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Allen V. Astin Memorial Symposium

National Bureau of Standards
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Allen V. Astin
1904-1984

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AGENDA

NBS special publication

9:30–9:45 a.m.

Ernest Ambler, Director, National Bureau of Standards
Introduction

9:45–10:15

Elliot Richardson, Former Secretary, Department of Commerce
"Scientific Evidence and the Policymaker"
In today's complex society, public confidence is vital. To that end, the policymaker must put a premium on obtaining reliable facts that are used and perceived to be used by that policymaker.

10:15–10:45

James D. Ebert, Vice President, National Academy of Sciences
"Rigor and Discipline in Science"
The scientific method, how science progresses, what is and what is not science.

10:45–11:15

Walter Hamer, Retired Chief, Electrochemistry Section, NBS
"Reminiscence on the AD-X2 Episode"
Dr. Hamer was a member of the Electrochemistry Section throughout the entire period AD-X2 was an issue.

11:15–11:45

Frederick Seitz, President Emeritus, Rockefeller University
"Controversies Affecting Science Today"
Science is involved in many more public issues today than in the past.
Why does this arise and how is science affected by it?

11:45–12:15

William Carey, Executive Officer, American Association for the Advancement of Science
"The Advancement of Science Today"
The problems of fostering science and an appreciation of it today.

12:15 p.m.

Conclusion

ALLEN V. ASTIN

A Commemorative Career Biography

Interstate highway 270 leads northwest from Washington, DC, joins its parent interstate 70 some 40 miles from the city at Frederick, MD, and thence continues west across the continent until it loses its identity in central Utah. While passing the town of Gaithersburg, MD, at a point 20 miles as the crow flies from the White House, even the casual traveler on I270 will notice a large fenced park-like area to the west of the highway, with rolling lawns, a patch of woods several acres in extent, and scattered trees artfully planted to blend in form and texture. He will see a tall building in the form of a rectangular parallelepiped dominating a series of long, low, modern buildings nestled into the landscape, with trees and shrubs softening their contours. In his quick passage, he will observe a tall flagpole and flag in front of the tall building, and, should he think about it at all, may wonder if the flagpole and flag denote that this is an official institution rather than a recreation area, and then the park will be out of view.

This is indeed an official institution. It is the headquarters of the National Bureau of Standards (informally referred to simply as "the Bureau"), custodian of the Nation's fundamental units of measurement on which all scientific and industrial measurements are ultimately based, and the Nation's primary measurement laboratory. The site is larger than appears to the motorist, totalling 576 acres to provide isolation essential for the delicate experiments carried out there. The tall building so obvious to the traveler is the administration building, and it presides over 25 others in which highly specialized scientific work is carried out. Some 2,770 scientists, administrators, and support staff work in these buildings and in addition to this headquarters site, the Bureau operates two others: a large one in Boulder, CO, where 470 people work, and small but important stations broadcasting standard frequency and time signals from Fort Collins, CO, and the island of Kauai in Hawaii.

That the headquarters site of the Bureau is located on this handsome, spacious site is due to the efforts and leadership of Allen V. Astin, the Bureau's fifth director, whose entire working career of 39 years was spent there—years for which the histories of the man and the institution are inseparable. Beginning with requests for appropriations in 1956 in the fourth year of his tenure, and culminating in the final move in 1967 from its previous 71-acre site at Connecticut and Van Ness Streets in northwest Washington, DC, Astin guided the acquisition, design, and movement to the Gaithersburg site, as it is now called.

THE EARLY YEARS

The headquarters site of the Bureau was not nearly so large when Astin first arrived to work there in 1930. The Bureau was then located on 58 acres on the north and south sides of Van Ness Street, 3½ miles northwest of the White House. In the 29 years of its existence it had already reached eminence in the scientific world. It had begun its existence in 1901 as the laboratory charged by Congress, in carrying out its constitutional authority "to fix the standards of weights and measures," with "the custody of the standards,... testing and calibration of standard-measuring apparatus... the solution of problems which arise in connection with standards... [and] the determination of physical constants, and the properties of materials when such data are of great importance to scientific or manufacturing interests and are not to be obtained in sufficient accuracy elsewhere." As such, it was one of a number of standards laboratories established by industrial nations at the end of the 19th century and at the beginning of the 20th century. The inexorable march of the industrial revolution, the expansion of science, and the requirements of national and international trade made mandatory a worldwide system of units of measurement and their associated standards. The burgeoning electrical industry showed that simple standards for mass, length, and time were no longer sufficient. The relatively simple offices of weights and measures had to be replaced with much more sophisticated institutions.

From its earliest days, the Bureau has always been a many-sided institution. Its work on the basic standards of science necessarily led it to become concerned first and foremost with highly accurate and sophisticated measurements. Moreover, since it has to serve the interests of the most advanced aspects of science and technology, it has always carried out a strong program of basic research. Thus, it has always been well known throughout the world as a scholarly institution with first class scientific work in physics and chemistry, devoted to painstaking accuracy and precision of measurements, and, most importantly, totally objective and dispassionate in its scientific work. But, in accordance with its enabling legislation, the Bureau has gone beyond basic research in physics and chemistry and questions related to the basic standards of physics. It has always carried out a strong program in materials science, and has always contributed to the voluntary standards system of the Nation. For a large part of its history the Bureau was involved in developing specifications for purchases by the Federal Government and in the testing of materials for those purchases, from which experience it occasionally issued bulletins of great utility to business and consumers. A large part of its work has been in investigations for other agencies of the U.S. Government so that in 1930 when Allen Astin first came to the Bureau fully 54 percent of its total budget of $2.94 million was funds transferred from other agencies of the Government.

This is the organization Allen Astin found when, as a young man of 26 he joined the Bureau on the first of September in 1930, unaware that he would spend the remainder of his career there. He had not had an easy life. He was born in Salt Lake City, UT, on June 12, 1904. His father, John Andrew Astin, from a coal mining family in Monongahela, PA, had been moved there at the age of 7 along with five siblings by his widowed and largely destitute mother, a converted Mormon. John Andrew became a school teacher and met and married Catherine Varley. The birth of Allen was followed by that of two sisters, Marie and Helen, but the father died when the young Allen was only 4 years old. His mother had to work to support the family, and

Allen helped out. Beginning at the early age of 8 he consistently held odd jobs—carrying newspapers, working on berry farms, digging ditches, and similar tasks. Totally disciplined, he was able to save enough money to enter the University of Utah where he studied physics. He was a campus leader, edited the school newspaper, and met and fell in love with Margaret L. Mackenzie, a student one year behind him and a talented writer. An excellent student, he won a scholarship for graduate school at New York University (NYU) and, upon receiving his B.S. degree, left for New York in 1925. In 1927, after receiving a master's degree, he returned to Salt Lake City long enough to marry Margaret, and the young couple returned to NYU where Margaret did graduate study in journalism and Astin finished his Ph.D. in 1928. He was then awarded a National Research Council Fellowship at Johns Hopkins University, and the family moved to Baltimore, where in 1930, their first son, John Allen, was born.

That same year, Astin's postdoctoral appointment was coming to an end. With a thesis and postdoctoral work on the dielectric constant of electrolytes, a wife and infant son, he was faced with the prospect of finding a job at a time when the great depression was just beginning and jobs were hard to find. Astin sent out, in his words, "what must have been scores of letters," in an attempt to find a job. One of the places he looked at was the Bureau, and he came to visit H. L. Curtis, who was Chief of the Capacitance and Inductance Section of the Electricity Division, because his title indicated that the group embraced the study of dielectrics. Providentially, Curtis had the previous year begun a project on the study of the dielectric behavior of very pure materials, and had money for the study, albeit from an unusual source. The funds came from the National Research Council, which in turn had received them from the Utilities Research Commission of Illinois. Despite its official sounding title, this commission was not a public agency, but a unit of the conglomerate built by the utilities magnate Samuel Insull, which was already experiencing difficulties because of the 1929 stock market collapse. Nevertheless, Curtis had the funds to support his project. He hired Astin, although not as a civil servant member of the NBS staff, but as a Research Associate, receiving his pay from the commission via the National Research Council. Astin began investigating the nature of energy losses in capacitors.

Astin's scientific inclinations were ideally suited to the Bureau. For his thesis work at NYU, and subsequently as a postdoctoral fellow at Johns Hopkins, he had done definitive measurements on the dielectric constant of electrolyte solutions. In 1925, the year Astin arrived at NYU, E. Huckel, using the theory that he and P. Debye had developed 2 years earlier, had published a theory of the dielectric constant of electrolytes. Experimental results were, however, widely different from his theoretical predictions. Astin set out to do a definitive measurement. He developed a new resonance method for measuring dielectric constants, exhaustively analyzing and eliminating possible sources of errors. For his work he built an oscillator and vacuum tube voltmeter, an experience in electronics that he was to use repeatedly in his career. His results were also widely different from theory, but from his viewpoint that was of lesser importance. He had done a definitive measurement. His scientific instincts were ideal for the Bureau.

Astin spent the next 2 years working with Curtis on losses in precision capacitors. He became known in the Bureau because of his experience in electronics, and also, one can surmise, because of his personal characteristics. Even as a young man he showed the characteristics that he would become best known for as director. He was a friendly man, but low key and rather reserved. He liked people, and people liked him because he listened and respected the opinions of others. A slender man with warm, friendly eyes, he never evinced anger, gave all questions serious consideration, and appeared always to be in control of his emotions. He was under the control of reason rather than emotion, and as a result, his opinions were always respected because they were above personal feeling. He became well integrated into the Bureau.

In 1932 the Insull empire collapsed; Insull was forced into receivership and eventually fled to Greece. Astin, of course, knew that Insull's situation was very poor, for it was a source of constant headlines, and in the winter of 1931–1932 he had warnings that the commission project was going to end. In 1981, reminiscing on those days, Astin recalled, "Well, I had another scramble for a job. . . . If I sent out in 1930 a couple of dozen inquiries, I must have sent out 50 inquiries in 1932." His anxiety was doubtless heightened by the fact that in that year his second son, Alexander William, was born.

In the depths of the depression finding a job was a difficult matter, but fortunately for Astin his future did not hinge on a positive response to his letters. He was accustomed to riding to work with M. F. Peters, a neighbor, who worked in the Heat and Power Division of the Bureau in a laboratory concerned with automotive ignition problems, and who had been after Astin to help him on his projects. Peters had funds from the Navy to study aircraft ignition, and he decided that he and Astin, in Astin's words, "could cook up a project for work for the Navy . . . so we concocted a project which (well, I guess in retrospect I can't be very proud of it) was one of the first death ray projects. Our goal was to try to bring down an airplane by radio waves . . . the principle being to . . . misfire the sparkplugs of the engine." A demonstration for the Navy was arranged in which an engine was stopped (by a high powered discharge of static electricity close to the engine, not by radio waves), the project was funded, Astin received a civil service appointment, and in this almost bizarre way became a member of the NBS staff, completely shifting the direction of his scientific work in the process.

The Bureau underwent a change of leadership in 1932, for on July 2, George Burgess, its director since 1923 died of a stroke while working at his desk, and Lyman J. Briggs, associate director for research and testing became director. Under Briggs, the Bureau was a very relaxed place to work. Astin recalled the atmosphere: "It was friendly, peaceful, cooperative . . . and free, very free [with] very little accounting. It was an ideal atmosphere, I think, and I enjoyed it and I'm sure my associates did as well." When Astin was asked in later years about the environment he tried to maintain as director, he replied, "From my knowledge of Dr. Briggs, I figured if I could be as good a director as he was, I would have succeeded admirably."

In this congenial, cooperative atmosphere Astin worked diligently on his "death ray" project, even though it became clear that the chance of success was small. But cooperation in Briggs' Bureau was the order of the day, and Astin had a rare commodity in those deep depression years: he was one of the few people at the Bureau who was experienced in electronics. Because of this, and certainly because of his polite, cooperative nature, he was sought out by another Curtis—L. F. Curtiss—for cooperative work that was to become of great importance in Astin's future career. Curtiss, an expert in radioactivity who worked at that time in the Atomic Physics, Radium and X-ray Section, had the idea of studying cosmic rays by sending up a Geiger counter in a weather balloon and transmitting the output of the counter back to the ground. He approached Astin, who, intrigued with the idea, and interested in the technique of doing the job, agreed to cooperate. Assistance from the Weather Bureau was obtained, and Astin, while working with Peters in the Heat and Power Division to find a way to bring down airplanes with radio waves, also worked with Curtiss of the Optics Division on telemetry from weather balloons, all without need for accounting time to the different projects. That such a situation could exist—indeed, was encouraged—exemplifies better than words the nature of the working environment at the time. And that Astin could work successfully on two different projects with two different people attests to his scientific talent, his ability to work with others, and his rising position at the Bureau.

The "death ray" project was to fail, but the cosmic ray telemetry was to succeed admirably. A system for telemetry of atmospheric pressure, temperature, and humidity—a "radio meteorograph"—was developed.

Balloons were launched from the roof of one of the Bureau buildings, achieving a then record height of 127,000 feet on March 23, 1956. Cosmic ray measurements were made with the cooperation of S. A. Korff, a world authority on cosmic rays from the Department of Terrestrial Magnetism (DTM) of the Carnegie Institution of Washington, DC, an organization that was to have a profound effect on Astin's later career. The telemetered counting rate data, rising to a peak and then dropping as the altitude increased, showed that the preponderance of observed cosmic rays are secondary showers caused by ionization of the air by the primary rays. They also showed that Astin had become one of the world's experts in telemetry, and had emerged from the laboratory and gained experience in field work.

