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BIOGRAPHICAL MEMOIR

OF

HENRY ANDREWS BUMSTEAD
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BY

LEIGH PAGE

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H. A. Bumstead

HENRY ANDREWS BUMSTEAD

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Henry Andrews Bumstead was born in the small town of Pekin, Illinois, on March 12th, 1870, son of Samuel Josiah Bumstead and Sarah Ellen Seiwell. His father, who was a physician of considerable local prominence, had graduated from the medical school in Philadelphia and was one of the first American students of medicine to go to Vienna to complete his studies. While the family was in Vienna, Bumstead, then a child three years of age, learned to speak German as fluently as he spoke English, an accomplishment which was to prove valuable to him in his subsequent career.

Bumstead was descended from an old New England family which traces its origin to Thomas Bumstead, a native of England, who settled in Boston, Massachusetts, about 1640. Many of his ancestors were engaged in the professions, his paternal grandfather, the Reverend Samuel Andrews Bumstead, being a graduate of Princeton Theological Seminary and a minister in active service. From them he inherited a keen mind and an unusually retentive memory. It is related that long before he had learned to read, his Sunday school teacher surprised his mother by complimenting her on the ease with which her son had rendered the Sunday lesson. It turned out that his mother made a habit of reading the lesson to Bumstead before he left for school, and the child's remarkable performance there was due to his ability to hold in his memory every word of the lesson after hearing it read to him a single time.

Unfortunately Bumstead was never robust physically. Even as a child he suffered from hay fever and indigestion and his early schooling was delayed and interrupted by poor health. In 1911 he underwent a serious operation for gastric ulcer, and the arduous labor of planning and supervising the erection of the new Sloane Physics Laboratory at Yale the year after brought on a recurrence of the former trouble and the necessity of a second operation in 1913. Only by taking continual care of his health and avoiding over-exertion of any kind was he able to accomplish what he did in science and in public service. Even so his achievement would have been much curtailed and probably his life itself shortened had he been denied the capable assistance of his wife. She took on her own strong shoulders all the financial and domestic worries of the household and the children and made his home at all times a haven of peace and rest.

Bumstead's early education was obtained at the Decatur, Illinois, High School, from which he went to Johns Hopkins in 1887, expecting to study medicine and to enter his father's profession. Courses taken under Fabian Franklin, however, turned his attention to mathematics and the influence of Rowland so stimulated the interest in physics which he had already shown that by the time he had completed his three years of undergraduate study he had definitely decided to devote his life to that science. After receiving his B. A. degree in 1891, he remained in Baltimore for two years as an assistant in the physics laboratory, taking as much graduate work as time would allow. Notebooks found among his effects show that he took a course in Thermodynamics under Rowland in 1891 which included, in addition to the classical thermodynamics, a considerable amount of the material contained in Josiah Willard Gibbs' great work "On the Equilibrium of Heterogeneous Substances." The following year he attended Rowland's lectures on Electrostatics and on the Electromagnetic Theory of Light.

In 1893 Bumstead was brought to Yale by Professor Charles S. Hastings as an instructor in the Sheffield Scientific School. Undoubtedly the prospect of coming into personal contact with Gibbs had much to do with his decision to make the move. What time he could spare from his teaching duties he devoted to continuing his study of physics in the Yale Graduate School. He took courses with Gibbs in Vector Analysis, Multiple Algebra, Thermodynamics, and Electromagnetic Theory of Light, his notes on the last two courses being extant and in the possession of the writer. Gibbs' high opinion of his brilliant student is evidenced by the notation "excellent" in the reports submitted to the graduate school at the termination of each of these courses. Evidently Bumstead's keenness of perception was thoroughly appreciated by Gibbs, for the latter once remarked to one of his colleagues "Some things come easier to Bumstead than to most men."

