and when he entered Oberlin College in 1888 he became a member of the college baseball team. The captain of the team, Edward K. Hall, later chairman of the Rules Committee of the American Athletic Association, always said that George Hulett's baseball playing was outstanding. Not only was he a natural lefthanded batter but his fielding had a rhythm that was a delight to watch. George was tall and thin with no hips, and his throwing of the ball, according to Hall, was like a musician playing the instrument of his choice. "I always thought he was a musician, whether he knew it or not," Hall declared.

Hulett never tried to do anything else left-handed until he took up golf at Ann Arbor in 1900. He picked up the clubs one at a time and said, "It seems natural to strike the ball left-handed."

In 1890 Hulett transferred to Princeton. After registering he found he was unable to take chemistry since he was in the regular B.A. course rather than the science course. So Professor Cornwall offered to lend him a blowpipe and such materials as would be needed and asked him to report from time to time. In 1892, when he graduated, he was asked to stay as an assistant in chemistry, the only other assistant being the man of highest standing graduating in the scientific course.

After four years as an assistant, Hulett went to Leipzig, Germany, for his doctorate under Wilhelm Ostwald, the founder of the then new discipline of physical chemistry. A friend of that period gives this picture:

"In Leipzig in 1898 he was a dark, tall, lean, energetic figure with black Mephistophelian mustache and Van Dyke. Scornful of pretense and formality and in awe of no dignitary, he at times startled his more ceremonious fellow students. On one occasion, locking up his desk in Ostwald's laboratory at the end of the day, he announced, 'Schluss der Vorstellung!' and even the horrified Privatdozent could not in the end restrain a chuckle.

"Hulett was a man of enthusiasms, intensely interested in his work but always in something else as well, such as the German card game of Skat, chess, golf, billiards. In play, as in work, he was thorough and skillful."

For many years, he spent a month every summer on a canoe trip in Canada, at first in the company of some friend, but later with his son, Barker, as a good companion.

From Germany Hulett went in 1899 to the University of Michigan as the first instructor in physical chemistry. His laboratory in Ann Arbor was in the top of an abandoned water tower, reached by three flights of stairs, up which with his never-failing energy Hulett would bound like a gazelle. In this room some of his most original work was done.

In Ann Arbor, as well as later in Princeton, Hulett was ahead of his time. Facilities for research and for lectures in the new physical chemistry were not readily forthcoming and he was always grateful for help provided by the Elizabeth Thompson Research Fund of Boston.

When golf came to Ann Arbor, as it did in a small way at first under the sponsorship of Professor F. M. Taylor, Hulett went at it very seriously. He chalked the face of his driver to study its contact with the ball. This was before Sunday golf became respectable, but Sunday to Hulett's mind was a good day for golf because he had time then and churchgoers left him plenty of room on the course. The university president manifested concern by diplomatically sending word to Hulett that he had seen a member of his faculty playing golf on the Sabbath. Hulett, however, in spite of being a member in good standing of the Congregational church, continued unperturbed. In a matter of months after he began to play, he and Lieutenant Commander Faust were selected to go to Detroit to play against the Detroit Golf Club, and they returned proudly with the cup.

One of his undergraduates wrote many years later: "He was an outstanding experimenter and manipulator of apparatus. He talked with his hands much more fluently than with his tongue. He taught glass blowing and when his class could not explain why heating glass would round off the corners, he blew a large glass bubble, pricked it, and heated the edges. As the class saw them shrink, they all yelled, 'Surface tension!' The best part of his lectures were the experiments. They always worked. Lazy or inattentive students got short shrift, although he did not lose his temper. He rarely praised, but when he did it was apt to be appreciated. All told, Professor Hulett taught me more about scientific thinking and manipulation than any one else. He maintained that a negative result is just as valuable as a positive result. 'It is just as important to know how not to do a thing as how to do it.' "

A colleague in the Department of Philosophy at Ann Arbor writes of him: "It was characteristic that Hulett decided it would be desirable to bring together a group of colleagues for common living. He sought out a group of men to occupy rooms and eat together and they proved to be very congenial. A visitor noted there were twelve of us and facetiously referred to us as the twelve Apostles. The name stuck and the group later organized under that name to buy a club house. The club continued for over forty years until conditions during the Second World War made it impossible to carry on.