Astin and Curtiss were not the only ones working in telemetry at NBS. In the Radio Section of the Electricity Division, the Navy's Bureau of Aeronautics had initiated a project with very much the same aims as the Weather Bureau had in the Curtiss-Astin project, but without the cosmic ray aspects. This work was carried out by Harry Diamond, W. S. Hinman, Jr., and F. W. Dunmore. An engineer by training, Diamond was an ingenious inventor whose career was to become intertwined with Astin's, and his group was in friendly competition with Astin and Curtiss. Two years after Astin and Curtiss had developed a working radio meteorograph, the Diamond group, using different physical principles, developed an improved one, which was to be called a "radiosonde." It was subsequently adopted by both the Navy and the Weather Bureau, and several million units were mass produced in the next 30 years. While carefully pointing out that he and Curtiss had made a radiosonde 2 years before the Diamond group, Astin recognized that the Diamond device was superior, and with characteristic objectivity said about Diamond, "Harry beat us out on that. I have no hesitancy in bowing to a superior inventor."

In the fall of 1935, it having become clear that it was not feasible to bring down airplanes by radio waves, Astin concluded that the "death ray" was impractical and wrote a final report. With the end of this project and the associated Navy financial support, the 31-year-old Astin was again faced with finding a job. He seriously considered transferring to the Navy Department, where Peters could help him in finding a job but he liked the Bureau too much—he fit in too well—so he went to see Briggs, who, having already identified Astin as a possible future director of the Bureau, found funds to support him. In January 1936, he was back in the Electricity Division with H. L. Curtis working on the dielectric research that had been terminated when the Insull funds had been discontinued more than 2 years previously, and, of course, the balloon telemetry work with L. F. Curtiss. Astin was much happier with this arrangement. He had always considered the ignition work with Peters a stop-gap and was happy to return to the scientific work for which he had been trained. He spent the remaining years of the 1930's working on the methods for measuring losses in capacitors and on the nature of those losses, publishing two classical Bureau papers on the subjects. At the same time he finished up his work on telemetry with Curtiss, his job—figuring out how to do it—having been accomplished.

Despite the depression, the 1930's were happy years for the Astin family. On coming to Washington, Allen and Margaret had rented a small, semi-detached house north and west of the Bureau near the Maryland-District line. Having lived in apartments in New York and Baltimore, the young couple found having a house a luxury. There they reared their children, and Astin began gardening, a hobby he was to indulge in for the rest of his life. Indeed, in later years, at a house they had built in Bethesda in the early 1940's, Astin was to become a test grower of hybrid roses for the famous Jackson and Perkins firm, having as many as 150 roses in his garden. Astin, having grown away from the Mormon church at the age of 20, and his family, along with Bureau friends, often took Sunday walks along the C&O canal towpath, where the children frightened Margaret when they played on the rocks at Great Falls. The woods were a cathedral for Astin, who was ever the romantic (in New York Allen insisted they live in a fifth-story apartment on 242nd street because it had a marvelous view of the Hudson). An avid sports fan, he was a passionate follower of the fortunes of the Senators, and later the Redskins and Orioles. The Astins often took the children to the Senators games as family outings. Equally passionate devotees of the theater, concerts, opera, and ballet, Allen and Margaret spent many evenings at Constitution Hall, in the cheapest gallery seats, as the family was by no means well-to-do. On national holidays, a flag always flew at the Astin house, for he was a staunch patriot. It was a quiet, peaceful time.

THE WAR YEARS

The march of world events was soon to affect Astin's career dramatically, as it did practically all other human beings in the world, for on September 1, 1939, Germany marched on Poland, England and France declared war, and World War II began. Despite the fact that the United States was still ambivalent about what its position should be, Briggs was a perceptive man. On the very day that Germany attacked Poland, he wrote a memorandum to the Assistant Secretary of Commerce detailing the types of activities that NBS was prepared to carry out should the United States enter the war, and thus began the Bureau effort in World War II. Besides its activities in testing supplies for the military, greatly expanded calibration services in response to requests from industry, greatly expanded production of optical glass, and many other such activities, the Bureau was to become involved in four major research efforts: the atomic bomb, synthetic rubber, guided missiles, and the proximity fuze.

The radio proximity fuze has been called the second most important military development of World War II—second only to the atomic bomb. The proximity fuze is an old idea in ordnance circles, and its advantages are obvious. If a shell can be made to explode when it is say within 20 meters of an aircraft target, the target size is greatly expanded, and many more hits are made. Moreover, bombs dropped against enemy troops on the ground are much more effective if the bomb explodes some distance above the ground, for then foxholes are no longer protection, as they are against bombs equipped with contact fuzes. Increases of five to twenty times in effectiveness can be expected, and this, coupled with the concomitant decrease in logistical requirements, makes the proximity fuze militarily worth almost any expenditure. England and Germany, in fact, had been at work for a number of years on such fuzes, and it is only natural that one of the first military research projects undertaken by the U.S. Government was the proximity fuze. It was begun by the National Defense Research Committee (NDRC) set up by the President in 1940 to initiate and speed the development of new and improved instruments of war. Three principal types of fuzes were considered: radio fuzes, photoelectric fuzes, and acoustical fuzes.

The first work was on the photoelectric fuze. It was started by Merle A. Tuve, chief physicist of the Department of Terrestrial Magnetism, who went to Briggs to ask for the assistance of his friend and professional associate Lauriston S. Taylor, an x-ray physicist in the Bureau's Atomic Physics, Radium and X-ray Section. The very next day Taylor was at DTM. Security procedures prevented him from knowing exactly what he was working on, but it involved electronics. Since he had not kept up with this burgeoning field, he in turn went to Briggs to ask for the assistance of Astin, who was Taylor's friend and neighbor, and whose scientific work he knew well. Briggs acceded to Taylor's request, as did Astin, and, as often happens, Astin got into work on proximity fuzes via an interconnected network of personal and professional acquaintances. Astin and Taylor began working together immediately.

Other parts of the proximity fuze effort were rapidly organized. After discussions between Briggs and the NDRC, Alexander Ellett, professor of physics at the University of Iowa but then with the NDRC, was given the responsibility of organizing work on the remaining types of fuzes. One of his first efforts was to recruit Diamond in December 1940 to work on the radio fuze. The situation with both Tuve and Ellett from the NDRC coordinating fuze work at the Bureau was clearly untenable. Tuve and the DTM were given responsibility for fuzes for rotating projectiles—anti-aircraft and artillery shells. Ellett and the Bureau were given responsibility for fuzes for bombs, rockets, and mortars. From then on, the two efforts were carried out separately. Ellett was the liaison man between the NDRC and the Bureau and responsible for all the Bureau fuze work.

By the time these administrative efforts were completed, the Astin-Taylor effort was well underway. After only a few days at the DTM, they moved to the Bureau, finding inappropriate but available space in the recently completed high voltage building. A staff was recruited, and early in 1941 Astin and Taylor were already carrying out field tests on bombs on which they personally had mounted fuzes, they alone having security clearances. Field testing was to become their main activity in the early fuze development effort. It soon became apparent that the photoelectric fuze had some inherent problems. It was sensitive to the sun, clouds, and so forth, and would fire prematurely. Moreover, the radio fuze project under Diamond was beginning to bear fruit, and by the end of the spring of 1941, Astin and Taylor were devoting their full time to field testing, which thenceforth included all types of fuzes. Further development of the photoelectric fuze was taken up by J. C. Henderson of the DTM, who moved to the Bureau for the purpose.

The first field tests were held at the Dahlgren Proving Grounds, about 75 miles south of Washington in Virginia. These were simple air drops—first from 5,000 feet and later from higher altitudes. Astin's telemetry experience was to prove useful from the very beginning of the testing. For all the fuzes, the theory of the devices and the circuit design were relatively clear. The real problems were in size limitations, mechanical rigidity, size and stability of vacuum tubes, and, most importantly, designing arming mechanisms so that fuzed bombs could be handled safely. The first failures occurred with the filaments in the vacuum tubes, since the filaments were operated at higher than normal current, and the repeated laboratory testing had weakened them so that they failed under the rigors of the field test. This was confirmed by attaching to the fuze a small transmitter which by telemetry transmitted to the ground information on the operation of the fuze circuits, and soon telemeters for various purposes were placed on all fuzes for testing. Astin's experience in telemetry was crucially important in developing these telemeters.

Testing expanded rapidly. Rockets became of intense military interest and fuzes for them had to be developed. The production of fuzes from the development effort increased. The size of the field testing unit grew. Dahlgren could not handle all this activity. Rockets were tested at Aberdeen Proving Grounds, north of Washington in Maryland. Bomb dropping from fighter planes onto enemy bombers in the air (a new tactic for defenses against bombing) was tried at Cape May, NJ. Scheduling at the sites became increasingly difficult, and a whole new proving grounds was sought and finally found at Corncake Inlet, some 30 miles south of Wilmington, NC. Corncake was more than a one-day round trip from Washington, so that a shop area, loading rooms, film processing room, and so forth had to be constructed, and the site itself had to be improved. Even the facilities of Corncake were to be exceeded by early spring of 1942, and another site—200 acres about 20 miles south of Washington at Port

Tobacco, MD—was acquired and equipped. This site was used for firing radio type proximity fuzes against chicken wire mock ups of airplanes suspended some 90 feet above the ground from a network of poles. Similar experiments were conducted at the Lakehurst Naval Air Station, NJ.

The whole proximity fuze effort had grown enormously, and the work pace was little short of frantic. Astin began to receive more and more leadership responsibility. With the size and geographic dispersion of the field testing operation he often had to act independently. By the end of 1942, the whole proximity fuze effort had been organized into the Ordance Development Division, with Diamond as chief and Taylor as his deputy until the latter left in the spring of 1943 to start an operations research effort for the 8th Fighter Command and 9th Air Force. (He returned to the Bureau after the war to resume his x-ray studies.) At about the time that Taylor left, Astin received his first official management post when he was appointed Chief of the Optical Fuze Section, where the work was concerned with the final stages of the photoelectric fuze effort (on which work was discontinued in the fall of 1943) and continuing efforts on electronics and circuit design. This position was to be the last in which Astin would be concerned primarily with technical activities.

A new item of ordnance is not sent to the field to be used until it is requested by the field commanders. Early in the winter of 1944, it was clear that the radio proximity fuze was ready for operational use. Three members of the Bureau staff were sent to the European Theater of Operations to explain the new bomb and rocket fuzes to the U.S. 8th and 9th Army Air Forces and the Royal Air Force. Hinman, who had worked on the radio fuze with Diamond from the beginning was the first to go. He was followed by Astin and later by R. D. Huntoon, who had worked extensively on circuit design on the radio fuze, and conducted many field tests with Astin. Astin went to England where he visited various Air Force units to introduce them to the fuze, and he conducted a field test to demonstrate its effectiveness at Ashley Walk in England. The tests were eminently successful, perhaps too successful, for the bomb fuzes were to play no part in the Allied invasion of Europe. As Astin was to recall later,

> I spent roughly six months in Europe to persuade Air Force generals to let us use the proximity fuze on bombers. The generals would not permit their use for fear that we would compromise our air superiority. Their general philosophy was that this was a much more valuable weapon to the enemy than it was to us. If we were to use it the enemy might get it and copy it and use it against us, and it would be disastrous.

This was doubtless a frustrating decision to all the people who had worked literally night and day to develop the fuze. But it was used in 1945 with great effectiveness by the 15th Air Force in the Mediterranean Theater against enemy anti-aircraft positions defending the approaches to Austria and Germany. It also was used effectively in the Pacific, particularly in the Iwo Jima campaign, and against the Japanese mainland. Indeed, 30 to 40 percent of all bombs dropped by carrier-based planes in the later stages of the war were equipped with proximity fuzes. The fuzes for rotating projectiles developed by the Tuve group at DTM and the Johns Hopkins Applied Physics Laboratory saw much more extensive use by all branches of the Allied Armed Forces in all the theaters of operation. For his work on the proximity fuze, in 1947 Great Britain awarded Astin His Majesty's Medal for Service in the Cause of Freedom, which, however, in accordance with the Constitution, he could not accept.

The trip to the European theater had a profound effect on Astin. Although he and his colleagues worked literally night and day (from 1941 to 1945, Astin worked every day of the year), and their work was to have an important effect on the war and on military history, Astin had always felt that he was not contributing as much to the war effort as members of the armed forces were. The sight of damaged aircraft returning from missions with their heart-rending cargo of injured and dead crew members affected him very deeply. He returned from Europe a more serious and even more motivated man.

Upon his return, Diamond asked him to become his deputy as Assistant Chief of the Ordnance Development Division. Astin accepted, and from then on was no longer to carry out research himself, but to become a manager of others who were carrying it out. Scientists who become managers often state (sometimes facetiously) that they would much rather be doing research than getting involved with all the administrative matters that management entails. Astin never felt that way, and certainly never said such a thing. When asked about becoming a manager, Astin replied with his typical forthright objectivity, "When I came back (from Europe), Harry Diamond wanted me to be his assistant chief, and I enjoyed it and never wanted to go back to technical work. I enjoyed the administrative work. It appealed to me, and so when the war was over I never gave it a thought." Indeed, in management Astin found his true talent. He had personality traits that made him an ideal manager of scientific people. Scientists—good scientists—are creative people; they need freedom if they are to be successful in their creativity, and more than most people, they need to feel that an idea is their own before feeling fully committed to it. Astin seemed instinctively to have understood all this, so that while he knew what he wanted, he also knew that in order to get it done he could not simply issue orders for it to be done. He had the ability to impart his wishes by the most subtle of suggestions, so that the person working for him would, by his own volition, and by his own logic, be led to do the thing that Astin wanted him to do. He gave a person a great deal of rope, but never permitted the person to hang himself; he pulled him back first. And he was always open to suggestions. A reasoned, logical argument for a change of course always found an attentive ear, and, if necessary, a change to the new direction. He also had a deep sense of humor and enjoyed a joke, even when it was at his expense. People felt comfortable with him. Thus, while it took 14 years for Astin to be appointed to his first managerial position, his career as a manager and executive was to advance rapidly.