Bumstead obtained his doctor's degree in 1897, submitting as thesis a paper entitled "A Comparison of Electrodynamic Theories." This work, although inspired by his contact with Rowland and Gibbs, was carried to completion with little aid from his supervisors and represents a more original contribution than is generally the case with doctor's theses. Unfortunately it does not seem to have been published, the only copy in existence being the manuscript in the author's own handwriting which has been preserved in the archives of the Yale library. In it Bumstead gives a critical survey of the electrodynamic theories in vogue at the time at which it was written. He states in the introduction that his principal object is "to set forth the true position of the experiments of Hertz in the history of the development of our knowledge of electricity; and to trace, in some measure, the influence of Helmholtz in the establishment of the true theory of electrodynamics,—an influence which was second only to that of Maxwell." Throughout the mathematical part of this essay the author uses Gibbs' significant vector symbols in place of the clumsy European notation of parentheses, brackets, grads, divs and curls. In view of the simple and unambiguous electron theory of Lorentz which has since put the subject of electrodynamics on a firm basis it is interesting to note the author's reference to "the multiplicity of electrodynamic theories and their wide differences as to physical basis and fundamental mathematical formulæ."

After an analysis of Ampère's and Grassmann's theories, he makes a critical comparison of the potential theories developed by Neumann, Weber and Helmholtz. The very general form of Helmholtz's theory appealed to him strongly, and he takes delight in showing how it contains as special cases most of the other theories proposed, including Maxwell's mathematical formulation of the results of Faraday's researches. While Helmholtz's attempts to discriminate experimentally between various discordant viewpoints did not seem to him conclusive, his admiration for Hertz's genius as an experimenter knew no bounds. He lays particular emphasis on Hertz's zeal in following up every unexplained phenomenon to its source, mentioning in particular the discovery of the effect of ultra-violet light on the conductivity of the spark gap. The influence of the British school of physicists is very evident in the point of view adopted in this paper, and it is clear that at this date the "ether" was very real to the author.

In 1900 Bumstead was promoted to an assistant professorship, and six years later he left the Sheffield Scientific School to succeed Professor Arthur W. Wright as Professor of Physics in Yale College and Director of the Sloane Physics Laboratory. The year before receiving his doctor's degree he married Luetta Ullrich, daughter of John Ullrich, a banker of Decatur, Illinois. A son, John Henry, was born in 1897 and a daughter, Eleanor, in 1902. The son has adopted the profession of his grandfather, having obtained his M. D. at Johns Hopkins University in 1923 and being at present connected with the Yale Medical School.

Bumstead's heavy teaching duties during the five years following the completion of his doctor's thesis left him little time for research. His interest in electrodynamics, however, was always keen, and in 1902 he published a short paper in which he showed how Maxwell's equations completely accounted for an anomaly in the reflection of electric waves which had been causing some discussion among his contemporaries. If standing waves are set up on a pair of parallel guide wires terminating in a conducting plane at right angles to their length, the node in electric intensity found at the end of the wires is at a distance from the nearest node on the wires agreeing with the distance between other adjacent nodes. If, however, the conducting plane is removed, the loop to be expected at the free end of the wires is found to be at a distance from the nearest node somewhat less than a quarter wave-length. Bumstead showed that the introduction of a fictitious magnetic conductivity into Maxwell's equations established a close correspondence between this case and the well-understood arrangement in which the ends of the parallel conductors are united by a short connecting wire.

The death of Gibbs the year following the publication of this paper brought to Bumstead the sad duty of writing the obituary of his friend and teacher. His broad knowledge of mathematical physics and his intimate association with Gibbs over a number of years enabled him to prepare an appreciation of the great physicist which could have been equalled by few of his contemporaries. The tribute to the personal character of Gibbs which forms the final paragraph of his article is worth quoting since it applies so well to Bumstead himself:

"Unassuming in manner, genial and kindly in his intercourse with his fellow-men, never showing impatience or irritation, devoid of personal ambition of the baser sort or of the slightest desire to exalt himself, he went far toward realizing the ideal of the unselfish, Christian gentleman. In the minds of those who knew him, the greatness of his intellectual achievements will never overshadow the beauty and dignity of his life."

While Gibbs' "Elementary Principles in Statistical Mechanics" had been published as one of the Yale Bicentennial Series in 1902 and E. B. Wilson had put in the form of a book Gibbs' lectures on vector analysis, many of the great physicist's papers were available only in journals not readily accessible. So Bumstead, in collaboration with Gibbs' nephew, R. G. Van Name, edited and published in 1906 his former teacher's Scientific Papers. The edition printed at that time has already been exhausted, but thanks to a generous admirer of Gibbs funds have recently become available to reprint the Scientific Papers and the Statistical Mechanics and to make possible the publication of two volumes of commentaries. The latter are now being prepared under the editorial supervision of Haas in Vienna and Donnan in London.

