NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVIII—TENTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

AUGUSTUS TROWBRIDGE

1870–1934

BY

KARL T. COMPTON

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1937

Augustus Thorndike

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Throughout history it has been notable when men of means and established position have served as patrons of science or art or social service. It is more notable when such men also devote their own talents and energies directly to useful achievement in such fields. Augustus Trowbridge did not need to earn a salary in order to live comfortably, and so lacked the urgent financial incentive for getting ahead which is necessarily of real power in the lives of most professional men. With his quick wit and unusual social gifts the life of a gentleman sportsman or dilettante could have been delightfully easy to a man of lesser character. But his ideals and self discipline, directing his unusual natural talents, carried him through a career in which scientific and human interests were blended in a remarkably unified and effective manner. His memory, like his life, will continue to be a stimulating example of the unselfish joy of intellectual life and of social responsibility courageously met.

Augustus Trowbridge was born in Brooklyn, New York, on January 2, 1870, the son of George Alfred Trowbridge. His father, born in New Haven of old New England parentage, was a man of vigorous constitution and genial social gifts, a merchant by profession and by avocation an enthusiastic sportsman particularly devoted to riding and hunting. Unfortunately, however, the father's health gave way at about the time of the birth of Augustus, so that the boy was more than usually thrown on the care of his mother and older brothers and a sister. A glimpse of this influence is suggested in his inaugural dissertation for the degree of doctor of philosophy from the University of Berlin, which is dedicated by its author "to his dear mother, in love and gratitude." His mother, Cornelia Polhemus Robertson, was born in New York in 1836 of old Dutch stock. Like her husband, she was socially talented and

of marked native intelligence, and was well educated for a woman of her generation. Evidence of the early cultural influence of that home, which left so strong a mark on Augustus, is seen also in the subsequent careers of his two brothers: Robertson Trowbridge became a writer of prose and verse, and a collector of books; Frederick Kellogg Trowbridge, his older half brother, was a banker by profession who found joy in collecting rare editions of letters and manuscripts.

In his autobiographical record in the archives of the National Academy of Sciences, Trowbridge mentions the fact that he was ten years younger than his nearest brother and that he had very few playmates of his own age,—a situation which evidently left its impression on his memory and which may have had some part in developing his unusual independence and maturity of judgment. His early schooling took him successively to the public schools, St. Paul's Military Academy, Phillips Andover Academy and to France and Italy in care of tutors just before entering college. He has expressed himself as liking all of these school experiences except the military school, and as being particularly fond of natural science, history and languages, both ancient and modern. At an early age he had acquired that fluent proficiency in French, German, and Italian which were to be so useful to him. He used frequently to remark in later life of his gratitude for this early training in languages which was to open to him so many unusual opportunities for interesting and useful work.

At the age of twenty, Trowbridge entered Columbia University where, like many another promising lad of subsequent fame, he came under the influence of that great personality and scientist, Michael Pupin. He had the usual undergraduate interests of which the most prominent, of an extra-curricular nature, was probably his membership on the varsity crew.

At the advice of Pupin and of Rowland, who was a distant cousin, he withdrew from the University in his junior year to accept an excellent temporary position as a civil engineer for the World's Fair in Chicago and then to go to Berlin to pursue the advanced study of physics, leading, after eight semesters in

residence, to the Ph.D. degree in 1898. It was in this period of early manhood that two influences of profound and lasting import came into Trowbridge's life,—the one personal and the other professional,—his wife and his introduction to that developing branch of physics which continued throughout life to be his principal, though not his only field of special scientific research.

Just before going to Berlin in the fall of 1893, Trowbridge married Sarah Esther Fulton, daughter of the editor and Baptist clergyman, Justin Dewey Fulton of St. Louis, Boston and Brooklyn. Dr. Fulton was intensely interested in education and, through education, in safeguarding the church and country from threatening influences. Undoubtedly from this early home influence, as well as by natural bent, Sarah Fulton brought into the home which she and Augustus Trowbridge were founding a deep religious and altruistic influence. She furthermore was a fair match for him in social gifts. Her queenly beauty, charming tact and never failing good spirits made their home a favorite rendezvous for young and old alike. Her companionship, her pleasure in the success of his scientific work and her real support in his social and professional relationships must have been a great factor in maintaining in him that joy in living and satisfaction in working that were so characteristic.