The Bureau at the end of the war was a far different place from what it had been at the beginning. The open, unfenced campus of 58 acres through which visitors and neighbors could roam freely had grown to 71 acres that were completely fenced and guarded. Van Ness Street, which ran through the campus, was closed to civilian traffic. Myriads of new and temporary structures were spotted over the site. The staff, which had numbered 950 in 1939, now consisted of about 2,300, of which almost 1,300 were scientists and laboratory assistants. The annual budget had grown from just under \$3 million in 1939 to just under \$13 million in 1945, fully two-thirds of which was transferred funds, mostly from the military services. Practically all the work was classified. Badges were worn by everyone and checked by guards at the gates.

It was to be some time before the Bureau could again become the open, civilian agency working primarily in support of the measurement and standards needs of the science and industry of the Nation that it had been before the war and that had been anticipated in its enabling legislation. Indeed, it took the traumatic experience of the AD-X2 battery additive affair, and the firing and rehiring of Astin, who was then its director, before this could be accomplished.

In the uneasy cold war atmosphere that followed the end of World War II, the Bureau was much too important a military resource to revert immediately to a civilian agency. Its capabilities in atomic energy, guided missiles, and the proximity fuze were too important to disband. Thus, already in 1944, Briggs had signed an agreement with Army Ordnance to continue the proximity fuze work; a contract had been signed with the Navy for the continuation of guided missile work; the Atomic Energy Commission (AEC) had been formed in 1946 to replace the Manhattan District and offers of support for enhanced Bureau programs were forthcoming. In 1945, ground was broken for a new building to house ordnance research; in 1951, with assistance from the AEC, a cryogenics laboratory was constructed in Boulder, CO, on 220 acres of land that had been donated to the Bureau by the citizens of that city, and in the same year, a guided missile laboratory was established on a Navy site in Corona, CA. At the height of the Korean war, funds from the military and the AEC were to exceed $40 million, which constituted more than 85 percent of the Bureau's annual budget. At a time when science and technology were getting ready to flourish and the Bureau's help in measurements and standards was to become essential, the Bureau was close to becoming a military laboratory.

Two events were to take place that had great importance on the future of the Bureau and on Astin's career. On May 7, 1945, the date of his 71st birthday, Briggs submitted a letter of resignation as director of the Bureau, and on November 7, Edward U. Condon, then associate director of research of the Westinghouse Electric Corporation, but better known as an outstanding theoretical physicist and coauthor with G. A. Shortley of the definitive monograph *The Theory of Atomic Spectra*, was appointed director by President Truman. Three years later, on March 21, 1948, at the age of 48, Diamond, the driving, energetic radio engineer and inventor with whom Astin had been associated since the radiosonde days, and who was then Astin's immediate superior and close personal friend, died. Astin became Chief of the Ordnance Development Division, soon to become the Electronics and Ordnance Division. Astin was now a full fledged independent line manager.

Where Briggs was rather retiring, content to let things go along peacefully and quietly, with everybody doing his own thing, Condon was the supreme activist and extrovert. Concerned that the Bureau had not kept up with the new science developed during the 1930's and the war, he began actively to emphasize basic research—particularly in physics—and to deemphasize many of the important but relatively routine testing activities being carried on. Feeling that the Bureau's management system was old and antiquated, he brought in a team of bright young people—"whiz kids" they were called by the older members of the staff—to streamline the management system. At the insistence of Congress he instituted a project accounting system, and, at least fiscally, the free and easy days of the Briggs years were gone forever. He astounded Congress by asking for an increase in appropriation from $5 million to $25 million, but his request was denied. Indeed, during Condon's years as director, direct Bureau appropriations grew hardly at all, while transferred funds from the military and the AEC mushroomed. But he was able to instill in the staff a great desire to do basic research. He preached that while the important applied research on rubber, textiles, coatings, alloys, and electronic devices should continue, those projects should not "interfere with the Bureau's work on fundamental problems of physics and chemistry, and on methods of measurements and the standards and instruments which provide the basis for measurements of every kind." So strongly did he feel about this that he set out to have Congress revise the Bureau's enabling legislation, which had not been changed since 1901. In 1950, as a result of his activities, Congress passed an amendment to the Organic Act of 1950, which, while not changing the Bureau's responsibilities significantly, did make them clearer and more explicit.

From the beginning, Astin and Condon got along very well. The two men, so different in temperament and appearance, had the same basic aims of making the Bureau a distinguished laboratory that would be attractive to good scientists and where they could be productive. Condon had enormous respect for Astin. While the Ordnance Division was the largest in the Bureau, with a staff of 400 in the early 1950's, and was working totally on transferred funds, Astin had not lost touch with the rest of the Bureau, nor lost sight of the Bureau's main mission in measurements and standards. Indeed, in some ways that division led the way in new technologies. Thus, for example, a large part of the division was concerned with electronics. It developed an electronics standards laboratory. Special equipment for measuring the characteristics of vacuum tubes was designed, and the principles by which their life might be extended were developed. The first Bureau work on germanium and silicon, which in a few years were to revolutionize electronics, was done there. Above all, the division was deeply involved in computers. Under the leadership of C. H. Page and S. Alexander in Astin's division, the SEAC (Standards Eastern Automatic Computer) was completed in 1949 and dedicated on June 20, 1950. This was the first truly automatic electronic computer. Indeed, as a harbinger of the future, it even utilized germanium diodes in all the switching and computing elements. It operated for 4,000 hours in its first 9 months of operation without a malfunction, and, among other things, carried out calculations on optical lenses, supersonic nozzle design, and the penetration of x rays.

Obviously impressed with Astin's leadership capabilities, Condon appointed Astin senior associate director in charge of all other agency activities, electricity, and atomic physics.

On August 10, 1951, having been under intermittent but invalid attack from the House Committee on Un-American activities for 4 years, and concerned that the attacks on him would harm the Bureau despite their lack of validity, Condon resigned as director effective September 30. Astin was appointed acting director on October 1, and director on June 12, 1952. It was the most trying time in the whole history of the Bureau. It was the height of the AD-X2 affair, and the story begins with George W. Vinal and the Bureau's activities on battery testing.[1]

[1]Much of the following account largely follows that given by S. A. Lawrence, "The Battery Additive Controversy," Inter-University Case Program No. 68., Bobs-Merrill Co. Inc., 1962.

THE AD-X2 AFFAIR

George W. Vinal, Chief of the Electrochemistry Section of the Electricity Division, was an eminent scientist who had written an authoritative text on lead-acid storage batteries. Since World War I, the Bureau had done a significant amount of battery testing, and also had tested a large number of battery additives, colloquially referred to as "battery dopes." Much of this testing had been done for the Post Office Department and for the Federal Trade Commission (FTC), which was concerned with protecting the consumer against fraudulent advertising claims. None of these additives was found to be beneficial. Many were simple mixtures of magnesium and sodium sulfates (Epsom and Glauber's salts, respectively), and were uniformly found to be without merit. Others contained iron salts or halogen compounds, and were actually harmful. Indeed, in 1931, the Bureau had published Letter Circular 302, *Battery Compounds and Solutions*, laying out its findings and warning the public against the use of battery additives. This letter circular was one of a series of pamphlets published occasionally by the Bureau when the results of its work were deemed to be of interest and help to the consumer. These pamphlets were used by better business bureaus throughout the Nation to carry out their intent of protecting the consumer and promoting good, reputable business practices. The National Better Business Bureau (NBBB) in New York had used LC302 in preparing its own publication *Facts About Battery Dopes* condemning battery additives.

In late April of 1948, while Astin was still Assistant Chief of the Ordnance Division, Vinal received a letter from Merle Randall, professor emeritus at the University of California, and a distinguished name in chemistry, having coauthored with G. N. Lewis in 1923 the definitive text on chemical thermodynamics, *Thermodynamics and the Free Energy of Chemical Substances.* He was now serving as a technical consultant to an Oakland, CA, company called Pioneers, Inc., the president of which was an entrepreneur named Jess M. Ritchie. Pioneers had developed a battery additive then called "Protecto Charge," but subsequently to be called "AD-X2." Randall wrote,

> The Protecto Charge process involves the addition of a powder mixture of anhydrous sodium sulfate and a slightly basic, nearly anhydrous, magnesium sulfate to the water while it is filled with standard sulfuric acid electrolyte. Curiously, the result is quite different from that when equivalent amounts of sodium sulfate and Epsom salts are added. . . . Actual large scale fleet operational tests. . . as well as my own observations, indicate a remarkable improvement in the service of both new batteries and those discarded as sulfated in use or on the shelf. . . .

Impressed with the stature of the writer, but having heard the same thing many times, Vinal put the letter aside.

With this letter began a chain of events that was to last more than 5 years; make newspaper headlines throughout the country; cause in 1953 the dismissal, temporary rehiring, and eventual reinstatement of Astin, who was by then director of the Bureau; prompt 4 days of Senate hearings; lead to the resignation of an Assistant Secretary of Commerce; and cause two committees of the National Academy of Sciences to investigate the Bureau. A number of important issues were explored, among them science policy, the politicization of science, the hindrance of small business by Government regulations, and the objectivity and impartiality of the Bureau. In brief, the story unfolded as follows.

In 1947 Ritchie bought partnership in a firm making the battery additive called Protecto Charge, which he found to be harmful. He then hired Randall, and together they developed the material about which Randall wrote to Vinal. He subsequently bought out the other partners in the firm and began marketing the new additive under the name "battery AD-X2." He never patented the product, preferring to protect himself by keeping details about it secret.

Ritchie was an aggressive entrepreneur, with a great persuasive ability. At the beginning, Ritchie's strategy clearly was to gain exception for his product from the National Better Business Bureau's general condemnation of battery additives, and to get the National Bureau of Standards to test it. His advertising claimed that his product should be excepted because the Bureau had not tested it and because LC302, on which the NBBB publication was based, was then very old. Moreover, he had the support of his local better business bureau—the Oakland Better Business Bureau (OBBB)—since apparently his customers in the area were satisfied. It is important to note that the instructions given to customers with the purchase of AD-X2—cleansing of terminals and slow charging—were excellent and would improve batteries without the use of AD-X2.

Thus, for the remainder of 1948, a series of pressures were put on Vinal. Under pressure from Ritchie to make an exception for AD-X2, the NBBB wanted Vinal to issue an up-to-date revision of LC302, something which Vinal had wanted to do anyway. The OBBB put pressure on Vinal to test AD-X2. Finally, late in the year, Senator Knowland, whose home was in Oakland, also requested tests.

Vinal did not bow because these pressures conflicted with two fundamental Bureau policies: it did not make commercial tests of materials unless requested by another agency of the Government, and it never endorsed, or even mentioned, commercial products in its publications. However, Vinal, on his own initiative, did carry out a limited test of AD-X2 along with other tests he performed for the FTC. The results were as expected; AD-X2 was a simple mixture of sodium and magnesium sulfate, and it showed no beneficial effect. Importantly, the Bureau did not then or at any other time, carry out field tests. Vinal did not disclose these results.

Early in 1949, five military installations tested AD-X2. Three found it without merit, but two, using methods that Vinal considered inadequate, reported positive results. The military suspended purchases of

AD-X2. The positive military results heightened the concerns of the NBBB about the validity of its battery additive publication, and it further pressed Vinal for a revision of LC302. Recognizing that a thorough revision would take some time, and in view of the pressing interest in AD-X2 and other additives, the Bureau reissued LC302 with a letter signed by Condon which summarized its contents. Neither AD-X2 nor any other additive was mentioned by name. From the Bureau's position, this quieted matters.

But the situation was to get more serious. Having the public statements from the Bureau, the NBBB asked the FTC to take action against Pioneers on the grounds that its advertising claims for AD-X2 were false, and notified Vinal that it was doing so. The FTC sent an examiner to Oakland, who found generally wide satisfaction among AD-X2 users, including technical personnel at military installations. A feud broke out between the OBBB and the NBBB, the former contending that the latter had no business "preventing a man from carrying out free enterprise... unless there is a reasonable basis for such action." Sales of AD-X2 increased, and Ritchie expanded his business by collecting and rebuilding junked batteries.

The San Francisco office of the FTC suggested to Washington that new tests be conducted on AD-X2, and on March 22, 1950, the FTC made a formal request for such tests to NBS. Tests were made, results of the previous tests Vinal had made were incorporated, and Vinal reported to the FTC on May 11 that these tests had failed to demonstrate any significant beneficial effect.

Ritchie had continued his advertising claims that the NBBB and Bureau statements did not apply to AD-X2 because it had not been tested, and then he played a trump card. He began collecting material to bring suit against the NBBB, whereupon it brought strong pressure on Vinal to identify AD-X2 by name as the only way of resolving the issue.

Vinal and the Bureau management were in a quandary. In order to resolve the matter they would either have to abandon a fundamental Bureau policy or remain silent and thereby give tacit approval to AD-X2. Moreover, the cherished impartiality and objectivity of the Bureau were being called into question.

The Bureau unprecedentedly broke its long standing policy. It permitted the NBBB to publish in August of 1950 a leaflet entitled *Battery Compounds and Solutions* containing a long statement in which the Bureau referred specifically to AD-X2. The crucial part is as follows:

> In view of the tests made here and in competent laboratories elsewhere it is our belief that AD-X2 is not essentially different from other preparations containing magnesium sulfate and sodium sulfate, and that as a class these materials are not beneficial. The results of recent tests are being prepared for issuance as a Bureau circular but in the meantime we see no reason to modify Letter Circular 302.