During the early years of the present century Sir J. J. Thomson's investigations of the properties of cathode rays and of gaseous ions were attracting more attention among physicists than any other line of experimental research. Bumstead was greatly interested in this work and it was largely through his efforts that the successor of Maxwell and Rayleigh was persuaded to come to Yale to deliver the first Silliman lectures in May, 1903. While in New Haven Professor Thomson told him of the work being done at the Cavendish Laboratory on a radioactive gas found in water coming from deep levels, and suggested work of a similar nature at New Haven. This Bumstead carried out in collaboration with his colleague L. P. Wheeler. They found evidences of radioactivity not only in gas driven off from water obtained from a well 1500 feet deep near New Milford, Conn., but also in that boiled off from surface water drawn from one of the New Haven city reservoirs. Comparison of the rate of decay of the soil-water gas with that of radium emanation (radon) showed the two to be identical. The rate of diffusion of the emanation through a porous plug was then investigated, and found to be about four times that of carbon dioxide. This determination led to an atomic weight of 180, which was, perhaps, the most reliable value which had been obtained up to that time, and, considering the difficulties of the experiment, surprisingly close to the values yielded by later more accurate methods.

Bumstead secured leave of absence from Yale for the college year 1904-1905 in order to devote his entire time to study and research at the Cavendish Laboratory in Cambridge. During this winter he took the opportunity of attending Sir Joseph Larmor's lectures on Electrodynamics and completed two experimental researches. The second of these, on the heating effects produced by Röntgen rays in metals, aroused a great deal of interest among scientists. This investigation was undertaken at a time when the attention of the scientific world was focused on the brilliant researches of Rutherford on atomic disintegration. Particular interest was being given to the attempt to hasten or retard radioactive disintegration by varying external conditions, and to the search for new sources of radioactivity. However, every effort to control the rate of decay seemed to be in vain. From the lowest to the highest extremes of temperature, under all conditions of electromagnetic excitation, radioactive transformation went on at the same invariable rate. Bumstead's research consisted in measuring the heat produced in lead and in zinc when Röntgen rays are equally absorbed in the two metals. His experiments seemed to lead to the surprising result that the heat developed in lead is approximately double that produced in zinc. The only plausible explanation seemed to be that the rays effected a disintegration of the lead atoms on which they impinged, liberating energy which was then converted into heat. This conclusion, if true, would have indicated a most important discovery: the artificial disintegration of atoms under the incidence of X-rays. Unfortunately the subsequent work of Angerer and of Bumstead himself failed to confirm the earlier results. By varying the conditions of the experiment Bumstead was able to show that the differential effect observed in the first instance was due to inadequate heat-insulation of the metals under investigation.

During this winter in England Bumstead had come into intimate contact with many British scientists, including Lodge, Darwin and Rayleigh in addition to J. J. Thomson and Larmor. His lovable character and versatile mind made him a friend much esteemed by all who knew him. During the summer of 1905 he joined E. F. Nichols and Duane on a trip through Holland and Germany, where many famous physical laboratories were visited and the travelers were entertained by a number of their European colleagues.

Shortly after Bumstead's return to New Haven he was offered a professorship in both the Sheffield Scientific School and Yale College. As Professor A. W. Wright was retiring from the faculty of Yale College, Bumstead felt that the need for him there was greater than in the Scientific School. Therefore he accepted the position offered by the College and succeeded Wright as director of the old Sloane Laboratory. At that time the physics departments in the College and in the Scientific School were entirely distinct, each having its own staff and the two being housed in separate buildings half a mile apart. Only in connection with the instruction of graduate students and at meetings of the Journal Club or when papers were presented at the Physics Club, which had been founded by Gibbs, did the two departments come together. Impressed by the anomaly of the situation and realizing the inadequacy of the College physics laboratory and of the yet more cramped quarters of the department in the Scientific School, Bumstead made every effort to effect a union of the two departments and to secure better laboratory facilities. It was largely as a result of these efforts that William D. Sloane and Henry T. Sloane of New York were led to give to the University and to endow generously the present commodious building which was completed in 1912. All those who have benefited by the facilities and conveniences of the new laboratory are under a great debt of gratitude to Professor Bumstead for his many months of painstaking planning and careful supervision of the erection of the building. In this new laboratory were housed together, for the first time, both undergraduate departments of study in a single subject. This union was the forerunner of the departmentalization which was so prominent a feature of the University reorganization undertaken at the close of the war. A few years after the opening of the new laboratory Bumstead was instrumental in introducing into the undergraduate curriculum honors courses patterned after those at Oxford and Cambridge. For many years he personally conducted the honors classes in physics, which were deservedly popular among the more serious minded students.