The period of Trowbridge's study in Germany was one of interesting and fruitful development in physics. Wien and Boltzman had just carried the theory of heat radiation to the point from which the brilliant young Planck was soon to deduce his famous radiation formula and thereby give birth to the quantum theory of radiation,—a theory which at the hands successively of Einstein, Bohr, Sommerfeld, Born, Schroedinger, Heisenberg and Dirac, and many others, was to lay a new foundation for the basic science of mechanics as applied to atomic processes. Drude was just ready to publish his "Lehrbuch der Optik," in which the electromagnetic nature of radiation was used to interpret the optical properties of materials. Paschen was developing powerful methods for investigating the spectrum of radiation, and Rubens was developing a brilliant technique for investigating the optical properties of solid surfaces. Radioactivity, X-rays, and

the electron were all just around the corner, but when Trowbridge went to Berlin, radiation was undoubtedly the subject of greatest interest and most rapid unfolding in physics. It was quite natural, therefore, that he should select this field for his special study and research, and that he should work under Rubens. It was also natural that another brilliant young American in Berlin, Robert W. Wood, should have made the same selection, and that he and Trowbridge should immediately begin a life-long friendship with frequent collaboration. Still another friend and future member of the National Academy of Sciences was in that group under Rubens, Ernest Fox Nichols, whose research was, in some aspects, the antecedent of Trowbridge's.

The scientific results which were embodied in Trowbridge's doctor's thesis, under the subject "The Reflecting Power of Metals," provided experimental knowledge of the reflecting powers of gold, brass, copper, iron, nickel and speculum metals in the infra-red region from 1μ to 15μ. Of interest in showing some of his thoughts on more general philosophical subjects at that time are the five propositions which he stated at the end of his thesis as statements that he could defend, after the German custom:

"1. The proposal of hypotheses in connection with established facts is an important factor for the further development of science.

"2. The ρ and σ functions, introduced by Weierstrass into the theory of elliptic functions, are of great importance for higher mathematics.

"3. The doctrine of inherited ideas, advanced by Locke, is not that taught by Cartesius.

"4. The study of specialized subjects in a foreign university offers an advantage, not to be undervalued, for gaining a general background as well as for arousing a freer and more comprehending mind.

"5. In the study of applied mathematics, it is important to understand clearly the physical significance of every equation."

In his entire career as a teacher he saw to it that his students followed this last precept,—considering departure from it to be almost a breach of scientific personal ethics.

Immediately following this period of training in Berlin, Trowbridge was called to his first teaching position, an instructorship in physics at the University of Michigan, which he held from 1898 to 1900. Here he was associated with Henry Carhart, eminent head of the physics department, and with Karl Eugen Guthe, who had recently come from Germany and who was largely responsible for bringing Michigan to its position of prominence in physics. Trowbridge's interests turned for a time to the field of radio with investigations of the coherer as a detector of electromagnetic waves. At the same time he had his "baptism with fire" in the teaching of elementary physics, for Professor Carhart was forced by illness to give up his work for the time being and Trowbridge took charge of Carhart's big freshman course in physics in addition to the duties for which he had been engaged. It was undoubtedly the brilliant manner in which the young instructor carried this double responsibility that brought him prominently to the attention of the American physics profession.

In the fall of 1900, Trowbridge accepted an invitation to an assistant professorship in mathematical physics at the University of Wisconsin, following his friend R. W. Wood who had just been called from Wisconsin to Johns Hopkins. In the following year came also to Wisconsin, Charles E. Mendenhall, who was also greatly interested in radiation and the optical properties of materials. Between these two men sprang up a close friendship which continued fruitfully throughout their lives, in their personal, scientific and administrative activities. They began there an interesting collaborative investigation of ether drift which was continued even after Trowbridge left Madison for Princeton, and which was terminated only by their quick acceptance of Einstein's general theory of relativity as closing the chapter in this field of experimental investigation.

After three years, Trowbridge was promoted to a full professorship in physics, which post he held for another three years until his appointment at Princeton in the fall of 1906. During his six years at Wisconsin, he continued his experimental and

theoretical investigations on various aspects of phenomena of electromagnetic waves.

During this Wisconsin period, Trowbridge took a leave of absence of several months to study in the laboratory of Professor Righi in Bologna. He had become much interested in the new wireless telegraphy and especially in the action of coherers, to which art Righi was making important contributions. From this contact also came his translation of Righi's treatise on "Modern Theory of Physical Phenomena, Radioactivity, Ions, Electrons".