"Hulett was above all a man's man, forthright in his opinions and vigorous in his expressions of principles. . . . He was a leader and commanded the respect of all. I was always struck with his alertness in applying his science to daily life and to problems that arose in other sciences. I remember an experiment to determine how sap rose to the top of the tallest trees against the pull of gravity. He showed that mercury would rise in a tube several times the height of the barometer under the pull of osmosis. . . . Conversation with him was stimulating, as he opened up new aspects of a topic, whatever it might be."

While at Ann Arbor, Hulett married Miss Dency Minerva Pierpont Barker (named for her two grandmothers, Dency Butler Barker and Minerva Pierpont), daughter of Dr. John W. Barker of New Haven. They had one son, Barker Hulett, who graduated from Princeton in 1930, took a degree at M.I.T. in mining engineering, and now lives near Philadelphia with his wife and two children.

In 1905 Woodrow Wilson, president of Princeton, came to Ann Arbor in search of preceptors. His conversations with Hulett, whom he had known as a student at Princeton, and who was then an assistant professor at Ann Arbor, resulted not only in Hulett's becoming Assistant Professor of Physical Chemistry at Princeton but also in a lasting bond between the two men based on mutual respect and understanding.

"With his advent the modern era in chemistry at Princeton began." As in any pioneering effort, the path at times was not smooth, but obstacles were surmounted and in 1909 the new discipline came into its own at Princeton when Hulett was made the first Professor of Physical Chemistry. Long before his retirement he was to take great pride in the progress of the department and especially in the caliber of the staff which he had attracted.

Over the years Hulett was much in demand for consultation and for services with various government departments. He worked closely with the Bureau of Standards on the voltameter. He served as expert witness for the Bureau of Chemistry in the bleached flour case, where his simple devices, which the jury could understand, enabled the government to win its first case under the Pure Food and Drugs Act.

His work for the Bureau of Mines is described by a later Chief Chemist, Dr. Arno C. Fieldner, in the following paragraphs.

"Shortly after the Bureau of Mines was created by act of Congress in 1910, the Director, Dr. Joseph A. Holmes, offered the position of Chief Chemist to Dr. George A. Hulett, then Professor of Physical Chemistry at Princeton University. The opportunities for new research in the broad field of mining and the mineral industries appealed to Dr. Hulett, and for some months he wavered between acceptance and remaining with his professorship where he had gained recognition as an outstanding experimenter in the relatively new science of physical chemistry. Dr. Holmes, seeking to build up his complement of scientific and engineering division chiefs, wanted Dr. Hulett for the scientific side of the Bureau's work and kept after him. Eventually Hulett agreed to take leave of absence from Princeton and accept the position for one year, beginning in 1912.

"This was a wonderful year for the chemical and physical staffs of the Bureau of Mines, especially at the Pittsburgh, Pa., Experiment Station, where most of the laboratory research was conducted. Hulett spent most of his time at Pittsburgh and at once took a deep interest in the men and their work, which had been in progress for several years in the Technologic Branch of the U.S. Geological Survey prior to the formation of the Bureau of Mines.

"When Hulett took charge of the Chemical Division of the Bureau of Mines, the laboratories at Pittsburgh were well staffed with chemists and physicists who were actively engaged in testing and research relating to fuels, explosives, mine gases, and the prevention of gas and dust explosions. Hulett's immediate contribution to the Pittsburgh group was scientific leadership; he reported directly to Dr. Holmes. The staff realized that they had not only a competent adviser but also a friend and vigorous supporter of their work. His understanding appreciation of the research problems of the staff and his readiness to think with them led to cordial cooperation and acceptance of many helpful suggestions. The weekly seminars that he held coordinated the group and stimulated the research spirit, especially that of the younger men who were engaged largely on routine work and who had no advanced degrees. He took them under his wing and trained them in the methods of research as he would have done if they had been candidates for Ph.D. degrees at Princeton. He inspired them so that they began to spend overtime on the improvement of the analytical and testing methods that they used in their work. And this led in turn to engaging on research problems dealing with the determination of properties of the materials that they handled. Hulett's superb experimental skill was infectious in the laboratory. It led the men to develop new and improved apparatus and instruments.