We can only surmise now the agony of the decision that led the management of the Bureau to break its tradition and allow the publication of this statement. We only know that a similar statement was never made before, nor has it been since. In the same leaflet, Ritchie was permitted to rebut the Bureau's findings, and he brought up field tests, which were to become a celebrated issue later:

> It has been mentioned many times by both Dr. Randall and ourselves that it is difficult to make a really definitive laboratory test of Battery AD-X2 and that the only practical means of determining the value of the product is through field test.

The NBBB made wide distribution of its leaflet. The story was by now receiving the attention of the press. While many accounts were critical of AD-X2, in December of 1950, *Newsweek* published an article reporting the favorable military results and the satisfaction of AD-X2 customers. Ritchie's sales mounted. The FTC examiner in San Francisco, feeling the Bureau report was not definitive because of the lack of field tests and because of the satisfactory experience of users in the area, recommended that the FTC drop its case against Pioneers. He was overruled by both the San

Francisco and Washington offices.

At long last, on Janury 10, 1951, NBS issued its revision of LC302, now called Circular 504, and followed it by a series of news releases. It showed in considerable detail the results of new laboratory tests, with the same conclusions as previously: no battery additive was found to be useful. None of the battery additives was identified by name. These findings were extensively published in the trade press, which refused to publish Ritchie's side of the story, and in many cases refused to accept his advertising. His sales plummeted.

Ritchie began to attack the Bureau. In August 1951, just as Condon was submitting his resignation, and less than 2 months before Astin was to become acting director, he urged his distributors to write to Congress, with the avowed aim of causing a congressional investigation of the Bureau. His position was that he, a small businessman, was being unfairly harassed and persecuted by an agency of the Government. Congress was flooded by mail. Senators and Congressman wrote to the Bureau, many several times. The volume of correspondence became so great in the fall of 1951 that the Bureau issued a mimeographed leaflet which stated that the results in Circular 504 were unambiguous: battery additives were worthless.

Astin, as acting director, was thrust into this highly charged political arena. He was immediately involved with the AD-X2 problem and attempted to bring it under control. He entered into correspondence with Ritchie, but it took him some time to become fully acquainted with the voluminous file, and the momentum of events could not be reduced. Ritchie went to the Senate Select Committee on Small Business, where he found a sympathetic reception—particularly from one of its staff members, Blake O'Connor. He also retained as consultant Keith Laidler, an expert on chemical kinetics from Catholic University, and found sympathetic support from Harold C. Weber, professor of chemical engineering at MIT. In February of 1952, the FTC, responding to pressure from Ritchie and from the Senate, and feeling that it needed more tests to uphold its position against Pioneers, Inc., asked the Bureau to conduct more tests. In early March, the Post Office Department notified Ritchie that it was accusing him of "conducting an unlawful enterprise through the mails" and scheduled a hearing for April 26, which it subsequently delayed to await the results of the Bureau tests. The tests were quite extensive, and as expected they also showed AD-X2 to be without merit. But they were immediately attacked by Ritchie as being technically flawed because the charging procedure was inappropriate, despite the fact that it was the same one used by Randall.

Astin decided to resolve the situation by performing a public test using a procedure that would be agreed to by all parties. By conference and by mail between Astin and the other Bureau people on the one hand, and Ritchie and his consultants on the other, a procedure was agreed upon in writing, except for one point on which there was only oral agreement, and which turned out to be crucial. This concerned the specific gravity of the electrolyte. Ritchie had wanted to add water if, during charging, the specific gravity rose above 1.280; the Bureau did not want to add water at all. Astin finally thought he had a compromise in which the specific gravity would not be allowed to rise above 1.325, and the tests were performed in June 1952.

Astin was now fully and directly in charge. Some of the battery cells were to be treated and some were to be controls. But which cells were which was not to be known to the personnel conducting the tests; only Astin was to have the key. The Bureau statisticians developed a random sampling scheme, and on the morning on which the tests were to begin, Astin and a technician assistant went alone into the laboratory. Consulting a chart prepared by the statisticians, Astin told the technician which cells were to have AD-X2 added and which were not. When this was done, he asked the technician to leave the room, and he personally affixed numbers to all the cells. Only he knew which numbers corresponded to treated cells. The tests were then run by the laboratory personnel over the next few weeks.

On July 15, 1952, the Bureau reported its results.

They were predictable: AD-X2 showed no beneficial effects. Ritchie's behavior was equally predictable: the tests were not properly done; he had never agreed to the permitted increase in specific gravity; and the tests were flawed in ten other ways. Astin's hopes of a conclusive test were dashed.

It was now clear, certainly to Astin, who firmly believed that he had obtained Ritchie's agreement on the conduct of the tests, that no test conducted by the Bureau would be acceptable to Ritchie. Moreover, the Senate Small Business Committee took Ritchie's side on the validity of the tests. On September 29, at a meeting in Astin's office involving Ritchie, O'Connor of the committee, and Bureau personnel, it was agreed that further tests were necessary, but no decision was made about who was to conduct the tests. Subsequently, O'Connor, acting unilaterally, asked MIT to carry out these tests, and MIT, contrary to their usual policy, agreed to do so. These tests were started by Weber in mid-October. In what in retrospect may have been an error, Astin decided that because of Ritchie's attitude toward the Bureau it would be better if MIT carried out their tests independently; the Bureau did not participate in the tests.

On December 17, 1952, the results of the MIT tests were delivered to the committee. The report *did* find differences attributable to the introduction of AD-X2, but qualified the differences and very carefully refrained from concluding whether such differences were of any practical consequence. In fact, it was to turn out later that these differences were only observable when using electrolyte that was so dilute that it bore no relationship to actual use conditions. Astin went to MIT to discuss this, but nothing came of the discussions. The committee ignored the qualifications and issued a press release stating that the MIT results completely supported the manufacturer's claims. The release included a statement by Laidler, who was now acting as a consultant to the committee, which stated in part, "The MIT tests. . . constitute by far the most thorough scientific tests of the effectiveness of AD-X2. They demonstrate without reasonable doubt that this material is in fact valuable, and give complete support to the claims of the manufacturer." In view of the MIT qualifications, this was a remarkable statement. The release ended with a statement attributed to Laidler but subsequently denied by him, that implied that Bureau scientists could only make "such grave errors" because they were associated with battery manufacturers.

The release was widely reported by radio and in the press. The Bureau and MIT—indeed the whole scientific community—were in a quandary. Two of the Nation's most highly respected laboratories had apparently arrived at conflicting conclusions on what appeared to be a simple problem. The scientific method itself was being called into question, as were the motivations and objectivity of Bureau scientists. The Bureau was at the lowest point in its history. The staff felt under personal attack and was in a state of agitation, although firmly united in support of the institution and its director.

The Bureau and Astin's woes were to mount, for Astin had a new boss. After the 1952 presidential election, a new administration came into office vowing to "clean up the mess in Washington." Sinclair Weeks, a businessman from Boston, was appointed Secretary of Commerce and promised to "cut out the dead wood." His mail was flooded by letters from Ritchie and his supporters claiming that Pioneers, Inc., was being unfairly persecuted by an antagonistic bureaucracy. Weeks was sympathetic to his case, which seemed tailor-made for the new administration. Ritchie's case was strengthened when in February 24, 1953, the Post Office, notwithstanding the MIT tests, halted Ritchie's mail because of fraudulent advertising. Political pressure on the Post Office Department from the Senate Small Business Committee caused suspension of the order a few days later. Weeks ordered his assistant secretary Craig R. Sheaffer to investigate the AD-X2 affair. Sheaffer was former president of the Sheaffer Pen Company, and no lover of the Washington bureaucracy, his company having come under investigation from the FTC because of the advertising of its "lifetime" pen.

In his direct way, Astin tried to see Weeks. In

January of 1953 he wrote a memorandum to Weeks containing a proposal that was to prove crucial for the future of the Bureau. He proposed that the National Academy of Sciences be enlisted to evaluate the Bureau with respect to both the AD-X2 case and all its other operations. For the moment, nothing came of this. Astin never saw Weeks; Weeks had placed the whole matter in the hands of Sheaffer. Astin later tried again to see Weeks, with the same result. As a result of his investigations, Sheaffer came to the conclusion that there were sufficient grounds to question the reliability of the NBS tests, and, with the concurrence of Weeks, on March 24, 1953, he asked Astin to resign. Although the Director of the National Bureau of Standards serves at the pleasure of the President, it is a post in which the incumbent is traditionally not replaced at the change of administration, but Astin, apparently feeling that this action was part of Weeks' general housecleaning and not personal, resigned. On March 31, 1953, his letter of resignation was at the White House.

On that day, two events occurred that were to cause a nationwide furor. The morning papers carried a column by Drew Pearson which read in part:

> Last week Dr. Astin was summoned to the Commerce Department by Assistant Secretary Craig Sheaffer...and was fired. He also was lectured regarding the National Bureau of Standards diagnosis of battery additives...and [Sheaffer] told Dr. Astin the Bureau of Standards in the future was to be run on a businessman's basis.

On the afternoon of the same day, Weeks testified at a hearing on AD-X2 before the Senate Small Business Committee at which he was the sole witness. He was sharply critical of the Bureau and very supportive of Ritchie. He made the now well-known statement:

> I am not a man of science and I do not wish to enter into a technical discussion or be accused of overruling the findings of any laboratory. But as the practical man, I think the National Bureau of Standards has not been sufficiently objective, because they discount entirely the play of the market place....

On a more positive note he promised he would have the Bureau evaluated by the "best brains I can find," and have more tests made of AD-X2 by impartial scientists. In this ironic and bizarre way did Astin's own proposals begin to be implemented.

At first, the attention of the press was limited to mere reporting of Week's statements but as the story developed, Weeks became enveloped in a veritable explosion of criticism. Except for a very few newspapers, the press was uniformly against Astin's summary dismissal. The scientific community rose up in support of Astin, and vehemently denounced Weeks for what it perceived as a blatant attempt to have scientists arrive only at politically acceptable results. Many Congressmen supported Astin, and the Senate Small Business Committee promised hearings. Political cartoonists had a field day at the expense of Weeks and Sheaffer. The Bureau staff solidified behind their director, and 400 (mostly engaged in military research, which caused considerable consternation at the Pentagon) threatened to resign, a fact which was proclaimed in banner headlines in the *Washington Evening Star*.

By law, the Bureau is required to have a Visiting Committee of five men appointed by the Secretary of Commerce, who are to "visit the Bureau at least once a year, and report to the Secretary...upon the efficiency of its scientific work and on the condition of its equipment." From the beginning, this committee has been made up of the most distinguished scientists and scientist-administrators from the Nation's universities and industrial laboratories. These elder statesmen of science began to work quietly and effectively. Detlev Bronk, chairman of the committee, President of Johns Hopkins University, and President of the National Academy of Sciences, and Mervin Kelly, President of Bell Telephone Laboratories and a member of the Visiting Committee, met with Weeks at his request. The whole question of the Bureau involvement with AD-X2 and the dismissal of Astin was explored. Weeks, of course was anxious to implement the promise he had made to the Senate Small Business Committee to have an independent evaluation of the Bureau, and the Academy was the obvious organization to carry this out. Shortly thereafter, at a meeting between Weeks and the full Visiting Committee, Bronk informed Weeks that he could not in fairness recommend to the Academy that it carry out such an evaluation unless the dismissal order of Astin were at least temporarily rescinded. Weeks capitulated. Three days later, on April 17, the day that Astin's resignation was to take place, Weeks made an announcement. The Academy would form two committees: one under Zay Jeffries, retired vice president of the General Electric Company, to evaluate the Bureau's work on AD-X2, and another, to be chaired by Kelly, to evaluate the general condition of the Bureau. Weeks temporarily rescinded Astin's dismissal, and stated that while there was no question involved of Astin's permanent retention, he had not meant to cast doubt on the integrity of either the Bureau or Astin. Astin agreed to stay on at least until the reports of the Academy were received. A relatively stable situation had been achieved.

How much Astin directly had to do with these actions of the Visiting Committee can only be surmised. A model of executive behavior, he had acted throughout the whole affair with his customary calm dignity; if he had been upset by the events he did not show it. That he had discussed the AD-X2 matter with the Visiting Committee is clear, for the committee met twice in 1952 and met early in 1953. Thus it is safe to assume that they were well informed about Astin's actions, and particularly his memos to Weeks asking for Academy evaluation. It would have been at a minimum discourteous and totally out of keeping with Astin's completely frank and open way of dealing not to have informed the committee of his actions. Moreover, in 1952, the committee had already recommended to the Secretary (not Weeks at that time) that a study of the Bureau be carried out by an ad hoc committee, and they would not have done this without Astin's knowledge. Thus it is certain that the committee knew of Astin's wishes when they spoke with Weeks. By working quietly and calmly within the system, Astin got what he wanted: an objective, dispassionate evaluation of the Bureau. He never had any fear of an objective evaluation; in Astin's mind such an evaluation could only lead to the truth, and the truth was never to be feared.

Before the AD-X2 drama was to come to an end, one last act had to be played. The Senate Small Business Committee scheduled hearings on AD-X2 for June 22, and Ritchie and Astin were to testify. Astin would be at center stage, and the whole Nation would be his audience. It was not a position he relished.

Ritchie testified first, and in a long, rambling testimony repeated his position that he had a good product and was being unfairly treated by the Bureau. He was followed by Astin, who had many issues to address in his testimony. He had to defend the Bureau's handling of the AD-X2 affair; he had to address both the technical accuracy and the validity of the Bureau's results; he had to explain how there could be so many satisfied users when the Bureau tests were uniformly negative; and he had to confront the MIT results. In addition to these relatively narrow issues, his testimony was concerned with the broader issue of the use of scientific results in public policy.