In 1905 appeared Einstein's first paper on relativity in which he proposed the principle which now bears the name of "special" or "restricted" relativity. This paper greatly stimulated Bumstead's ever-present interest in electromagnetic theories, and led him to publish in 1908 a critical comparison of the viewpoints of Einstein and Lorentz. Among other things he devised elegant methods of deducing some of the consequences of the relativity principle. In particular, mention should be made of his derivation of the ratio of longitudinal to transverse mass from a simple consideration of the period of a moving torsion pendulum. Furthermore, he made an attempt to extend Einstein's method to gravitational problems, and pointed out clearly the fallacy of the oft-repeated assertion that a finite velocity of propagation of gravitational force should lead to a first order perturbation in planetary orbits.

Although geatly impressed by the beauty and symmetry of Einstein's theory, the ether had such a real significance to Bumstead that he was never able to accept completely the view-point of the relativist. He believed in holding close to the facts revealed by experimentation, and he often stressed the point that all physical laws are the result of experimental discoveries and that no mathematical formulation can contain more than is involved in its premises. Therefore he doubted the value of Einstein's new principle in opening up unexplored fields of research. To him it seemed a closed discipline, perfect but infertile. Hence Einstein's ultimate success in generalizing the principle, so as to make possible the application of the equivalence hypothesis to gravitational fields, appealed to him all the more as a great work of genius.

In 1911 Bumstead began an investigation of the delta rays emitted by metals under the action of alpha rays, a study which he continued for the following three years. Delta rays—so named by J. J. Thomson—are the slow moving electrons detached from metallic surfaces under the bombardment of the more massive alpha particles. The ionization curves obtained by Bumstead show all the characteristics of the Bragg curve for gases, but, unlike the latter, the curves for different metals have very nearly the same form. This observation led him to suspect that delta rays come from a gas adsorbed on the metal surface rather than from the metal itself. An investigation of the velocities of the particles constituting the rays revealed the fact that some of them have velocities corresponding to a potential difference as great as 2000 volts. These swifter rays seem to be the primary result of the impact of alpha rays, and to give rise to secondary slow-moving electrons when they collide with other atoms.

The results of these experiments suggested to him that the impact of alpha particles might cause high speed electrons to be emitted as well by gaseous molecules in the free state. To test this point he brought home from England on his trip in 1914 an expansion apparatus made by the Cambridge Scientific Instrument Company after C. T. R. Wilson's design. This apparatus he modified so as to enable him to work in hydrogen at pressures between 90 and 100 mm., and with it he obtained a number of photographs of alpha ray tracks which showed very clearly electronic trails radiating from the column. These trails supplied the evidence of high speed delta rays for which he was searching.

Following his second operation in 1913 Bumstead's health made necessary a respite from academic duties. Consequently he obtained a year's leave of absence and took his family abroad in the summer of 1913. After passing through Italy, Switzerland and France he settled in Germany for the winter. While there he was greatly puzzled by the change in attitude of his friends among German scientists. Their cordiality to him was as warm as on the occasion of his visit in 1905, they were eager to entertain Mrs. Bumstead and himself at tea or dinner, but to all suggestions that he would like again to visit their laboratories they turned a deaf ear. Whereas in 1905 he was welcome in every German physical laboratory that he cared to visit, in 1914 he did not succeed in passing through the doors of one. Not until August did he fully realize the meaning of this change.