Trowbridge was called to Princeton at a most interesting period. Under the leadership of Woodrow Wilson, that University was undergoing a new burst of intellectual activity and a remarkable group of scientists was being added to the staff. L. P. Eisenhart, Gilbert Bliss and Oswald Veblen had been made assistant professors of mathematics in the previous year, as had Henry Norris Russell in astronomy and George A. Hulett in physical chemistry, and George Birkhoff was soon to come. Edwin P. Adams, three years previously, had joined the staff in mathematical physics (though he was then actively interested in radioactivity). O. W. Richardson, one of Sir J. J. Thomson's most brilliant pupils, came in the same year with Trowbridge to initiate a great program of research in the new field of electronics. James Jeans came from Cambridge as professor of mathematical physics. It is doubtful if so many brilliant young men destined to fame in the physical sciences have ever been assembled within so short an interval of time, unless it were in the early days of J. J. Thomson at Cambridge.

Furthermore, the great Palmer Physical Laboratory was just then being built at Princeton, to provide those splendid facilities without which Princeton's rapid rise in the field of physics would have been impossible. With Howard McClenahan, who had entered physics via electrical engineering, Trowbridge took a particularly prominent part in planning the equipment of this laboratory; and with Richardson and Adams he shared for many years the supervision of the research by most of the physics students in the Graduate School.

Three other men played a particularly important role in Trowbridge's professional career at Princeton. One was William F. Magie, head of the Department of Physics during the entire period of Trowbridge's service in that department, a thermodynamicist trained by Helmholtz, and a gentleman whose fine personal qualities inspired a remarkable loyalty and cooperation among his younger colleagues. A second was Magie's predecessor, emeritus professor Cyrus Fogg Brackett, a splendid physicist of the old school, with whom Trowbridge collaborated for several years in the construction of optical instruments of high precision. The third was Andrew Fleming West, to whose educational philosophy and plans for a great graduate school Trowbridge and most of his colleagues in physics gave their strong support.

Trowbridge's service at Princeton divides naturally into three periods: from 1906 to the Great War; from the close of the war to his leave for European Directorship of the International Education Board in 1924; and from his return in 1928 to succeed Dean West as Dean of the Graduate School until his death.

During the first Princeton period, 1906-1917, Trowbridge's work in physics centered around three activities: his graduate course in physical optics, given usually as a reading-seminar course following Drude's "Lehrbuch der Optik"; his undergraduate courses in optics and in electricity and magnetism; and his research, both personal and in supervision of a small but able succession of graduate students.* To the latter he was an unusually inspiring teacher, because he worked hand-to-hand and idea-to-idea with his students in the spirit of an elder collaborator in the search for truth rather than as a taskmaster, director or critic.

Into the research of this period, Trowbridge carried the interests acquired under Rubens in Germany. His program

**Editor's Note:* Among the graduate students coming under Trowbridge's instruction were: F. C. Brown, A. K. Chapman, A. H. Compton, K. T. Compton, I. B. Crandall, C. J. Davisson, L. A. Turner, O. S. Duffendack, G. P. Harnwell, C. W. Heaps, A. G. Shenstone, H. D. Smyth, K. K. Smith, A. T. Waterman, C. T. Zahn, and others.

was centered around the spectrum of infra-red radiation and the optical properties of metals and crystals in respect to such radiation. He recognized the lack of instruments and methods of sufficient power and accuracy to give the desired data, and so undertook a major program of design of such instruments, with most fruitful results.

Among the instruments thus designed and used were a bolometer of increased sensitivity for detection of infra-red radiation, and a vacuum-infra-red spectrometer for extending spectrum measurements through the regions of air absorption and for investigating the absorption of different gases. But by far the major work was the development of a new type of diffraction grating which has found wide use. This work was begun in collaboration with Professor Brackett and involved the following principal features.

First was required a ruling engine to draw some thousands of fine parallel lines to the inch, accurately spaced and uniform in texture, over several square inches of accurately polished concave mirrors of speculum or other metal. This involved much delicate apparatus and adjustment, but especially a long driving screw of practically perfect accuracy and uniformity of screw threads. Such a screw was produced by a final long period of grinding three screws back and forth against each other. After several years of intensive work, a really good dividing engine was built.

Then came the problem of ruling gratings. Here Trowbridge's interest quickly turned to investigation of the effect of the shape of the grooves, or cross-sectional shape of the ruled lines, on the spectrum produced by the grating. This study involved careful selection and grinding to shape of the diamond points used for ruling, and the testing of the gratings produced by each. From this work was developed a new type of grating, the "echelette," characterized by remarkable power of concentrating the spectral energy into certain regions of the spectrum, which could be predetermined in the construction of the grating by aid of a theory which Trowbridge worked out.

Though some good use of these gratings was made by Trow-

bridge and his pupils, he devoted his main energy to further perfection of the gratings. At the same time he generously loaned his most successful gratings to other laboratories interested in infra-red spectroscopy. Notable among these was the University of Michigan where, under H. M. Randall, a most significant program of infra-red investigations was established largely with aid of these instruments.