"Important coal studies started in Pittsburgh during Hulett's year as Chief Chemist resulted in the following classic publications: 'The Primary Volatile Products of Coal'; 'Some Properties of Water in Coal'; 'A Study of the Oxidation of Coal'; and 'Graphic Studies of the Ultimate Analyses of Coal.' To this new field of research, Hulett brought his boundless energy and infectious enthusiasm. He gloried in the opportunities for suggesting new and unique experimental techniques and inspired his colleagues along pioneering scientific lines, not only during his year at Pittsburgh but also after he returned to Princeton and continued in active consultation with the work at Pittsburgh.

"Dr. Holmes had hoped that Hulett would make up his mind to stay with the Bureau of Mines as Chief Chemist before his leave of absence from the university expired. Unfortunately for the Bureau, Hulett's ties to Princeton and to his students in physical chemistry were too strong for him to break. Although Hulett returned to Princeton at the beginning of the school year in the fall of 1913, he made frequent trips to Pittsburgh and continued in close touch with the chemical and physical research of the laboratories as consulting chemist. He encouraged fundamental studies on the origin and constitution of coal along three lines of attack: (a) the microstructure and paleobotanical composition of coal, (b) the action of solvents and chemical reagents on coal, and (c) the pyrolysis and distillation of coal. The paleobotanical studies led to a classical bulletin published by the Bureau of Mines on the origin of Paleozoic coals. In the pyrolysis studies, Hulett noted the far-reaching changes produced by high-temperature carbonization and suggested distillation at low temperatures and low pressures to reduce the degradation of the products.

"Hulett's connection with the Bureau of Mines research program brought to his attention some interesting problems in physical chemistry as thesis subjects for graduate degrees. One that deeply interested him was the nature of water in coal that is not chemically combined with the mineral matter or with the coal substance. He and his students developed a special vacuum distillation apparatus for determining the water and gases removed from coal at various temperatures. An important pioneering paper was published on this subject. Another problem of the Bureau's analytical laboratory in connection with the analysis of graphite led Hulett to study the constitution of the graphitic oxides. One of his postwar students made this the subject of his thesis research. The results published under the title of "Graphitic Acid—a Colloidal Oxide of Carbon" gained the Electrochemical Society's Award for Distinguished Research.

"One of the most important new lines of work introduced at Pittsburgh by Hulett was the initiation of research on the fundamentals of the pressure-cracking of petroleum for the production of gasoline. This problem was attacked from a modern physicochemical point of view. One of the by-products of this research was a method for producing toluene from petroleum. This chemical was in great demand for the manufacture of trinitrotoluene for explosives in the First World War.

"These are a few of the examples of Hulett's beneficial influence in developing the scientific stature of the Bureau of Mines in its formative period before the First World War. His consulting service was so active and his interest in the research program so great that the Bureau staff considered him a colleague in their research rather than an outside consultant.

"When, a few days after the entry of the United States into the First World War, the Bureau of Mines started its War Gas Investigations in cooperation with the Army and Navy, Dr. Hulett's graduate students at Princeton quickly wound up their year's work and volunteered for war service. Four of them came to the Pittsburgh Experiment Station to join the Gas Laboratory staff that was already engaged in April, 1917, on testing charcoal and soda lime absorbents for filling gas mask canisters. This group was of major assistance in working out methods of testing and of analyzing poison gases. These prospective Ph.D.'s became an important part of the nucleus of the Gas Mask Research Section, a unit in the Research Division of the Chemical Warfare Service of the U.S. Army, into which the Bureau of Mines War Gas Investigations group was merged."

Hulett, himself, was one of the first of America's leading scientists to be called for important foreign service. Eight days after the United States declared war, Hulett sailed on the steamship *Rochambeau* as one of two chemists on a six-man scientific team, with Professor J. S. Ames of Johns Hopkins as chairman, for the study of scientific developments on European battlefronts. Later, on Pershing's arrival, Hulett became consulting chemist at A.E.F. headquarters, and it was in consultation with Hulett that the Chemical Warfare Service was set up both in France and at home. A copy of the organization chart which Hulett prepared after six weeks in France is preserved among his papers. Although one cannot take literally the word of an admiring army officer that as a civilian consultant Hulett actually headed the chemical service during the war, his influence certainly was great.