Leaving Germany in the Spring he went to Cambridge and was in England at the outbreak of the war. There men of science were petitioning the government to avoid war at all costs. In a few days time Germany's invasion of Belgium caused a revulsion in public opinion, and the same scientists who had been deploring war urged their government to join France and Belgium without delay.

In the stress of the early days of war it was with difficulty that accommodations were secured for the return voyage to the United States. Although his country was not an active participant Bumstead found the minds of his friends at home filled with indignation and apprehension as to the future. In his own mind there was but one course for his country to pursue, and at every opportunity he urged the importance of joining the Allies at the earliest possible moment. When finally the people of the United States, aroused by the ruthless sinking of the Lusitania, declared war with Germany, he placed all his time and ability at the service of his country. During 1917 he was a member of the national committee appointed to examine the merits of proposed anti-submarine devices, and he took an active part in the experimental development of such devices which was carried on at New London.

The distance of the seat of government of the United States from the capitals of her allies and from the scene of hostilities made it difficult to meet promptly the requirements of the officers in the field and to cooperate as closely as was desirable with the governmental agencies of England and France. In a war in which scientific devices played such an important part it was vital to secure rapid interchange of ideas and to supply each one of the associated powers with immediate information of the technical advances made by the others. For this purpose it was decided to locate a liaison officer at London who would command the confidence of British and French scientists, and who could acquire and transmit to Washington information without the delay and red tape inherent in diplomatic channels of communication. Bumstead, on account of his broad scientific knowledge, his wide circle of friends among British men of science, and not least on account of his tact and discernment in dealing with others, was an ideal candidate for such a post, and in February, 1918, he sailed for London as Scientific Attaché to the American Embassy. Immediately upon his arrival Admiral Sims put office space and stenographers at his disposal, and due to this hearty cooperation he was able to start his work with the minimum of delay. He quickly made points of contact with scientific workers in Great Britain and in a very short time the desired technical information was flowing rapidly and steadily to Washington. In fact his position and his relations with those at home enabled him to return the many kindnesses shown him by officers of the Navy by securing for them in several instances needed information more speedily than it could have been obtained through the official channels of the Navy Department.

In a letter home Bumstead gives an account of his first air raid, which occurred early in March, 1918:

"Last night I experienced my first air raid; it was something of a novelty even to Londoners, since there was no moon. The guns gave the warning just after I had gone to bed. I got up and looked out of the windows but could see nothing except some distant flashes in the sky and, as it was cold, I went back to bed. No bombs were dropped anywhere near here, so I did not hear them; if I had I am sure I should have been much frightened. As it was I heard only the firing of the defensive barrage and the bursting of the shrapnel high in the air. It sounded just like the Italian who was 'cured by miracles,' only there was more of it. So I was not in the least frightened, but was surprised to find that I was thoroughly enraged and filled with hate for the infernal Germans when I thought of what must be happening somewhere in London. It was a much more intense and violent feeling than I have ever experienced when reading about their various atrocities. It is curious that actual physical proximity makes a difference. Just as when I first saw wounded soldiers at Liverpool, I had a much stronger feeling of pity and sorrow than I had got from reading about them."

Not only did his friends among British men of science facilitate his mission through their connections with the research staffs of the Munitions Inventions Department and of Woolwich Arsenal, but they brightened his leisure hours by week-end invitations, luncheons and dinners. In his letters he mentions a week-end at Trinity Lodge shortly after the induction of Sir J. J. Thomson into the office of Master of Trinity, and speaks of other week-ends spent with Ambassador and Mrs. Page, with the Jeanses, Schusters, Braggs, and Rayleighs. On two occasions he dined with Sir Joseph Larmor at the House of Commons, and Sir J. J. Thomson introduced him into the exclusive Athenaeum Club. In a letter to Mrs. Bumstead he says:

"I have been received absolutely with open arms by every single Britisher I've come in contact with—not only the actual scientific workers, but the officers and officials who have charge of such work. There is not the slightest holding back and they welcome enthusiastically the idea of direct communication between the scientific workers."

He was planning to extend his activities and had already arranged for one of his colleagues at Yale to join him in London as his assistant when it became evident that the war was coming to a close and that an armistice could not be more than a few weeks distant. It required a few months after the close of hostilities to disband his organization and it was not until February, 1919, that he returned to New Haven to resume his duties at the University.