During this time the Trowbridge family had quickly become most popular and influential in the Princeton community. They became closely identified with the activities of the Trinity Church. Their beautiful new home on the western outskirts of the town was a center of social interest for children as well as their elders, for the three Trowbridge children were ever leaders in sport and play, as well as in more serious activities.

The boys, George and Cornelius, attended Miss Fine's School, the Hill School and then Princeton University, where they graduated with the degrees of B. A. in 1920 and 1921. In extra-curricular activities, George gained international distinction as a track star, and Cornelius was a member of the soccer team and of the editorial staff of the *Daily Princetonian.* Both boys subsequently attended theological school. George Trowbridge is now rector of All Angels' Church in New York, and Cornelius Trowbridge is canon of St. Paul's Cathedral in Boston.

Katherine Trowbridge graduated from Miss Fine's School and then attended the Shipley School in Bryn Mawr, from which she entered Bryn Mawr College. Family reasons causing her to leave Bryn Mawr after one year, she later attended the New York School of Social Work, being more interested in real life than in the conventional routine of social life. In June of 1917, she was married to George Walbridge Perkins, Jr., of New York.

Then came the entrance of the United States into the world war. There had been set up early in 1917, by order of President Wilson as a measure of national preparedness, the National Research Council under the National Academy of Sciences of which Trowbridge was a recently elected member. On the

outbreak of the war, this National Research Council became the coordinating and recruiting agency through which the scientific men of the country were to make their best contribution to the vast variety of important technical problems suddenly thrust forward with desperate insistence. R. A. Millikan and C. E. Mendenhall were at once commissioned as majors in the U. S. Signal Corps to take the lead in this liaison between the military and naval services on the one side and the scientific personnel and laboratories of the country on the other.

Immediately after the declaration of war, a French Commission, consisting of physicists M. Abraham and C. Fabry, came to the United States to disclose some of the newer applications of science to warfare, among them the location of enemy artillery by "sound ranging" and "flash ranging." The former, particularly, of these services demanded apparatus of high precision and considerable complexity, and an operating personnel with technical training. Because of his knowledge and skill in the matter of apparatus, his unusual administrative ability which was even then notable and his excellent judgment and tact in dealing with men, Trowbridge was nominated to General Squier, by Millikan and Mendenhall, to be the technical director of the American Sound and Flash Ranging Service. So Trowbridge was at once commissioned Major in the Signal Corps and given the job of organizing this important service. The manner in which he carried out this commission was one of the features of America's war record which can be recalled with unqualified satisfaction.

The first move was to study the types of equipment, and two groups were recruited at Princeton University and the Bureau of Standards to build instruments of the four types disclosed by Fabry and Abraham. These were tried out on the artillery at the Sandy Hook Proving Ground, and one of them selected for construction, which was at once begun on a production basis in the shops of the Palmer Laboratory and the Bell Laboratories. Associated with Trowbridge in this early work were H. B. Williams, F. A. Saunders, H. M. Dadourian, K. T. Compton, J. Q. Stewart, and N. R. French,—and an important part in

design and construction was played by the head of the Palmer Laboratory Shop, William Duryea.

As soon as this work was well started, under Captain Williams as second in command, Major Trowbridge went to France on September 9, 1917, and immediately made a study of the flash and sound ranging operations on the French and British fronts. His quality of quick decision and open-mindedness was shown by his early cablegram back to Captain Williams ordering transfer of attention to another one of the original four types of equipment, since he discovered that front-line conditions were relatively less favorable to the type originally selected.

Soon good equipment and personnel for sound ranging began to go from America to France, among the notables in the service being Captain Theodore Lyman. A preliminary training school was established in France in charge of Lieutenants Stewart and French. From this school the men went next through a period of training in active service with the British sound ranging units, and finally to their regular duties with the American Army. The service was organized as a battalion of five companies, and by this time had been transferred to the Engineers Corps, with Trowbridge promoted to be a Lieutenant-Colonel, attached to the General Staff at Chaumont. His immediate superior officer was Colonel Roger G. Alexander, of the regular army.

After most creditable operation, the active work of the sound ranging service came to a close on Armistice Day. Trowbridge was proud to show two records of his organization: one was a table showing that the accuracy of enemy gun locations by his men was about equal to the possible accuracy of counter battery fire,—for example an average error of about thirty yards in locating a concealed gun four miles distant; the other was a photographic record of the sound of gun-fire just before and just after the exact time of the Armistice,—a sudden transformation from the din of battle to peace.