In his prepared testimony, Astin first gave a description and analysis of the Bureau's functions and its responsibilities and discussed how it came to be involved in product testing. His principal theme here was one that was to occupy him for the remainder of his career. Since measurements and the standards based on them are all pervasive, the Bureau is inevitably led to have close contact with all of science and industry. The main function of the Bureau is the continued development of measurement methods, but its abilities are also put to specific Government use. Hence the principal functions of the Bureau, Astin stated, were "to serve the Government as a scientific laboratory, and to serve the Nation's science and industry by establishing and maintaining the fundamental standards of science, [and] related instrumentation and measurement methods. . . ." One of its functions as a Government scientific laboratory is product testing for other agencies of the Government. He pointed out that this function, important as it was, amounted to 1 percent of the total Bureau effort, and that portion that was done for regulatory agencies was only 0.05 percent. This was how the Bureau came to be involved in the testing of batteries and battery additives. The reports of such tests are the property of the other agencies, and the content and dissemination of the information in them is their responsibility. However, as a result of this activity the Bureau occasionally amassed an amount of knowledge that it felt could be useful and of interest to the general public. In that case, in view of the statement in its enabling legislation of 1950 for "the compilation and publication of general scientific and technical data. . . when such data are of importance. . . to the general public. . . ," the Bureau publishes these results. Complete impartiality is obtained, Astin stated ". . . by confining the reports to straightforward presentations of scientific and technical data on the properties of the materials and devices used." Trade names are not used, and the name of the Bureau in advertising is not permitted.

He then had to confront the issue of why the Bureau, in the AD-X2 case, had permitted the use of its name and the name of the product by the NBBB. To him the issue was very clear and very simple:

> This deviation from the usual practice was at the request of the NBBB in order to reply to statements made by the proponents of AD-X2 that the generalizations made in prior bulletins did not apply to that product and that it had not been tested by the Bureau. . . . Every action which the Bureau has taken with respect to the testing of AD-X2 and the dissemination of information with respect thereto has been brought about as a direct consequence of the representations and the pressures of the proponents of AD-X2.

Sometimes, Astin seemed to be saying to the committee, the simple and obvious answer is the correct one. The Bureau had acted objectively and impartially; it broke its long-standing policies only because it was forced to.

With respect to the question of field tests versus laboratory tests, Astin was on familiar grounds. He had, after all, been engaged in field testing throughout most of his career. His statement was again clear and unequivocal. Without ever mentioning himself personally, he reminded the committee of the Bureau experience in field testing of ordnance devices. He continued,

> In the development of a new ordnance device the field test is the final stage of evaluation and approval. The field test, however, is not resorted to until some improvement or effect is developed in the laboratory which would then make the field tests worthwhile. . . . The Bureau has not resorted to field tests with battery additives, because it has not been possible to find in the laboratory any effect which is related to the normal use of lead-acid batteries. . . . Since no worthwhile effect has been found. . . it has been concluded that the field tests would serve no useful purpose.

It is pointless, Astin was saying, to carry out field tests when no effect was found in the laboratory.

The issue of customer satisfaction had two sides. The first and relatively simple one was the question of how customers could be satisfied while the laboratory tests showed no beneficial effects. The second broader question was the use of customer satisfaction in assessing the validity of products. The first question Astin answered by explaining the results of the final tests the Bureau had run on AD-X2—those that had been agreed to by Ritchie and in which Astin had personally participated. He pointed out that in these tests half the batteries had been treated and half had not, and that only he knew which was which. No difference was found among the batteries—they all took the same charge—and neither the Bureau people nor Ritchie and his supporters could distinguish between the treated and untreated batteries. It was then clear that if a person had treated a battery with AD-X2, and not used an untreated battery as a *control*, he would have been satisfied, but would never have known that he could have achieved the same result with proper handling but *without* AD-X2. The battery handling instructions provided with AD-X2 were in fact excellent. Astin replied, when confronted with the experience of satisfied customers, "You should ask them if they have any control so that they have a base with which to compare their measurements."

On the broader issue of using customer experience and testimonials, Astin took a very firm position:

> . . . there are generally no adequate measures included in a testimonial, no rigorous specifications of the operating conditions under which the measurements were taken, and usually no controls whatever are used—for those reasons we cannot accept testimonials as scientific evidence.

Finally, with respect to the differences between the Bureau and MIT results, Astin told the committee that the Bureau had reproduced the MIT results, but that they occurred only with dilute acid concentration, "so dilute, in fact that it appears to be of no significance whatever in normal storage-battery operation." However, the whole matter was being evaluated by a committee of the National Academy of Sciences and he welcomed their scrutiny and results. Weber, who testified after Astin, was essentially to end the matter when he stated, "I cannot say that this effect is correlated with a beneficial action from the standpoint of the normal use of such a battery."

So much for the specific issues concerning AD-X2. On the broader issues of the relationship of science to politics and public policy, Astin's position was clear and firm. Concerning the issue of the dissemination of scientific data when it might adversely affect some business interests, he took the hypothetical case of data on aluminum:

> A laboratory study on the properties of aluminum under a particular set of environmental conditions might disclose characteristics for aluminum superior to those of steel. . . . The publication of such data would not be considered as prejudicial to those promoting the use of steel; rather the withholding of such data would be considered as prejudicial to the interests of the general public and those interested in promotion of the use of aluminum. *In science and technology a specific, reproducible observation is a fact that knows no favorites.* (Emphasis added).

Again on the same point, "would we withhold the dissemination of that data because the steel people would not like it? It is a cold, hard scientific fact. To withhold the dissemination of scientific information I think is the most prejudicial action."

Astin and the committee were dealing here—for the first time, it appears—with the proper place of scientific data in politics and public policy. In later years, this issue was to be debated extensively with respect principally to regulatory questions in public health and safety and environmental problems. To Astin the issue apparently had a clear resolution. He made a sharp and clear distinction between science on the one hand and politics and public policy on the other. Science deals with the discovery and quantification of physical facts and natural law; politics and public policy deal with the use of those facts for social, economic, and other purposes. But the facts exist independent of their use, and their dissemination should not—indeed, cannot—be suppressed or withheld.

Astin's testimony began on the afternoon of June 23 and ended in the late afternoon of June 24. Throughout all of the questioning—which was mentally and physically exhausting and not invariably friendly—he showed only composure and dignity, and firmness but courtesy, and, as the following exchange near the end of his testimony shows, he never lost his sense of humor or his acuity. Earlier in his testimony, the ratio of the selling price of AD-X2 to the price of the raw materials had been compared to the same ratio for aspirin. The first questioner was the sympathetic Senator Smathers.

> *Sen. Smathers*—Now, just one last question. . . . About the relative worth of the product aspirin as compared to the relative worth of AD-X2, in your offhand opinion, do you think the value of aspirin has been proved or established

more so than the value of AD-X2?

Dr. Astin—I buy aspirin.

Sen. Smathers—No further questions.

Sen. Sparkman—In considerable quantity?

Sen. Hunt—Lately?

The Chairman (Senator Thye)—Doctor, I hope we weren't the cause of you buying any.

Dr. Astin—I have got a great big 85-grain tablet that I keep in my desk. It is National Bureau of Standards size.

(Eighty-five grains is 5,500 milligrams. The normal aspirin tablet is 500 milligrams.)

Astin had won the day; the AD-X2 affair was ending. He was reinstated permanently as director on August 21. Sheaffer resigned, and Astin thenceforth reported to James C. Worthy, Assistant Secretary of Commerce for Administration. Worthy had recommended Astin's reinstatement to Weeks, who in turn became a strong supporter of Astin and the Bureau. Ritchie continued marketing AD-X2, went into politics, and sued the Government by means of a private bill introduced by his Congressman, but the suit was dismissed "with prejudice." When the Jeffries Committee reported in October 1953 that the Bureau's work had been of high quality and that AD-X2 was of no value, the Bureau's involvement in the AD-X2 affair ended. The Bureau had been exonerated. Astin and the Bureau staff had brought it through its hardest days.

That the AD-X2 affair caused Astin to think very deeply about his beliefs in scientific research as a part of intellectual and emotional life, and about the place of the Bureau in science and industry is shown best by an address he gave to the American Physical Society on May 1, 1953, during its annual Washington meeting. Better than anything else in existence, this remarkable document gives a clear, but passionate and almost emotional statement of Astin's scientific beliefs. (It is reproduced in the Appendix.) From the sentence near the beginning, "The Bureau staff believes first of all in the importance of scientific research as a means of intellectual and spiritual achievement...," to the closing statement, "...we know that the opportunity to assist in attaining [the Bureau's goals] affords a high degree of intellectual, moral, and spiritual satisfaction," the intensity of thought and feeling that pervade the document attest to the depth of the emotion he experienced during those trying days. His declaration of the "spiritual" and "moral" values of scientific research shows that his regard for science transcended the utilitarian and approached the artistic, mystical, and almost religious. He says the document "represents some of the traditions and creeds of the staff of the National Bureau of Standards," but it is clear that the statement is Astin's own. It deserves to be called "Astin's credo."

The most important positive outcome of the AD-X2 affair was the report of the Kelly Committee, made on October 15, 1953. Its principal findings were that the Bureau was a respected and competent organization which was of vital importance and whose importance would increase with the increasing technological sophistication of the Nation. However, the Bureau's basic programs had not kept pace with the increase of science and technology, and the amount of weapons work had become too great. It made a total of ten recommendations, the most significant of which were:

- A higher level of activity in the basic programs
- Modernization of facilities and increased space for basic programs
- Transfer of weapons projects to the Department of Defense
- Improvement of the organization at the associate director level
- The formation of advisory groups to the director.

All these were recommendations that Astin welcomed. They would form the basis for his agenda during the remainder of his term as director.

THE POST AD-X2 YEARS

At the time when Astin became director of the Bureau, the United States was in the midst of a new and trying period—the Cold War. In 1948 the U.S.S.R. instituted a blockade of Berlin, necessitating a year-long U.S. airlift. The Nation had been shocked when late in 1949 President Truman announced that Russia had exploded an atomic bomb. A national debate on the production of a hydrogen bomb had taken place, with the decision to proceed. A hydrogen weapon had been exploded on November 1, 1952, and was followed 9 months later by the explosion of a Russian hydrogen bomb. On June 25, 1950, North Korea attacked South Korea, and thus began the U.S. involvement in another war that was to last until July 27, 1953—3 days after Astin had ended his testimony in the AD-X2 case. The McCarthy hearings with their accusations of communists in Government made daily headlines. The race to develop an intercontinental ballistic missile was in full force, with separate programs by each of the armed services. Finally, on October 4, 1957, Russia launched a 180-pound beeping object named Sputnik I into orbit, to be followed 33 days later by Sputnik II, weighing 1,120 pounds and containing a dog. Initial U.S. attempts to launch a satellite ended in failure. The Nation was in the midst of an arms race which it felt it was losing. It was a nervous and uneasy time.

The involvement of the Government in science increased greatly. With the formation in 1946 of the Atomic Energy Commission, new national laboratories were organized at Oak Ridge, TN, Argonne, IL, Brookhaven on Long Island, and Livermore, CA. The Office of Naval Research, a landmark institution for the funding of research, was formed the same year as the AEC. After one unsuccessful attempt in 1947, the National Science Foundation was formed in 1950. Early in 1958, the Defense Department, recognizing that it needed more advanced research, formed the Advanced Research Projects Agency. Finally, in response to the Sputniks, in October 1958, the National Aeronautics and Space Agency (NASA) was formed from the old National Advisory Committee for Aeronautics (which had been in existence since 1915 and with which the Bureau had always worked closely) with responsibilities for all civilian space activities. It was a decade of growth in Federal science.

Of more specific importance to Astin, the White House recognized that science was now a crucial part of policy decisions, and both Truman and Eisenhower established advisory structures. In 1947 Truman formed the Interdepartmental Committee for Scientific Research to coordinate research among the various agencies of the Government and to aid in solving common administrative problems. In 1951 he formed a Science Advisory Committee of 11 of the Nation's top scientists to advise him on scientific matters relating to defense. President Eisenhower revised this organization, first forming the post of Science Advisor in his Executive Office one month after Sputnik, and shortly thereafter forming the President's Science Advisory Committee from Truman's Science Advisory Committee. Finally, in 1959, he formed the Federal Council for Science and Technology from Truman's Interdepartmental Committee. In 1962, the Office of Science and Technology in the Executive Office of the President was formed. This, along with the Bureau of the Budget, was the almost unbelievably complex scientific management structure that Astin had to work with throughout his term as director.

Astin was well suited to work within this structure. He had known many of the people who worked within this intricate interconnecting network of coordinators and advisors from his work during the war and from the visiting committees of the Bureau. As director of the Bureau, he automatically became a member of Truman's Interdepartmental Committee and its successor, the Federal Council for Science and Technology. Indeed he chaired the former in 1954, and served as chairman of the Subcommittee on Federal Laboratories of the latter from 1962 until his retirement in 1969. Because of his experience in defense-related work he served on the Advisory Committee for Naval Research from 1952 to 1959, and on the Defense Science Board, which advised the director of the Office of Defense Research and Engineering in the Pentagon. He was thus fully in contact with all that was going on in research management and research policy formulation in the Federal Government, and in all of these posts he was held in the highest respect because of his complete, unequivocal honesty, his mature, objective judgement, and his self-effacing, quiet, and courteous manner. No one ever had the fear of being misled by Allen Astin.

In this atmosphere and with these connections, Astin set about remaking the Bureau. He had to rebuild its civilian scientific base, which had deteriorated during the war years, and to carry out the other recommendations of the Kelly Committee. But he had his own agenda and goals as well. When asked 30 years later what these goals were when he became director he replied,

> I guess my primary goal was similar to both Condon's and Briggs'. I think above all else I wanted to make the Bureau an attractive place for scientists to work. That, more than anything else, dominated my goals and decisions. More specifically, I wanted to develop a sense of mission and define a mission. Another [goal] was to reduce the dependence of the Bureau on transferred funds and to make the primary source of financing the Bureau's own appropriation [and] at a sufficient level to carry out the Bureau's mission. I would say these were the main objectives.