General Pershing's letter on the subject seems of sufficient interest to reproduce:

Headquarters American
Expeditionary Force
Office of Commanding General

From: The Commander in Chief, A.E.F.
To: The Adjutant General U.S. Army
Subject: Chemical or Gas Service

1. This letter will be presented by Dr. Geo. A. Hulett of the United States Mining Bureau, who has been in France for some months, making a study of the use of gas in warfare.

Dr. Hulett has been of the greatest assistance to this office in the study of its organization for a Gas service, and it is desired to utilize in our organization his very expert technical knowledge.

2. It is recommended that all Chemical or Gas Service in the U.S. be united under one head who shall be an officer of the U.S. Army with suitable rank and staff.

3. In all technical questions, the Chemical Service of the U.S. shall be guided by the experience of the Service in France, as this service is being developed here and improvements occur which should be adopted here as they appear.

4. A Laboratory Service for the A.E.F. should be organized and sent to France at once. It is desired that the experience and knowledge of Dr. Hulett be utilized in creating this organization and that he be sent as a member of it with appropriate rank.

5. For your information there is enclosed herewith copy of the Chemical Organization for the A.E.F. which Dr. Hulett is in position to explain in all details and the reasons for its adoption.

(*Signed*) John J. Pershing
Major Gen. U.S. Army

After the war General William L. Sibert, Director of the Chemical Warfare Service, wrote: "Your work has been praised in the highest terms."

Rather than take high rank as an officer Hulett felt impelled to contribute to the Chemical Warfare Service the research capabilities with which he was peculiarly endowed, and after returning from France he did work of signal value on gas mask absorbents and similar projects.

In the year 1920, when he was fifty-three, an accident left Hulett partly paralyzed, and although mentally as acute as ever he could not carry out with his own hands the experimental work which he loved and in which he so greatly excelled. For years afterwards, however, he and his students continued to publish papers of high quality. In spite of his physical handicap, he served as associate editor of the *Journal of Physical Chemistry* from 1923 to 1927, as vice-chairman of the Division of Chemistry and Chemical Technology of the National Research Council in 1927–1928 and as chairman in 1928–1929, and as chairman of the Division on the Origin and Classification of Coal at the International Coal Conference held at Pittsburgh in 1931. Even after becoming professor emeritus in 1935, he continued to come to the laboratory for some years until increasingly bad health curtailed his activities more and more.

A friend who knew him after 1948 wrote that "his last years were marked by quiet dignity and a gradual lessening of powers. The inevitable weaknesses of the body were accompanied by cheerfulness and good humor. Depression, if he had it, he kept very much to himself."

He would say, "If I could only get my hands on that apparatus," but it was a wish, not a complaint. "Just marking time," he called it after 1920. But in reply to congratulations on his seventy-fifth birthday, in 1942, he could write: "Three-quarters of a century has been a long time, but it has been a good one and I need another like it to circumvent the many questions that have popped up."

Of his last years a friend writes:

"During the years from 1948 Mrs. Hulett took care of her husband while she suffered increasingly from arthritis. His comfort came largely from her cheerfulness, resource, and ingenuity. The devotion of Mrs. Hulett and his love for her were most touching. Nearly to the end they played their evening game of chess and were ready for a lively conversation. He and she were always abreast of the news of the day." After thirty-five years of courageous inactivity and, toward the end, invalidism, he passed away September 6, 1955.

Spontaneous tributes from Hulett's Princeton associates afford a picture of his character and of the esteem in which he was held:

"Although Hulett worked night and day in the laboratory and never spared himself, his zest for living and his capacity for friendship won him a wide circle of friends, among whom his graduate students were always numbered."

"His generous and friendly nature endeared him to his students and associates. So many of us owe so much to him."

"His outstanding characteristics were great kindliness, a ready wit, and total lack of either conceit or envy."

"I always admired Dr. Hulett very much both for his understanding of young men and for his gracious personality as well as for his achievements."