As evidence of the success and value of this war work, the following extract concerning one of the sound ranging sections

is quoted from a letter by a Coast Artillery Officer to a superior in the Army Artillery:

"(The) men were always on the job, never seemed to shirk and accomplished many things which seemed impossible. It is with regard to this section's action in moving warfare that I especially desire to call your attention. (It) followed closely our infantry line and in a very few hours after the line stabilized was functioning with two posts. Since such prompt installations of stations during war of movement is in my opinion rare, I feel called upon to compliment you on the excellence of this section not only in overcoming the difficulties of movement but in the general reliability and accuracy of its reports which at all times were satisfactory. I wish to state that I consider this section the best I have ever seen, French or American."

Official recognition of this work was further given by letters from General John J. Pershing and from Brigadier-General D. E. Nolan. The latter letter is here quoted because of its more intimate detail:

"General Headquarters

American Expeditionary Forces

January 20, 1919.

From: Brig. Gen. D. E. Nolan, A.C. of S., G-2, G.H.Q., A.E.F.
To: Lt. Colonel A. Trowbridge, Engineers, A.E.F.
Subject: Letter of Appreciation.

"1. With your relief from duty under G-2, G.H.Q., A.E.F., I wish to take this opportunity of congratulating you upon the excellent work you have done.

"2. It was indeed fortunate, both for you and the American Army, that you could be engaged on Flash and Sound Ranging work, where your high technical ability and long experience could be utilized to the best advantage. The experiments on equipment conducted by you in the United States, your active participation in the organization and operation of the Sound and Flash Ranging School in the American E. F., and your able and energetic work towards the equipping and operation of sections at the front contributed most materially to the successful operation of the Ranging service.

"3. That this service was successful is attested on all sides, and this success is due in no small way not only to your technical

ability but to your resourcefulness, good judgment, and ability to estimate new situations and to get results.

"4. It has been a pleasure to have you as a member of G-2 for these many months. I thank you most cordially for your loyal assistance and support, and assure you of my continued interest in your future welfare and success.

D. E. NOLAN,
Brig. Gen., Gen. Staff
A. C. of S., G-2"

The allied governments also were quick to recognize this significant service, and Trowbridge was given the Distinguished Service Medal of the United States on July 9, 1918; was made Chevalier de l'Ordre National de la Legion d'honneur of France on April 4, 1919; and was made an honorary member of the Distinguished Service Order by King George V on July 18, 1919.

In the midst of this successful active work in France, however, Trowbridge and his family suffered a grievous loss in the death of the lovely and talented daughter, Katherine Trowbridge Perkins, on October 7, 1918, following a particularly sharp attack of the influenza which made such ravages in this country and in Europe during that year.

On his return to civil life early in 1919, Trowbridge began his second period at Princeton, a period marked by a broadened range of responsibilities and a shift in his special scientific interests. But his first major problem was to decide between continuation of his career in teaching and research or acceptance of some one of several invitations to enter other fields, such as university administration. With characteristic grasp of essentials, he made his analysis of the chief weakness of Princeton's work in physics and his recipe for its improvement, and decided to stay in Princeton on condition that he be given opportunity and help to put these improvements into effect. This condition being met, he remained. These improvements were educationally interesting:

Heretofore, no distinction in class work in physics had been made between students who had passed college entrance physics examinations and those who had made no previous study of

the subject. Trowbridge believed that this resulted in holding the most promising students of physics down to a low level of achievement, with resulting loss of opportunities and even of interest. He therefore instituted a special sophomore physics class for students who had passed entrance examinations in the subject with a good grade; he selected a more advanced text-book than had ever before been used with sophomores in Princeton; he himself gave the lectures and he recruited every professor in the department to assist him in handling the recitation sections; he so arranged schedules that every six weeks came a test and a regrading of students up-to-date, with reallocation of the best twenty to the top section, the next best twenty to the second section and so on down to the lowest twenty. Thus every student was thrown with others of comparable abilities, and each group was encouraged to go ahead rapidly and to go into subjects thoroughly, subject only to the limitations of its ability. Never before had Princeton students studied so hard, or the physics staff worked so hard, and the results were most encouraging. There was never a doubt but that this plan marked a decided improvement in the interest and accomplishment of the undergraduates, and its effects were felt all through the higher undergraduate courses and into the graduate work. Trowbridge himself worked unremittingly and with great energy to make this program successful.

At the same time, he entered upon a new phase of research, built largely around applications of the powerful new instruments which had been developed for the sound ranging work during the war. These instruments were (1) a fast acting, multiple-element string galvanometer, (2) an automatic camera for photographing, developing and fixing any continuous record of events, with a time scale, on a roll of photographic tape, (3) sensitive radio-tube amplifying systems. With these, and subsidiary devices, he developed a new method for studying vibrations of automobile crank shafts, and assisted automobile companies in minimizing these vibration troubles. He developed a continuous photographic method of recording and counting

optical interference fringes and applied it to precision measurements of thermal expansion and of refractive index. With Karl T. Compton he made a study of the basic action of cathodes in ordinary high pressure metal arcs.