The peace-time routine of teaching and conducting research at Yale had been seriously deranged by the war. Undergraduates had left in large numbers before completing their courses to enter the army or the navy, regular classes had dwindled in size, many of the faculty had obtained leaves of absence to engage in war work and those who remained had dropped their normal research to devote themselves to training officers for various branches of the service. The staff of the physics department, in particular, had been engaged in supplying officers of the signal corps with intensive training in radio communication. Under these conditions the abrupt ending of the war and the necessity of returning to a normal basis provided an excellent opportunity for effecting a reorganization, the need for which had been felt for some time. On his return to New Haven Bumstead found the University engaged in reviewing the situation and in making plans for a future of greater usefulness and service. His remarkable power of coordinating the divergent viewpoints of others and his excellent judgment made him much in demand as a member of the faculty committees which were moulding the new Yale. He gave freely of his time and his strength to this service, in spite of his desire for the opportunity to devote himself to a life of quiet study and research.

The war having emphasized the value of research in all fields of human activity, far-sighted and patriotic donors had provided the National Research Council with generous funds to promote scientific investigation. Committees were organized to prepare reports on various phases of research in order to acquaint investigators more rapidly with current progress and to suggest to them new points of attack. Bumstead was appointed chairman of one of the first of these committees—that on Atomic Structure. While the pressure of other duties forced him to sever his connection with the committee before its work was completed and while he did not partake personally in the writing of its report, his leadership and advice were invaluable to the other members of the group.

Bumstead's activities in connection with the reorganization of the University had taken so much of his time during the college year 1919-20 that he had been seen little in the physics laboratory except during the hours when he was engaged in lecturing. This labor ended, he was planning a resumption of experimental research when the call came to succeed James Rowland Angell—president-elect of Yale—as chairman of the National Research Council. The incumbent of this position was changed annually, so his acceptance would necessitate only a single year's leave of absence from Yale, and he did not feel justified in refusing the opportunity of a wider service. His administrative ability and his power of inspiring the loyalty and best efforts of others made his success in his new position a certainty.

Bumstead's residence in Washington did not preclude occasional visits to New Haven, and on one of these (October 21, 1920) he contributed a lecture on the History of Physics to the series on the History of Science which had been planned under the auspices of the Yale Chapter of Gamma Alpha. In reading this lecture—and this statement is true of all his publications—one is impressed with his broad knowledge of science, his lucid style and his deep insight. Tracing the progress of physics from Galileo to Planck and Einstein he uses as his motif the rise and increase in number of the "imponderables" to a state of maximum significance during the nineteenth century, followed by an increasing doubt as to their reality or even importance and the gradual rejection of one after another.

Unfortunately Bumstead was not destined to live out his term of office as chairman of the National Research Council. The day after Christmas, 1920, he took train for Chicago to attend the annual meeting of the American Physical Society. During the first two days of the session the windy city did her best tc discourage her visitors with high gales and bitter cold. Nevertheless, to his many friends who talked with him there Bumstead appeared to be at the height of mental and bodily vigor. On Wednesday evening he attended a meeting of the National Research committee of which he had been chairman, and contributed his keen analysis to the discussion until almost midnight. The morning of Friday, December 31, he spent with R. A. Millikan, at whose home he had been staying, in going over the research work of the Ryerson Laboratory. He left Millikan about 11:30 and started on the return trip to Washington in the early afternoon. During the evening he mentioned a feeling of fatigue to friends on the train and decided to retire early. The next morning his friends were surprised at his absence from breakfast in the dining car, and one of them—Dr. Vernon Kellogg—went back to his berth to ascertain if he had been taken ill during the night. The curtains before the berth were still closed; on pulling them apart Dr. Kellogg found him dead. Apparently he had passed away from heart failure during his sleep.

Recognition of Bumstead's eminence as a scientist has come from many sources. Long a fellow of the American Physical Society he was a member of the board of editors of its official publication, "The Physical Review," from 1914 to 1916 and succeeded R. A. Millikan as president of the society in 1918. He became a fellow of the American Association for the Advancement of Science in 1910 and vice-president of Section B in 1916. Retiring from this office in 1917 he delivered the vice-presidential address at the Christmas meeting in Pittsburgh, choosing for his title "Present Tendencies in Theoretical Physics." In this speech he emphasized the demoralizing effect of war upon research in pure science, noting the absence of progress in both theoretical and experimental physics since August, 1914. The address is a succinct summary of the history of theoretical physics from Newton to Einstein and Bohr, ending with a prediction of great advances in the future as a result of the effort to reconcile the many apparently discordant and mutually contradictory elements which had been revealed by the study of radiation and atomic structure.