"He was good company for any one, any time. He liked a joke and told good stories. . . . a very active mind, many interests of his own, and a lively sympathy for the interests of others."

"His entrance into a laboratory was like a breath of fresh air, and all looked forward to and were inspired by his visits."

"He hypnotized students into enthusiasm for research."

"He was indeed a remarkable person."

It is interesting to follow in his eighty-odd publications the influences which led to successive phases of Hulett's research career.

He published two papers while still an assistant at Princeton, one, in 1894, on a lecture apparatus for showing the volume composition of water, and the other, in 1896, on purification of water by distillation. Purity after distillation was measured by electric conductivity, a method which he applied frequently in after years.

In Leipzig it was at Ostwald's suggestion that he undertook investigation of liquid crystals, the result of which, published in 1899, proved to be the definitive treatment of the liquid-solid transition, "a rare circumstance in doctoral theses." A second Leipzig paper, which in common with the first involved application of pressure by means of a capillary thread of carefully cleaned mercury, was entitled "Calibration of a Glass Tube, and Some Compressibility Coefficients."

It was in Ann Arbor that Hulett's experience in preparing suitable mercury for his high-pressure work led to the 1900 paper on distillation of amalgams and purification of mercury.

Then, in 1901, in trying to see how fast gypsum would dissolve to a saturated solution for an electrolytic conductivity standard, he came upon and recognized the proof that solubility is increased by fineness of particles, in the case of gypsum as much as 20 percent, of barium sulphate 80 percent, and of mercuric oxide some 300 percent. In later years, when asked what discovery he regarded as his most important, he wrote:

"On returning from Ostwald's laboratory in 1898 I accepted a position as Instructor in Physical Chemistry at the University of Michigan. There were there at that time few facilities, but due to mechanical and glass-blowing experience I was able to construct most of the apparatus used in my teaching and research.

"Many conductivity cells were constructed, and in determining their capacity factors I employed the method proposed by Kohlrausch of using a saturated solution of gypsum. While adding the finely powdered gypsum to the saturated solution I noticed that the conductivity increased to a maximum and then began to decrease slowly. Small drops of a liquid distill to larger drops in their vicinity due to the well-known relation of vapor pressure and curvature of surfaces, and Ostwald had pointed out that the same phenomenon should occur in the solubility relation of fine and coarse powders in contact with their solution.

"It at once occurred to me that I was observing this phenomenon with my gypsum powder. The finest particles supersaturated the solution and there then followed a crystallization on the coarser crystals. On following up the observation this proved to be the explanation, and it was found possible to prepare a concentration of gypsum some 20 percent more concentrated than a normally saturated solution.

"Incidentally, conductivity proved a most satisfactory means of following this phenomenon, and it was possible to observe the effect with many other substances and in some cases to even greater degree. By observing with a microscope the size of the particles it was possible to calculate a value for the surface tension existing between a solid and a liquid solution."

A sequel to this publication was a mild David and Goliath encounter when a top German physicist incautiously attributed the increased solubility observed by Hulett simply to impurities. Hulett's refutation was characteristically painstaking and convincing.

Stemming directly from the powder solubility work with $BaSO_4$ were two 1904 papers, one on chlorine in precipitated $BaSO_4$ and another on volatilization of platinum, as well as a later treatment of isomorphism and solid solution in mixed barium-strontium chromates.

The fact that in his work with mercury the metal sometimes would stick to the closed end of a barometric tube and thus establish a higher than atmospheric column led to an investigation of the relation between negative pressure and osmotic pressure in which Hulett ingeniously demonstrated the lowering of vapor pressure in a liquid under tension.

Hulett's experience with mercury led in Ann Arbor to what became his lifelong interest in the cell for standard electromotive force, a cell having mercury as cathode and amalgam of cadmium or zinc as anode. Taking the precautions dictated by his knowledge of what were then the new teachings of physical chemistry, and especially avoiding hydrolysis, he prepared cells of unprecedented stability and reproducibility, to the astonishment and delight of his physicist colleagues.