Probably his most active research dealt with a study of flame speeds and efficiencies of internal combustion engines, as affected by variations in the method of firing the explosive mixture. In this he was ably assisted by William Duryea. He developed a quick acting pressure gauge, which could be used with the string galvanometer and photographic recorder to give a continuous record of the pressure-volume-temperature relations during a cycle of the engine. With aid of this equipment for quick indication of conditions, he carried through a series of studies on the effects of withdrawing the spark-gap into a tube, through which the flame could be shot into the cylinder in such manner as to ignite the explosive mixture more suddenly,—with resulting higher temperatures and efficiencies.

Along with this teaching and research program, it was but natural that Trowbridge should have been called upon extensively for administrative service, both within the University and in such external affairs as the National Research Council and the American Philosophical Society. To these calls he responded generously, and always with that peculiar effectiveness which was possible only because of his unusual background of experience and personal gifts. Perhaps the most important of these duties in Princeton was his work on the discipline committee. This cannot be better described than in the words of his closest friend and colleague, Howard McClenahan, who had become Dean of the College and *ex officio* chairman of the discipline committee:

"As a long time member of the discipline committee he easily showed himself to be the most nearly human member of the Princeton faculty. His inherent sporting qualities made him recognize instantly the difference between boyish pranks, of which he was tolerant but bored, and offenses involving moral obliquity or lack of personal integrity, of which he was wholly intolerant."

The best picture of Trowbridge's broad contacts with organized science is afforded by his active service in the National Research Council during its period of transition from a war-time to a peace-time basis. In its important Division of Physical Sciences he was member-at-large 1919-1922, Vice-Chairman 1919-1920 and Chairman 1920-1921. The latter office involved also the Executive Secretaryship of the National Research Fellowship Board in Physics, Chemistry and Mathematics,—an activity in which he took especial interest and pride. During his secretaryship, the Board expended nearly $42,000 in fellowship awards to ten promising young physicists and nineteen similar young chemists. Among them may be mentioned at least six who have come to highest positions of leadership in research: Gregory Breit, James A. Beattie, George L. Clark, Leonard B. Loeb, Robert S. Mulliken and Henry D. Smyth. It was in the success of such young men, whom he had been able in some way to help, that Trowbridge undoubtedly found his greatest satisfaction.

His other chief work in the National Research Council involved the preparation and publication of a great series of monographs on research, designed in part to assemble and make easily available the scattered scientific developments of the war period, and in part to stimulate to further work in these fields the cooperating scientists in the groups which were assembled to prepare the monographs. Largely under his supervision the following monographs were prepared, and later widely distributed:

Acoustics
Algebraic Numbers
Atomic Structure: Quantum Theory
Celestial Mechanics
Electrodynamics of Moving Media
Luminescence
Mathematical Analysis of Statistics
Orbit Theory
Photoelectric Effects
Physiological Optics
Quantum Theory
Research Methods and Technique

Spectroscopy
Theories of Magnetism
Thermo- and Magneto-Electric Effects
X-Ray Spectra
Ionizing and Radiating Potentials

His remaining National Research Council activities comprised membership on the following committees: Building 1921-34; Cooperation with Research Corporation 1921-24; Electrical Insulation 1921-28; Executive Board 1919-21; Publication of Mathematical Books 1920-22; International Astronomical Unions in Astronomy, Mathematics and Radio-telegraphy 1920-21. Of his work at the National Research Council, its Executive Secretary, Dr. Barrows, writes:

"He (Dr. Trowbridge) was held in very high esteem on account of his sound and broad judgment, his impartial and objective attitude and his generous and sympathetic interests."

As a side-light on Trowbridge's ready wit the following incident is related. There had been a jewel robbery in the Trowbridge's Princeton home, which had given Trowbridge occasion to observe professional detectives in action. Not long afterward, there was an outbreak of thieving of small apparatus, mostly radio equipment, from the Palmer Laboratory research rooms. A local boy of rather rough character was suspected, and several times questioned, but without results. Finally Trowbridge asked to have five minutes alone with the boy, during which time he secured a confession and later return of the stolen property. When asked how he had induced the boy to confess, Trowbridge replied: "You fellows don't talk this boy's language. Last summer I observed that the detectives always talked to a suspect in his own lingo. So I just talked like a dick to the boy and said as gruffly as I could: 'Come on now an' can the guff. Yuh better spill the game. Yuh done it and yuh know yuh done it.' And he came right out with the story."