He was to realize them during his tenure.

Two of the recommendations of the Kelly Committee—reduction of weapons work and the formation of advisory committees for the Bureau director—were easily implemented. In September of 1953, having seen a preliminary copy of the Kelly Committee report, Secretary Weeks signed an agreement with the Department of Defense to transfer to it the proximity fuze and guided missile work. The laboratories and people working on the proximity fuze remained at the Van Ness site, but were renamed the Diamond Ordnance Fuze Laboratories and transferred to Army Ordnance. The division at the Corona Laboratories was transferred to the Navy, and when a year later the Institute for Numerical Analysis, which had been operated by the Bureau for the Department of Defense since 1947 at UCLA, was transferred to the university, the largest portion of the transfer was complete. The Bureau had lost 2,000 of its staff of 4,800.

Equally swift was the implementation of the recommendation for the establishment of advisory committees. In accordance with the recommendations of the Kelly Committee, nine scientific societies and the National Conference on Weights and Measures were asked to form such committees, and by June 1954 ten committees consisting of 60 of the most distinguished academic and industrial scientists were in existence. Each of the committees investigated the Bureau yearly and advised Astin in its particular field of expertise. This method of operation continued until 1957, when the formation and operation of the advisory committees (subsequently called advisory panels) were taken over by the National Research Council. At that time a panel was appointed for each division of the Bureau, and a variant of this system still exists today.

The strengthening of the Bureau's basic research effort was to prove much more difficult. Science was entering a period of unparalleled growth, and new demands for services from the Bureau were increasing dramatically. To increase the level of activities in basic science and to expand into new areas, along with the implementation of Astin's own objectives to make the Bureau an "attractive place to work" where the atmosphere was "free, very free" as in Briggs' day, three things were needed: people, equipment, and space.

These had one common ingredient: money. Astin had to find a way to increase the appropriation for the Bureau's basic program.

Money meant Congress, for it held the purse strings. But before the Congress could be approached, any increases in appropriation asked for by Astin had to be agreed to by the Secretary of Commerce and the Bureau of the Budget. After the AD-X2 affair, Weeks, who had come to have great respect for Astin, became a supporter of the Bureau, and the Bureau of the Budget was also supportive. Thus, for the first few years of his tenure as director, Astin was permitted to ask for increases ranging from 11 percent to 35 percent. But Congress was economy minded and did not understand the role of other agency projects at the Bureau, feeling it had no control over this peculiar agency that could go to other agencies for funds, so that it didn't much matter what Congress did. Its puzzlement was expressed by Representative Preston of Georgia:

> If we were to try some economies. . . there would be nothing in the world to prevent the Bureau of Standards from doing a little staff negotiation with Navy, or somebody, 'Look, fellows, come to our rescue. . . .' The Navy would say, 'All right, we will give you a project.' They would be going to some other source to get the money we denied. I do not know what the answer is.

As a result, the basic Bureau appropriation for research dropped from $6.9 million in the 1952 fiscal year, while Astin was still acting director, to $4.93 million in fiscal year 1954 and $5.29 million in fiscal year 1955—2 years after the AD-X2 affair. As a result of these cuts, and because a great deal of Defense Department work was still done at the Bureau, the percentage of other agency work in 1955 was still 68 percent, despite the loss of the ordnance and missile divisions.

Astin began to educate the Congress. At appropriations committee hearings before the House and the Senate, he explained patiently and courteously, but with dogged persistence and tenacity, that the Bureau needed funds to do *its* work, not that of other agencies. Every year he pointed out to the Congress that the rapidly increasing scientific activities of the Nation were greatly escalating demands for Bureau measurement services. After Sputnik, he pointed out to the Congress that Russia was investing far more money in measurement and standards research than the United States. Over and over he reiterated the theme that measurements were pervasive throughout all of science and industry, and hence the Bureau had to keep up with all the new and important developments. Astin did not enjoy the stylized verbal ballet of the appropriations hearings where he was a supplicant, and always in an inferior position. Moreover, despite the fact that he was held in enormous respect by members of the committee, he was not always treated gently by some of them. Nevertheless, he pressed his case; the unpleasantness came with the job.

Slowly Congress became more supportive. In fiscal year 1956, Congress granted a budget increase of 39 percent. Two years later, Sputnik gave all research budgets a boost. By 1962, the Bureau research appropriation was $23.8 million, having risen from $6.9 million in 1952. In those 10 years, the percentage of other agency work had decreased from 85 percent to 32 percent, and, from its low point of 2,800 in 1954, the size of the staff had risen to 4,000. Fiscally, and with respect to the distribution of work, Astin had the Bureau he wanted.

As important as money was, it was not the only thing necessary to make the Bureau "an attractive place for scientists to work." The Bureau had to be able to pay scientists wages that were competitive with organizations outside the Federal Civil Service. This was a well recognized problem. Civil service rules restricted the level a person without administrative responsibility could achieve. These and other civil service rules were one of the principal reasons the AEC national laboratories were formed outside the civil service, and the reason that shortly after the end of the war Congress passed a law (Public Law 313) exempting a number of positions from civil service requirements. Designed especially for the Defense Department and the newly formed National Institutes of Health, very few of these positions were available to other scientific agencies. Astin, along with the directors of other Federal laboratories who worked with him on first the Interdepartmental Committee for Scientific Research and later on the Committee for Federal Laboratories, set out to revise civil service rules to permit individual scientists to achieve the highest levels available. These activities were to change dramatically the positions of scientists in the whole Federal Civil Service and hence went far beyond the Bureau alone. In these activities, Astin showed his mastery of the bureaucracy, and demonstrated how important advances can be made by working quietly but persistently within the system.

First, at the entrance level for Ph.D.'s, the Bureau acted independently of any outside committee activities. In the fall of 1952 two staff members, D. E. Mann and J. Hilsenrath, conceived the idea of having postdoctoral research fellows at the Bureau. Their concept was that the program be administered by the National Research Council (NRC) in the same way that it administered the prestigious Rockefeller Fellowships. They did not know that this was similar to the mechanism by which Astin had been supported as a Research Associate by Insull's Commission. Approaches to the NRC found a sympathetic response, for the Rockefeller Foundation was phasing out its program and the NRC had a plethora of worthy candidates that could not be supported. Approaches to the Civil Service Commission were equally encouraging, but it took 15 months of work before the Department of Commerce made a formal request to the commission for such positions, which were appointments outside the competitive civil service. But the way had been well cleared. In 1954 authority was given for a maximum of ten such positions (increased to 20 in 1959), the appointments lasting one year, with the option of extending them for one more year. Funds were first allocated by individual division chiefs, but in 1958 Astin made the program a line item in his budget, in this way increasing the breadth of the program. The program went into effect at the Bureau in the fall of 1954. It was so successful that the Naval Research Laboratory followed with its own program 2 years later, and now practically all Federal laboratories have such a program. It has been one of the principal means of attracting young, talented scientists to the Federal Government laboratories.

Changes at the upper end of the grade scale were to prove more difficult. The impetus for changes at this end came in the late 1950's and early 1960's when, to keep up with escalating wages outside the Government, grade compression occurred at the highest grade level then available—GS15. Early in the 1960's, the positions of "supergrades" were formed—GS16 to GS18—with higher pay and higher prestige. The problem with obtaining these grades for scientists was that of "position descriptions." Within the civil service rules as they were before they were changed by the activity of Astin's committee, a *position* was rated at a certain grade, not a *person*. Moreover, a laboratory director could not (and still cannot) unilaterally promote a person to a supergrade position; the appointment has to be approved by the Civil Service Commission. This was done on the basis of "position descriptions" which defined (often in agonizing soporific detail) the tasks and skills that the position required. The Civil Service Commission could not understand how a research scientist who worked alone merited the same pay as a person filling a position that supervised 50 people.

Astin recognized that the flaw in this structure was the position description. Such a description cannot be written for a senior level research scientist, for the scientist defines the job, not some other person. The position does not exist independent of the scientist.

With this idea, the Committee on Federal Laboratories, which Astin chaired, developed the concept of the man-in-the-job—the concept that the man defines the job, not some other person. This was a difficult point for the bureaucratic mind to appreciate, but with patience and persistence it was sold to the Civil Service Commission, and from then on scientists could be appointed to the highest civil service levels even without administrative responsibility. This is the situation still in existence today, although the concept has to be resold periodically, and grade compression at the upper civil service levels is again a serious problem.

In the early 1950's, with decreasing appropriations threatening reduction in force, and changing research directions causing anxiety, staff morale was low, but later, increasing appropriations eased fears. An aggressive hiring program was instituted, and new and talented people were recruited, two of whom—Lewis M. Branscomb, atomic physicist from Harvard, and Ernest Ambler, low temperature physicist from Oxford—were to become directors of the Bureau. New directions were given to old areas of work, and new areas were opened. The Heat and Power Division became the Heat Division, with new emphasis on critical phenomena and low temperature physics. The Chemistry Division spawned a new Physical Chemistry Division, with emphasis on absolute reaction rates in gas phase reactions, and became the Analytical and Inorganic Chemistry Division. The Atomic and Radiation Physics Division split into the Radiation Physics Division and the Atomic Physics Division, attesting to the increasing importance of these two fields in modern science and industry. The Division of Organic and Fibrous Materials metamorphosed into the Polymers Division, emphasizing the rapidly growing field of polymer science. The Metallurgy Division did not change its name, but shifted in orientation toward metal physics. Attesting to the increased emphasis on science, the Building Technology Division became the Building Research Division. By the early 1960's, the divisions and sections of the Bureau were under the leadership of staff recruited during the Condon and Astin years. The Bureau's interaction with the outside world of science and industry was now primarily concerned with the basic research activity of the Nation's laboratories in universities, industry, and Government.

In the early 1960's, an important new function was undertaken. The post-war explosion of scientific activity and the exponential growth of publications threatened to inundate the scientific worker with masses of scientific data which he found increasingly difficult to locate in the literature, and, more importantly, whose validity he could not assess. The International Critical Tables, sponsored by the National Academy of Sciences (NAS), had not been systematically updated since 1938. The NAS-NRC had, since 1955, encouraged the formation of groups for the critical evaluation of scientific data and the publication of data compilations and had formed an Office of Critical Tables. Recognizing that this passive effort was not sufficient, Astin formed a committee of Bureau staff members to determine what an active effort sufficient for the task might be. The work of this committee was picked up by the Federal Council for Science and Technology, and on June 7, 1963, the President's Science Advisor announced the formation of the National Standard Reference Data System, with responsibility for its operation given to the Bureau. Data centers, with the responsibility for the collection, critical evaluation, and dissemination of quantitative chemical and physical (not biological) data on properties of definable substances or systems, were established and funded both within and outside the Bureau, and the efforts of non-participating data centers were coordinated. In 1968 Astin requested and received congressional authorization for the system, which is now a flourishing effort.

But these changes and new activities did not occur at the expense of more direct Bureau services. Calibration activities proceeded apace, and became more sophisticated, using statistical analysis techniques so that direct Bureau calibrations were minimized while still providing the required services. Testing of Government purchases was still carried on, and assistance to other Government agencies in determining the cause of failures of structures and equipment continued. The standard samples program was given added status and importance by being formally organized into the Office of Standard Reference Materials. The Bureau had become a modern scientific laboratory, but had not reduced its more routine but vitally important services.

GAITHERSBURG

By the early 1960's, the Van Ness site was bursting at the seams. The Diamond Ordnance Fuze Laboratories still occupied space on the site, and the expansion of staff had brought the total occupancy of the Van Ness site to the point it was at the time of the Kelly Committee report, leading to their recommendation that facilities be modernized and increased space be provided for basic programs. In 1961, indeed, the Van Ness site contained 138 buildings, ranging from the original South building, built in 1905, that housed the Bureau Administration, to a gas cylinder storage building built in 1961. One hundred and eighteen of these buildings had been built prior to 1951. The Bureau had grown like the proverbial Topsy; its buildings were connected by a rabbit-warren maze of tunnels and a tangled labyrinth of wires and pipes. Importantly, proximity to the city caused a variety of mechanical, electrical, and atmospheric interferences with delicate scientific measurements. It was evident even during Condon's tenure as director that new facilities were mandatory.

In the early 1950's, at the depth of the Cold War, serious attention was given to the possible effects of a nuclear explosion over the center of Washington, DC—the location occupied by the White House. Blast and destruction radii were reported in the newspapers. The Federal Government quietly began the dispersion of facilities which it was not essential to have close to the center of the city. Thus, in 1955, James Worthy, who was Assistant Secretary of Commerce for Administration, and through whom Astin reported to Weeks, approached Astin and informed him that the Bureau of the Budget had suggested NBS as a possible agency for relocation. Would the Bureau be interested? Astin, doubtless recognizing that in the Federal bureaucracy doors to opportunity open only for a short time, to be closed almost indefinitely thereafter, said, "Yes, we would," and walked through the door. He was given only a few weeks to come up with an estimate of the cost.