In 1913 Bumstead was elected a member of the National Academy of Sciences, an honor conferred only upon the foremost of American scientists. He was a fellow of the American Academy of Arts and Sciences, and a member of the American Philosophical Society and of the Connecticut Academy of Arts and Sciences. The University of Toronto conferred on him the honorary degree of Doctor of Science the June preceding his death.

Not only was Bumstead's advice always in demand on the part of his scientific associates, but it was frequently sought by those whose interests lay outside the domain of science. As an example may be cited Henry Adams' request for a critical opinion of those chapters of "The Degradation of the Democratic Dogma" which contain the author's bold excursion into the scientific method. Bumstead pointed out the dimensional difficulties involved in applying the "law of squares" to historical phases, and repeated his criticism to Brooks Adams when the latter was preparing his deceased brother's manuscript for publication. However, the importance of this hypothesis to the argument of the essay was sufficient in the eyes of the editor to warrant its retention in spite of its obvious fallacy.

In addition to the papers published under his own name, Bumstead supplied most of the underlying ideas and much of the motive force responsible for the great majority of the doctor's theses in physics coming from Yale during his association with the University. He was always generous in giving his time and ideas to others, and never asked the students who worked under him to share with him the credit of authorship. On several occasions his interest and kindness of heart led him to supply pecuniary aid from his own pocket to needy graduate students in the department.

In view of his extensive knowledge of theoretical physics and his high attainments as a mathematician it is rather surprising that Bumstead's research was mostly confined to the experimental side of his subject. In fact, half of the theoretical papers which he published were more of the nature of critiques than of new theoretical developments. Perhaps the explanation lies in the feeling he often expressed that experimentation is the real business of the physicist and in a certain distrust of speculative ideas which he frequently manifested.

Bumstead's power as a teacher was perhaps even greater than his ability as an investigator. His insight and his deep understanding of his subject made his lectures on Electrodynamics and Electromagnetic Theory of Light the inspiration of the graduate work in physics at Yale. He was never too busy or too hurried to spend an hour discussing a knotty problem with a member of his class. His illuminating discussions at meetings of the Journal Club or of the Physics Club were eagerly looked forward to by students and colleagues alike.

Eminent as a scientist, inspiring as a teacher, in his personal character he was the embodiment of the perfect Christian gentleman. Modest regarding his own achievements, cheery in his attitude toward life, always ready to lend a helping hand, unfailing in his interest in the work and ideas of others, never backward in bestowing praise when he felt it was deserved, he was loved by his students, his colleagues and all those who had the good fortune to pass his way. His high ideals, in human relationship as well as in scientific attainment, have had a profound influence in moulding the characters of the young men whom he has trained. President Arthur T. Hadley summed up the feeling of the Yale community when he said, in speaking of Professor Bumstead's death:

"His charm as a man will live in the memory of his friends here longer even than the great things he accomplished in physics. No man in the whole faculty of Yale was more universally loved and admired."

RESOLUTION PASSED BY THE INTERIM COMMITTEE OF THE NATIONAL RESEARCH COUNCIL, JANUARY 3, 1921.

RESOLVED, That the National Research Council learns of the death of Dr. Henry A. Bumstead, chairman of the Council, with great sorrow and profound sense of loss. Dr. Bumstead in his association with the Council had revealed to its officers and members not only a high capacity for administration, and a most loyal fidelity to the aims and work of the Council, but also a sweetness of disposition and personal attractiveness which had won for him the devoted and affectionate regard of all of his colleagues in the Council. In his death the Council and the scientific world lose a man of most eminent attainments, highest character, and lovable personality.

The National Research Council extends to the bereaved wife and family its deepest sympathy and condolence and wishes to express to them its full appreciation of the great value of the services which Dr. Bumstead rendered it in the period of his association with it and the great loss which it suffers by his untimely death. But may we all remember that "that life is long that answers life's great ends."