The Princeton publications began in 1906 with papers on the cadmium standard cell and its chemistry, the silver coulometer, and a standard battery based on the standard cell, followed by others on the atomic weight and electrochemical equivalent of cadmium and on a proposed calomel standard cell; also a suggestion that constant-boiling hydrochloric acid be used as a standard in acidimetry (1909).

In 1908 Hulett showed that metallic mercury, despite its lower position in the electrochemical series, will reduce cadmium and zinc from their sulphates.

A 1911 paper, "An Exact Electrolytic Method for Determining Metals," was based on deposition of the metal in mercury to form an amalgam, thus avoiding the inclusions which may accompany a solid deposit. This paper affords an instance of the uncomplicated means by which Hulett solved annoying problems. Failure of mercury to wet platinum had caused uncertainty in work such as that on the silver voltameter, because water or electrolyte could be trapped between the platinum container and the mercury or amalgam. Hulett simply amalgamized the contacting surface of the platinum and thus caused the mercury or amalgam to wet it and exclude other liquid.

The importance of clean free-flowing mercury in so much of Hulett's work and the fact that mercury so easily dirties and sticks to glass or forms globules which do not coalesce led (1912) to a study the conclusion of which was that mercury oxidizes in air under ordinary conditions, more rapidly with a catalyzer. This was followed by an atomic weight determination of mercury based on the composition of the oxide. Altogether there were some thirty papers on the cadmium cell and the silver voltameter. The voltameter data were of great interest to the Bureau of Standards, where work on an international standard was in progress. Unfortunately, obscure factors brought it about that similar work carried on elsewhere was at variance with that of Hulett, and the ensuing discussions by letter and in print became rather warm. Here, as usual in a difference of opinion, Hulett was factual and conciliatory but skillful in presenting his own point of view. In the end the values obtained jointly by Hulett and the Bureau of Standards were accepted.

In 1915 a connecting link between Hulett's interest in mercury and amalgams on the one hand and his newer activity with the Bureau of Mines on the other appeared when he proposed cadmium amalgam for reducing ferric sulphate in the analysis of mine waters. For a period thereafter publications relating to the old subjects were interspersed with reports on mine waters and coal. His Bureau of Mines accomplishments in general are well outlined in the paragraphs above quoted, contributed by his associate, Dr. Arno C. Fieldner.

Upon his return from France following service as consultant to General Pershing, Hulett's interest centered on chemistry related to the war, and especially on gas mask absorbents such as charcoal. His papers in that field have been described as "classical efforts."

From 1928 to 1937 some sixteen papers were published in collaboration with his students, chiefly continuing his long-time study of the standard cell.

Hulett's papers show, above all, unusual ingenuity and skill in devising and carrying out ways of solving the problems which presented themselves, combined with keen observation and a scrupulous striving for accuracy. Such expressions as "most carefully," "most accurately," "thorough," "painstaking," a "clean" agate mortar, "every care was taken," a "tightly fitting" stopper, "washed 22 times," testify to his conscientious attention to detail. His theoretical work was sound, but his interest and aptitude were primarily in skillful manipulation to get at the facts. He wrote of himself modestly, "Guess my fingers were the best part of my work," and quoted not entirely without satisfaction an allusion to his competence as a glass-blower: "Hulett thinks in glass."

George A. Hulett has rightly been called "one of the great experimentalists of his generation."

For material used the compiler is under obligation especially to Mrs. Hulett, Sir Hugh Taylor, Dr. Arno C. Fieldner, Professor Charles P. Smyth, and Dr. G. W. Vinal, as well as to many others among George Hulett's former associates.

KEY TO ABBREVIATIONS

Am. J. Sci. = American Journal of Science
Am. Philos. Soc. Year Book = American Philosophical Society Year Book
J. Am. Chem. Soc. = Journal of the American Chemical Society
J. Ind. Eng. Chem. = Journal of Industrial and Engineering Chemistry
J. Phys. Chem. = Journal of Physical Chemistry
Phys. Rev. = Physical Review
Trans. Am. Electrochem. Soc. = Transactions of the American Electrochemical Society
Zts. anorg. Chem. = Zeitschrift für anorganische Chemie
Zts. Elektrochem. = Zeitschrift für Elektrochemie
Zts. phys. Chem. = Zeitschrift für physikalische Chemie

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