The Bureau then made an error that it was to pay for in constant headaches and heartaches for the next 12 years. It went to the General Services Administration (GSA) for the estimate. The Bureau informed the Public Building Service (PBS) of the GSA that it required one million square feet of laboratory and office space. The PBS made an estimate on the assumption that the space was to be contained in a cube—a very inexpensive but highly inappropriate concept for a specialized national laboratory. But, in all fairness, there was time to do little else; the door of opportunity was open for only a short time. In this way, an estimate of $58 million was arrived at, including land, building, and planning and architects' fees. For the 1957 fiscal year budget, the Bureau was permitted to present to the Congress an estimate of $40 million for the building and to ask for $2.75 million for land acquisition and planning and architects' fees. Congress was supportive but concerned about the magnitude of the request and wary about its accuracy. Representative Preston, chairman of the House Committee remarked, "Naturally, our first reaction would be we feel it is a matter of national pride in having a splendid scientific laboratory set up for the National Bureau of Standards, but at the same time $50 million is a large sum," and Representative Thomas interjected, "It will probably be $85 million to $100 million before you get through." His words were prophetic. Congress did not appropriate money for buildings, but did for land acquisition and preliminary planning. The relocation of the Bureau had begun.

Astin gave the responsibility for guiding the Bureau's move to Robert S. Walleigh, his Associate Director for Administration and close friend. Walleigh was to handle all the administrative details involved in the move. The first was, which way to go? In typical scientific fashion, the center of gravity of the Bureau staff residences was determined and found to be at Chevy Chase circle, about 2 miles northwest of the

Van Ness site. Clearly, minimum staff relocation would occur in a move to the northwest of Washington. Twenty miles from the White House was the minimum distance security required, and Walleigh began surveying possible sites. After many attempts, he found one to his satisfaction a few miles west of the small town of Gaithersburg, MD, just 20 miles from the White House, 3 miles below the site chosen by the AEC for relocation, and adjacent to the then planned interstate 70S, which later became I270. It was a farm of 555 acres and to Walleigh it seemed ideal. In the early spring of 1956 he brought Astin to see it. Leaning on the post of a barbed wire fence, Astin looked over the site and characteristically made a quick decision. He approved of Walleigh's selection and told him to proceed. The decision about what to pay was put into the courts and the Government eventually paid $458,000 for the land.

Further progress was slow, however. The firm of Smith, Haines, Lundberg and Waehler, which had had extensive experience in the design of scientific laboratories, was chosen for the design and engineering of the laboratories. It became immediately apparent that the estimate of $40 million was woefully low. In the next appropriation request, the Bureau asked for $85 million, coincidentally just the amount Representative Thomas had mentioned. Congress was horrified; after endless inquiry it gave Astin a tongue lashing and sent him back to do his homework, but did appropriate funds for detailed planning in fiscal year 1959. By the end of that year many of the Gaithersburg buildings were in the final stages of detailed design. Working from general criteria for general purpose laboratories established by a committee drawn from the Bureau scientific staff and the unique requirements of the more specialized activities (such as engineering mechanics and the linear accelerator), the original cube envisioned by the GSA had grown to 20 buildings at a cost now estimated to be $95 million. There were to be a power plant; specialized laboratories for engineering mechanics, radiation physics, fluid mechanics, magnetic studies, sound, hazardous investigations, industrial activities such as a paper mill and large-scale specimen preparation; seven general purpose laboratories; a central complex which included an 11-story administration building with the library, a cafeteria, splendid meeting facilities, and instrument shops; and a service building. A gatehouse was built, and a nuclear reactor added to the original plan which necessitated the purchase of ten more acres to provide the required distance from the site boundary. The subsequent addition of the original farmstead and the construction of three more buildings completed the present inventory.

Grudgingly and complaining at every step, Congress appropriated the funds piecemeal. Astin was given continuous tongue lashings. Representative Rooney of New York constantly accused him of having known from the beginning what the final cost was to be, and that the low original estimate was only designed to set Congress on a course from which it could then not veer. Astin took the abuse with his usual stoicism; it came with the job, and the cause was worth it. The indignity of the abuse would pass; the Bureau's Gaithersburg facility would last indefinitely.

Ground was broken on June 14, 1961, with the large Engineering Mechanics Building being the first constructed. On March 3, 1966, the flag in front of the Administration Building was raised for the first time, and dedication took place on November 15, 1966.

The move of the staff and equipment from the Van Ness site, itself an operation of immense proportions, took place in stages as the buildings were completed. The major move was that into the Administration Building and the general purpose laboratories. For this move, with a detail befitting the Nation's central measurement laboratory, every desk, every chair, every bookcase, every item of laboratory equipment had its location marked on the floor plan of buildings, was labelled accordingly, and delivered to its assigned location. The move began in 1966 and extended into 1967.

The Gaithersburg site was famous before its completion. Delegations from other laboratories in the United States and foreign countries came to discuss the design and the logistics of the design, the construction, and the move. This was, after all, the movement of a basic standards laboratory, with its specialized problems, as well as one of the few moves of a major laboratory of any kind. After completion, the site became renowned for the excellence of its facilities and the beauty of the grounds. More than 3,000 trees and shrubs were planted, two ponds with a total area of about seven acres were constructed for hydrologic control, and two plots of woods were kept from the original farm. Astin had made a new home for the Bureau, and had taken it there.

REORGANIZATION AND MISSION

With the move to Gaithersburg, Astin had carried out all of the major recommendations of the Kelly Committee save one: reorganization of the Bureau's management structure. This structure had not changed since the founding of the Bureau. The technical work was carried out in divisions, the number, name, and function of which varied as the organization grew and developed. The chiefs of these divisions reported directly to the director. In addition to this simple "line" organization, there were three associate directors, whose titles also changed from time to time, but whose areas of responsibility covered the full scope of all Bureau technical activities. These associate directors did not, however, have "line" responsibility for the divisions under their cognizance; they served, in the words of the Kelly report, as "programmatic aides to the Director in the areas that correspond to their titles." In addition to these associate directors, there was an assistant director for administration (a title that was later changed to associate director shortly after Walleigh was named to the position) who had responsibility for carrying out all the administrative activities of the Bureau, thereby relieving the technical division chiefs of this task. In 1955 there was added another post, associate director for planning, with obvious duties.

The Kelly Committee felt that this organization "ties the Director too closely to division supervision and places an unnecessary limit on the full use of the Associate Directors." Paraphrased, the committee felt the director had too many people reporting to him (at the time there were 15 divisions and 2 offices). The committee recommended that the associate directors be given "full line responsibility for their areas of responsibility."

This recommended reorganization added a layer of management. Greater freedom for the director would be bought at the price of reduced access to him by the division chiefs. Astin did not act for almost 10 years, although the organization continued to evolve. Thus, in 1959 a new post of deputy director was formed, with Huntoon its first occupant. In 1962, on the initiative of Branscomb, then Chief of the Atomic Physics Division, and with the complete support of Astin, a new type of cooperative institution was formed that was to prove a model for many subsequent institutions. This was a research laboratory jointly operated by the Bureau and the University of Colorado for the study of the atomic physics and radiation theory underlying the science of astrophysics—the Joint Institute for Laboratory Astrophysics, or JILA for short. Central to this concept was the idea that the Bureau staff at JILA would have adjunct professorships at the university, and the associated university staff would participate in the research activities of the institute. A key ingredient was provision of ten positions for visiting fellows on one-year appointments, the funds for which Astin was able to obtain by a budget increase.

Important as these and other new organizational moves were, they fell short of the reorganization envisaged by the Kelly Committee. When Astin acted on the reorganization issue, he was to propose a far grander scheme. In 1962 he wrote to the Secretary of Commerce, who at that time was Luther H. Hodges, a proposal for the formation of a National Institutes for Science and Technology within the Commerce Department. In Astin's words, this was

> . . . to do for the Nation's industrial economy what the National Institutes of Health do for the Nation's public health. I actually made the analogy there. I also made the analogy with agriculture, the fact that we had far and away the most efficient agricultural system in the world. [This] was largely through the operation of a strong agricultural research program . . . with central laboratories . . . branch laboratories . . . and field stations. Essentially, the Bureau would have been part of this.

His scheme may have been too grand for implementation in any case, but it fell afoul of J. Herbert Holloman, who occupied the newly created position of Assistant Secretary for Science and Technology, and to whom Astin reported. Holloman, trained as a metallurgist at MIT, had been general manager of the engineering laboratory at the General Electric Research Laboratory before coming to the Commerce Department. He was a strong willed man of action, and it is fair to say that his personality did not mesh well with Astin's. He vetoed Astin's concept. What eventually resulted from their interaction was a much more limited restructuring of the Bureau, but one that was very much in keeping with the recommendations of the Kelly Committee. In 1964 the Bureau was reorganized. The existing divisions were grouped into three institutes and one laboratory. The institutes were the Institute for Basic Standards, which provided "the basis . . . for a complete and consistent system of physical measurement"; the Institute for Materials Research, with the objective "to make possible a better understanding of the basic properties and behavior of materials, and to make available reliable quantitative data on their performance"; and the Institute for Applied Technology, to "foster and stimulate the application of technology to national needs." The laboratory was the Central Radio Propagation Laboratory, which had evolved from wartime activities that provided information on radio propagation and radio weather predictions for military purposes. After the war, it had become the central agency for the collection, analysis, and dissemination of information on the propagation of radio waves. In October 1965, it was transferred to the newly formed Environmental Science Services Administration within the Department of Commerce, and the Bureau lost the last of its wartime entities.

Astin took some criticism from the Bureau staff on this reorganization. Many felt that this addition of another layer of management reduced contact with the laboratory levels, hindered communication, and made cooperation among the Bureau staff more difficult. What was essentially a collegial organization had become a hierarchical one. Astin was concerned about this, but the grouping into institutes followed the development of a Bureau mission, and the sense of mission, that were important aims of his as director. In September 1960, after many years of thought and staff work, he had announced the mission to the staff. It was: (1) the provision of a central basis within the United States of a complete and consistent system of physical measurement, and coordination of that system with the measurement systems of other nations; (2) provision of essential services leading to accurate and uniform physical measurements throughout the Nation's science, industry, and commerce, and consonant with their advancing requirements; and (3) provision of data on the properties of matter and materials which are of importance to science, industry, and commerce, and which are not available of sufficient accuracy elsewhere.

That the functions of the new institutes followed quite naturally from this mission statement is clear. Many years later Astin was to say,

> The institutes essentially coincided, in my judge-

ment, with the mission development. That is, the Basic Standards Institute being essentially responsible for the measurement system—that is, the general framework of the system and its extension; the Materials Research Institute being that which. . . supplements the measurement system through standard reference materials. . . ; and the Institute for Applied Technology is. . . to serve industry directly in areas mainly related to the mission through engineering standards and measurement techniques. Of course, the major drawback of the institutes was the fact that [they] imposed another layer, which I did not like. But I felt it was an important adjunct to keeping the Bureau's activities focussed on a central mission. It doesn't have to dominate every decision that's made, but the fact that you're carrying out activities in a group called the Institute for Basic Standards defines a certain framework in which you operate, and the same for materials research. And I don't see why it has to be a barrier to cooperation.

It is not clear that the reorganization was done totally at his initiative, but it is clear that Astin was not unhappy with the results. The reduction in contact was a price he was willing to pay for organizing the Bureau along the main lines of its mission.

Indeed, the development of a mission was Astin's personal intellectual challenge. Many scientists turned executives continue to carry out personal research, particularly if they are theorists and hence do not require a laboratory. Astin's personal research was the mission development. For this it was necessary to place the functions of the Bureau into the whole structure of science, technology, and industry and their historical development, particularly during the industrial revolution. For this, Astin became a scholar of the measurement systems of the United States and of the other industrial nations. His thoughts may be paraphrased as follows: In science and technology, knowledge means quantification. Ideas are expressed by equations whose validity is determined by experiment, which requires quantitative measurement of physical phenomena. In Lord Kelvin's well known words, ". . . when you cannot measure [what you are speaking about], when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind. . . ." Astin, indeed, traced this whole concept back to Plato. In *The Republic*, Socrates is quoted

> We are exposed to many delusions. But reason thus confused by false appearances is beautifully restored by measuring, numbering and weighing . . . . By this is eliminated the rule of the senses over us. We disregard non-sensual impression of magnitude, of number and weight of the objects, but calculate, measure and weigh them. And it is this part, which relies upon measuring and calculation, which is the better part of the soul.

If scientific knowledge requires quantification and measurement, then communication of scientific knowledge requires units, and units require standards, so that everyone may speak the same quantitative language. Moreover, as nations become industrialized, communication in science, technology, and industry becomes nationwide and worldwide, and the standards upon which measurement and communication are based must be common. Meters and amperes have to be the same in San Francisco as they are in Paris, or Rome, or Cairo. As science, technology, and industry develop, new standards must be developed and old standards expressed ever more accurately. Hence nations need central standards laboratories whose primary function is the development of standards and the associated measurements. And since measurements are ubiquitous throughout all of science and industry and need to be traceable back to the fundamental standards of physics, these laboratories will be concerned with all of science and industry. The management question is not one of rationale, but one of size and areas of effort.

Astin developed and expanded these ideas in a series of several dozen lectures and papers before such diverse groups as Utility Commission Engineers, Official Agricultural Chemists, and the Institute of Radio Engineers (now incorporated into the IEEE). He traced the erratic course of standards development in the United States, the more systematic development of the metric system in France, the adoption of the meter in 1866 as a legal basis for measurements in the United States, and finally the treaty of the meter in 1875. He showed how the inexorable course of industralization forced the formation of national standards laboratories at the turn of the century—the Physikalische Technische Reichsanstalt in Germany in 1877, the National Physical Laboratory in England in 1899, and the National Bureau of Standards in 1901. Over and over again he expounded the same theme he had before Congress: measurements are ubiquitous, hence the Bureau's work is all pervasive, and since science and technology are constantly developing, the Bureau must remain at their leading edge, or it will not be fulfilling its obligation. That Astin deeply believed in this mission, that his attachment to precision measurement had an almost mystical and religious quality is shown by his lecture before the American Physical Society.