We come now to the activity which Trowbridge himself undoubtedly felt to be his most important contribution to human welfare through education and science. At the close of the

academic year in 1925 he resigned from Princeton University to accept the directorship of the division of the natural sciences of the International Education Board, which had just been established by the Rockefeller Foundation. Given a hearty "God-speed" by their host of Princeton friends,—featured among other things by a men's dinner at the Nassau Club which will never be forgotten by those privileged to attend on account of Dean West's Ode to the Modern Caesar Augustus and Trowbridge's graceful and affectionate reply,—Dr. and Mrs. Trowbridge departed for their new home in Paris, with official headquarters at 20 Rue de la Baume. In this work he was later joined by Dr. W. E. Tisdale as assistant director,—a most happy arrangement in view of their previous relationship in the work of the National Research Fellowship Board.

Perhaps the vast scope and significance of this aid to science on an international scale can best be realized through examination of the record of accomplishment by the International Education Board during the period of Trowbridge's administration. Approximately $12,500,000 were granted to educational and research agencies for scientific purposes, $1,011,000 were used to support international fellowships in science, nearly $40,000 were used to promote exchange and travelling professorships in the scientific fields and over a million dollars were spent for studies and educational projects generally. In addition to these items for which Trowbridge had direct responsibility, some fifteen million dollars were appropriated to work in agriculture and the humanities under the jurisdiction of his other colleagues on the Board.

Among the forty-six recipients of grants for scientific purposes the following are notable examples: Institute of Physics and Chemistry in Madrid; Jardin des Plantes in Paris; High Altitude Institute on the Jungfrau in Switzerland; Institutes for Physiology, Theoretical Physics and Physical Chemistry in Copenhagen; Department of Zoology and Comparative Anatomy of University College in London; Mathematical and Physical Institutes in Gottingen; Department of Zoology in University of Edinborough; Biochemical Institute at University of

Stockholm; various grants to University of Paris; Zoological Station in Naples; Norwegian Institute for Cosmical Physics; California Institute of Technology for 200-inch telescope. All of these projects involved careful analysis of needs and opportunities and some of them required extraordinarily difficult and skillful negotiations with governments and other bodies in order to insure reasonable certainty of permanence and future actions in the spirit of the terms under which the grants were made. One of the most important of these projects was the building of a great central library at Cambridge University. Formerly the library facilities were scattered, poorly housed and lacking the convenient services of modern library technique. Trowbridge conceived the project of a central library and engaged in a long and arduous series of negotiations with the authorities. The affair was hampered by the inertia of traditions and by entrenched interests. Finally, as one of his last achievements in his European work, Trowbridge brought the negotiations to a successful conclusion whereby the central library was undertaken jointly through a gift from the International Education Board and funds provided locally, and the building was completed and dedicated after Trowbridge had resigned from the International Education Board.

The great program of international research fellowships in the sciences of biology, chemistry, mathematics and physics had, when Trowbridge retired from this post, involved 469 fellows from 37 countries carrying out their fellowships in 16 countries. In this group is found a remarkable proportion of the young scientists who are now the world leaders in their respective fields. It cannot but involve invidious distinctions to mention some by name and not others; yet the following names will mean much to those who know modern science: W. Heisenberg of the "uncertainty principle"; F. Hund who applied quantum rules to chemical molecules; R. H. Fowler, inspiring leader of modern mathematical physics in Cambridge University; and such men as Andrews, Brode, Catalan, Cleveland, Condon, Dicke, Fermi, Frenkel, Goudsmit, Hartree, von Hippel, Kistiakowsky, Krogman, Landis, Liddell, Laporte, Oldenberg,

Oppenheimer, Richards, Rabi, Robertson, Rossland, Spier and Struik. These men Trowbridge considered his scientific children, and he followed their successes with almost paternal pride.

Concerning this work and "many of the scholars to whom he granted fellowships and who afterwards acquired great distinction," Mrs. Trowbridge has said "I think he would like best of all to have mentioned the names of some of those 'potential geniuses' whom he was first to recognize. His negotiations with regard to the new library at Cambridge, the building of the Mathematical Institute in Paris,—the attempt to bring the different parts of the University of Paris onto one campus by buying the site where the Halles des Vins now stand, the establishment of the first laboratory under the Junta in Madrid, the building of the laboratory in the far north of Norway,—all these and many more which I only remember vaguely, read like a romance and gave him the keenest satisfaction. I think the happiest years of his whole career were those spent in Paris."