FROM SCIENCE, JANUARY 28, 1921
(Abridged)

My personal acquaintance with Henry A. Bumstead dates from a meeting of the British Association in Winnipeg in the summer of 1909.

He had studied in Cambridge, England, where his engaging personality, keen intelligence, and unusual *savoir faire* had made him a place in the hearts and homes of English scientists which has been held by few Americans. I was then almost unknown both to him and to them, but I soon learned that if Bumstead was in any gathering I should at once feel at home.

I was walking with him one day through one of the busy streets of Winnipeg when he asked if I would not step into a shop with him while he bought a little memento for Mrs. Bumstead, a "bad habit" which he said he had formed on trips away from home.

I mention these two trivial incidents because they reveal the soul and heart of the man; and what, after all, is either science or art in comparison?

When in 1917 the important and difficult post of scientific attaché in London was created, Bumstead was the only man considered, for no scientist in this country had his tact, his judgment, his knowledge of England, and his ability to assist in bringing about what was then, and what is now, the most important need of the modern world, namely the cooperation and mutual understanding of the two great branches of the Anglo-Saxon race.

Bumstead's success in London was extraordinary. The British liked and trusted him. Admiral Sims and our own War Department placed large responsibilities upon him, and his office became the center of a very active and very important service. Young American officers who went abroad on scientific missions found him the center of their contacts and the prime source of their usefulness. They all became his devoted admirers. Not one or two but a dozen or more of both British and American officers who came to Washington during the war told me that they owed their success in their work in England and the continent primarily to Bumstead, and counted it the most valuable part of their experience that they had had an opportunity to become acquainted with him. One of these officers described him as the most influential American in England.

As chairman of the National Research Council, as member of the National Research Fellowship Board, and as participant in other important groups with which he was associated at the time of his death, Bumstead showed the same broad outlook, the same big human interest, the same tact, the same sane intelligence and sound judgment which had characterized his work in England.

. . . .

He leaves a big gap in the ranks of American physicists. . . . He had a brilliant analytical mind, profound scholarship, exceptional critical capacity, excellent judgment, an extraordinary winsome personality, the finest culture, and a great heart. His personal scientific contributions were important, though they had been much interfered with by his none too rugged health. His effect upon American physics, however, was not limited to his own scientific papers, but he exerted a powerful influence upon his pupils and upon his fellow physicists.

It is not merely American science, however, which can ill afford to lose him twenty years before his time. American life in all its aspects is sadly in need of men of Bumstead's type. The cause of sanity, of culture, of Anglo-Saxon solidarity, of scholarship, of science, of world civilization, all suffer irreparably through his death.

ROBERT A. MILLIKAN.

FROM THE YALE ALUMNI WEEKLY, MARCH 18, 1921
(Abridged)

As a teacher, he (Bumstead) showed . . . . a rare power of lucid exposition and an unusual ability to understand the difficulties of the student in grasping novel and abstruse concepts. . . . . Every one of the fortunate five hundred (who took his courses) would rank him among the greatest teachers of whom Yale boasts.

During his entire career, Bumstead was active in performing and instigating research. . . . He made important contributions to our knowledge of atmospheric radioactivity and to the understanding of some of the puzzling phenomena in the conduction of electricity through high vacua. In addition to the work in print under his own name, there is a great deal in the published work of his students and colleagues which owes much to his insight and inspiration. And his influence on research extended beyond the walls of the University. In the American Physical Society, in the American Association for the Advancement of Science, in the National Academy of Sciences and its Research Council, he exerted a profound influence on research in the fundamental sciences which was national in its extent.

It is impossible to give in any reasonable compass an adequate picture of such a man. Great as was his achievement, the man was larger than his work. The University and the world of science have lost a leader notable for qualities of heart as well as of mind, which were never more needed in the nation than at the present time. A teacher with the power to make the student see for himself; a councilor wise, broad-minded and far-sighted; an administrator with the ability to make the practicable policy achieve the ends of an ideal. His friends, the University, the world of science, and the nation at large are at once the poorer in his loss and the richer in the heritage of his memory.

LYNDE P. WHEELER.

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