The record of Trowbridge's official accomplishments during these three busy years in Europe speaks for itself. It was signalized also by many new honors, such as promotion to "Officier de la Legion d'Honneur" of France and award of the Order of St. Olaf by the King of Norway. Striking evidence of the warm personal affection and respect which he inspired in his European acquaintances is shown in the speeches and letters occasioned by his resignation from the International Education Board in 1928, when its great program of grants-in-aid-of-research had been completed. Since that time, the fellowship program only has been continued, under the able and experienced direction of his junior colleague, Dr. W. E. Tisdale.

With the retirement of Dean Andrew F. West from active service on account of age, the Trustees of Princeton University elected Dr. Trowbridge to be his successor as Dean of the Graduate School. A warm friend of Dean West and in full sympathy with his policies regarding this school, Trowbridge was a natural choice for the position. There was great rejoicing as he and Mrs. Trowbridge took up their residence in Wyman

House, the beautiful official residence of the dean, adjacent to the Graduate College.

Of this third period in Princeton there is little to recount, since the work of the dean went forward with skillful and efficient management and the citations for honorary degrees were models of terse characterization so appreciated by critical commencement audiences. Example, Norman Thomas, Litt. D. 1932:

"Norman Thomas, a graduate of this university in the class of 1905, a brilliant and successful clergyman, son and grandson of ministers of the religion whose earliest disciples held all things in common for the common good, who, for conscience' sake gave up a conventional form of ministry to his fellow men to become the fearless and upright advocate of change in the social order. A vigilant assailant of the corruption and the crime which batten on our complacent civic indifference notably to the conduct of municipal affairs. Irrespective of party preference we join to honor this valiant and distinguished son of Princeton."

Unfortunately the warnings of ill-health began to appear,—a new experience for this man whose activity at work or play had scarcely suffered interruption. Leave of absence failed to halt the encroachment, so that his resignation was regretfully accepted by the Board of Trustees in the spring of 1932. In so doing they adopted the following resolution:

"The Trustees cannot allow the retirement, because of continued ill health, of Augustus Trowbridge as Dean of the Graduate School to take place without giving expression to their high appreciation of his exceptional ability as a teacher, his outstanding position as a scientist, and his unfailing efficiency as an executive. In every task assigned him throughout his distinguished career, his sincerity of purpose in its undertaking and his enthusiasm in its performance have made him eminently successful in what he has accomplished, while his charm of personality has endeared him to all—students and colleagues alike—who have come in contact with him.

"Returning to Princeton in 1928, he gave four years of notable service as Dean of the Graduate School. In that position

he displayed high administrative ability in handling the many difficult problems assigned to him, and maintained without impairment the high standards that had been established under Dean West. A notable addition to the excellence of his administration was to be found in the delightful hospitality of Mrs. Trowbridge and himself, which distinctly added to the advantages of residence in the Graduate College.

"In teaching, in research and in administration he leaves behind him a high record, and his active presence on our campus will be sorely missed."

For nearly two years following his resignation, Trowbridge made a courageous effort to maintain his health. He spent the summers with his family at their summer home at Hancock Point, Maine. He put his records and papers in order. His cheerfulness and good sportsmanship never failed him,—they were too deeply rooted in his character. In the winter of 1934, seeking the beneficial climate of the Riviera which he so loved, he and Mrs. Trowbridge left on his last journey. After a happy winter, death overtook him quite suddenly on March 14, 1934, as he and Mrs. Trowbridge were together in Taormina, Sicily.

After a most impressive funeral service in the beautiful new chapel of Princeton University, he was buried in the Princeton cemetery on March 29, 1934.

There can be no more fitting close to this all too inadequate record of the life and work of one of the noblemen of science than the prayer offered by his friend Dean Wicks at Dr. Trowbridge's funeral:

"O God we stand in reverence and awe before the unseen source of more than we could ask or think, in debt for all rare lives gifted to embrace what lies beyond our ken and able to make vivid that to which we might aspire.

"We would remember before Thee and for our good, one who lived to be real, above all false sentiment and cant, and by his fruits rather than by words proved his nearness to the Great Reality; who with faithfulness in work given him to do, and with refined taste that put the cheap and crude to shame, ever kept himself responsive to an excellence beyond the requirements of men; who was guided by the inclination of love to find needs where no rules could prescribe; who let no narrow

zeal blind him to the wider ranges of a cultured life, and made himself a counsellor and friend in many lands to those who sought to keep alive, in a shattered world, the interests of the mind and spirit; and whose sympathy and humor and inner resource made his companionship a blessing, especially at home, and enabled him through sorrow and ill health to fight the good fight to the end, living his life for the things that abide. Amen."

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