Commitment to excellence and self-expression arose from Astin's personal philosophy which he expressed as, "everything we do should be done better." This led him to a unique definition of basic research. In his view, this is "characterized. . .only by the intensity or depth of inquiry" rather than by subject matter, and the investigator is "encouraged to pursue a level of inquiry to the outer edge of knowledge." Since the Bureau must be working at the "outer edge of knowledge" in measurement science, it perforce must be doing basic research in Astin's definition. Moreover, in this pursuit, the investigator not only explores nature, he also explores himself, and thus research becomes a means of spiritual and intellectual fulfillment.

Although most consider the move to Gaithersburg as the most important heritage Astin left the Bureau, in Astin's mind the mission statement and the concomitant sense of mission were more important. The mission was to have its fullest expression in the development, principally at the hands of Huntoon, of the National Measurement System, which traces in detail all the various measurements made throughout the Nation and their relationships to the fundamental units of physics. Astin considered this the full expression of the Bureau's measurement mission and role.

His scholarly work on the mission was not Astin's only outside activity. He was a member of many advisory councils, boards of scientific societies, and committees, some of which have already been mentioned. Of particular importance were his activities concerned with international aspects of standardization and scientific exchange and cooperation. As director of the Bureau, he automatically became the U.S. member of the International Committee on Weights and Measures which coordinates the international development of basic standards. During his tenure, important changes were made in the basic standards for length and time (frequency). In 1960 the wavelength of the orange-red line of krypton 86 was adopted as the international standard of length, replacing the platinum-iridium bar kept at the International Bureau of Weights and Measures at Sévres, France. This replaced an artifact with a physical phenomenon, making possible the realization of the standard in any good laboratory. In 1964 the frequency of a hyperfine transition of cesium 133 was adopted as the standard of frequency, replacing the period of rotation of the earth. At one stroke this improved the accuracy of frequency measurements by a factor of 10,000. Also during his tenure, Astin was able to initiate an international program on measurements in ionizing radiation, and, working with the English-speaking nations, arrived at a consensus definition of the yard in relationship to the meter, a problem that had been standing since 1830.

At the other end of the standards spectrum, Astin recognized the need for international coordination of commercial and industrial standards for materials and products. He worked closely with organizations in the U.S. voluntary standards system, particularly ASTM and the American Standards Association and its successors the United States of America Standards Institute and finally the American National Standards Institute (ANSI), which is authorized to represent the United States in the International

Standards Organization. So well was his work regarded by ANSI that it instituted an award called the Astin-Polk award in 1973. He and Louis F. Polk, chairman of the National Metric Advisory Council to the Department of Commerce, were the first recipients.

His advice was eagerly sought by foreign nations on standards issues. As their guest, he traveled to Australia, Iran, and other countries to advise them on standards laboratories. This advisory activity grew. At the request of the Agency for International Development (AID), teams of advisors were sent on an ad hoc basis to advise developing countries—Turkey, Korea, Peru—on standards laboratory problems. This ad hoc activity developed after Astin's retirement into a continuing program with AID for standards assistance to developing and "third world" nations.

Astin continued his international activities after his retirement. Beginning in 1969, he participated in the establishment of an intergovernmental agreement to facilitate scientific cooperation between the United States and France, and was designated as U.S. delegate to the committee that guided the scientific exchanges under this agreement, attending annual meetings of the committee. His work was so well regarded that the French Government awarded him the Legion of Honor.

CONCLUSION

Astin's management style remained the same throughout his career. Self-effacing, deliberate, reserved, yet warm and friendly, he was tolerant to a fault, particularly of younger staff members. An inveterate pipe smoker, Astin began meetings with individuals in his office with small talk and the ritual of pipe stoking, putting his visitor at ease. When the time came to broach the subject, and should it be a delicate one, he would lean back in his chair, cross his lanky legs, and broach it in such a manner as not to give offense or to elicit anger. Yet his decisions were firm and decisive, but could not be resented, for they were never based on emotion, or anger, or personality. They were arrived at by deliberate, thoughtful consideration and careful reasoning. He always led people to arrive at the decision he wanted; only rarely did he issue orders. In large meetings at which he was a participant rather than a leader, he often would sit hunched down in his chair, his eyes closed with his ever present pipe cradled in his hands, seemingly dozing. But should the discussion begin to ramble and a decision be difficult to reach, he would open his eyes and make the incisive comment that brought order and logic back to the proceeding.

As he demonstrated in the AD-X2 affair, Astin could be adamant on matters of principle. At least one time when asked by a superior to do something that went contrary to what he considered a moral, if not a legal, principle, he listened for a time and then said simply, "I won't do it," which ended the matter. It is tempting to say that his stature in the scientific community, particularly as a result of AD-X2, permitted him to take such a stand with impunity, but that would be misleading. Beneath the tolerant, understanding, courteous exterior lurked a steel will that would not bend when moral principles were involved.

He had a habit of visiting laboratories unannounced. He would show up at a laboratory or office and ask how the work was going, and he always knew what the particular scientist was working on. To a theorist he might ask if experiments were confirming the theory, and to an experimentalist he might ask if the results were reproducible and consistent with theory. The staff enjoyed these visits; it was not the director who was visiting, it was another scientist, and he knew the subject matter well. This implies that Astin prepared for these meetings, but it is not clear he needed preparation. It was his Bureau and he knew everything that went on. He had, after all, been there his whole career. He knew all the closets, and all the skeletons within them. At one time one of his managers told him of his plans for one of the units under his jurisdiction. Astin listened as usual, and then remarked "Fine, but I'm interested to see what you do with Mr. ______," and named a name. The manager went away scratching his head, wondering what Mr. ______ had to do with it, but knowing he better look into it.

Allen Astin was a sentimental man, aware that science is not all cold, hard facts. At several places in England there exist apple trees authoritatively reported to be direct descendants of the tree that perceptively dropped the apple on Isaac Newton. Cuttings of a tree at the East Malling Research Station were brought to the United States, nurtured at the Beltsville experimental farms of the Department of Agriculture, and one of them transplanted to the Van Ness site. Subsequently, further cuttings were again nurtured, and one transplanted to the Gaithersburg site. In season, Astin was fond of presenting apples from these trees to visitors. Before each tree stands a plaque with the inscription, "Science has its traditions as well as its frontiers." The apple tree and the plaque still stand at the Van Ness site, the only remnant of the old Bureau occupation.

At the time of his retirement in 1969, Allen Astin could already look back on a full career and life. He had directed one of the world's most distinguished laboratories through its most trying days, guided it to a new home, given it a new sense of direction, and left it better than he had found it. He had entered new ground in the relationship between science and public policy, and set the direction for much subsequent development. He and his wife Margaret had been happily married for 42 years. They had reared two successful sons who had in turn gone on to have distinguished careers, John to become a noted actor, director, and writer, and Alexander a university professor, author, and research administrator. At the base of the flagpole that stands before the Administration Building at the Gaithersburg site there is inscribed a quotation from George Washington, "Let us raise a standard to which the wise and honest can repair." Meant to apply to the Bureau, it can equally apply to the career and life of its fifth director.

Elio Passaglia, Physicist
National Bureau of Standards
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the National Bureau of Standards

An invited address before the American Physical Society, at the Shoreham Hotel, Washington, D. C., May 1, 1953

By A. V. Astin

SINCE THE TIME I was first asked to speak at this meeting of the American Physical Society, events have occurred that are of appreciable importance to the National Bureau of Standards. These events have been sufficiently well publicized that there is no need for me to specify them. Furthermore, committees of specialists have been or are being set up to resolve the basic issues of the controversy involving the Bureau and its directorship. Hence, I believe it to be inappropriate for me on this occasion to discuss the case except to convey appreciation to the members of the American Physical Society, and others, for their expressions of confidence and support. For these we are sincerely grateful.

Tonight I plan to speak as the Director of the National Bureau of Standards and attempt to explain why I and the other members of the organization believe in the Bureau and the importance of its operation to the national welfare and security.

The Bureau staff believes first of all in the importance of scientific research as a means of intellectual and spiritual advancement, as the foundation of our technological economy and high standard of living, and as the bulwark of our national security.

We believe in the teachings of Galileo that theory and hypothesis must conform to the results of experimentation and observation. We believe in the philosophy of Lord Kelvin that basic understanding in science depends on measurement—the reduction of observation to numbers. We believe further that the reduction of observation to meaningful numbers requires the development and maintenance of uniform standards for physical measurement, and that this need provides the first and primary reason for the Bureau's existence.

The development and maintenance of the standards for physical measurement, with the associated calibration procedures, are to us a challenging and dynamic activity. This standards work must not only keep abreast of the expansion of the frontiers of science, but in the older regions there is a continuing demand to increase the precision and reliability of measurement.

We believe that there is romance in precision measurement, and that ability to extend the absolute accuracy of measurement by one decimal place frequently demands as much in ingenuity, perseverance, and analytical competence as does the discovery of a new principle or effect in science. We believe further that many of the important advances in science are possible only through the availability of instruments of high precision which enable the measurement of small differences or minute effects.

We stress reliability and accuracy in our operations and in checking and rechecking our results. In fact, an inadvertent error of 10 parts in a million (representing a whole wave length of light) in a length calibration made some months ago was a cause of grave concern to the Bureau's management, and there was no rest until the cause of the error was located and remedial action was taken to prevent a recurrence.

We stress objectivity and fairness in our operations and attempt to insure them by a willingness to accept the results of well-planned reproducible experiments and the logical conclusions therefrom. We follow as far as possible the established or clearly defined observational techniques and analytical procedures of science but welcome the opportunity to evaluate and accept new ideas and techniques. We believe that scientific conclusions should be made only by following such procedures. We believe further that complete freedom of inquiry in scientific investigation is essential to insure not only the soundness of a particular set of results or conclusions but also the development and healthy progress of science itself.

Related closely to this is our conviction that a substantial portion of the program of any sound scientific or technical laboratory should be devoted to fundamental or nonprogrammatic research. Such provisions afford an opportnuity for the more imaginative scientists to explore freely ideas of their own choosing and help to provide vigor and strength to the entire laboratory.

We believe that communication between scientists, through discussions, meetings, and visits between laboratories, is essential to the development and evaluation of new ideas. For there is no ultimate authority or supreme court in science except that resulting from general acceptance through free interchange. The results of a particular experiment are not considered established unless they can be reproduced by other observers, in other laboratories, and with different equipment. The

Allen V. Astin was asked to give this address some months before his emergence as a controversial figure in the national scene. He spoke before an overflow audience at the banquet of the American Physical Society during its Spring Meeting in Washington, and upon the completion of his talk he was given a standing ovation. For the views of the APS, see p. 20.

conclusions of a theory or hypothesis are not considered valid until they survive the scrutiny and criticism of other analysts and/or conform to the results of experience.

Therefore, we believe that the broad dissemination and publication of the results of research investigations are essential to the healthy progress of science to be limited only by strict considerations of national security.

Because of the potential importance of the results of scientific work to the general public, we believe that scientists have a serious responsibility to interpret or to translate their major findings into terms that can be generally understood. In this connection, however, it is imperative that there be no compromise with accuracy since altering or blurring the facts in the interest of popularization would probably be worse than no popularization at all.

Hence, the Bureau, in rendering scientific and technical advisory services to other agencies of the government, particularly when the contacts in the other agencies are nontechnical people, has recognized its responsibility for evaluating the results of its findings in objective and nonambiguous terms.

In our advanced technological economy we believe that there are many ways in which a laboratory like the National Bureau of Standards can render valuable services to other agencies of the government. For example, we believe that appreciable savings in government procurement operations are possible through the intelligent use of technical purchase specifications and acceptance testing based on carefully planned laboratory investigations.

We believe that there are many areas in government operations where the application of modern technology can bring about substantial increases in operating efficiency. Electronic information processing machines afford a notable example.

We believe that the development of standard practices such as safety codes has resulted and will continue to result in substantial savings in human life, time, and money both within and out of the government. The development of such codes generally involves, however, extensive knowledge of the properties of materials, devices, and structures under a variety of environmental conditions.

We believe that in times of national emergency the facilities and resources of the National Bureau of Standards should be as far as possible placed at the disposal of those charged with the country's defense. This was in fact done during the two world wars. Even during peace time or periods of limited emergency there is an appreciable utilization of the Bureau's facilities by the defense agencies. Since World War II, and particularly since the Korean episode, these activities have grown substantially until now more than three-quarters of the Bureau's staff are working on problems for the Department of Defense. This means that the general character of the Bureau's work and the nature of its fiscal support are markedly different than they were 15 or 20 years ago. Whether or not this is a desirable utilization of the National Bureau of Standards under the present conditions is undoubtedly a question which will be considered by one of the special study committees. We will welcome their recommendations and advice on this matter.

We believe that in order for the National Bureau of Standards to carry out its various functions and activities we must have an alert and competent staff, suitable equipment and facilities, and an environment favorable to scientific investigation and methodology. This environment or climate essentially means the provision of the opportunity to practice the beliefs I have been stating.

We believe that there should be suitable recognition and promotion of the more productive and creative scientists together with a careful weeding out of the nonproductive. We believe that the highest positions in the civil service should be available to the most outstanding scientists and engineers, and that it should not be necessary to encumber them with administrative responsibilities in order to attain such positions. This principle is fortunately recognized by the Civil Service Commission.

We believe that we should bring in new blood by the recruitment and training of young scientists and by promoting them to more senior positions as rapidly as they develop and opportunities open. We further believe that education should not cease when an individual joins our staff, and we take pride in the graduate school that has been conducted by and for our employees for more than forty years.

We take pride in our many illustrious alumni now serving in responsible positions in industry and elsewhere in government, and we have reason to believe that they value the experience gained as members of the Bureau's staff.

We take pride in the concept of service, in providing assistance to science, to industry, and to government.

We believe in the dignity of the government service and further believe that the primary incentives and rewards of a civil service scientist are not financial but rather stem from the pride in organization and its functions and from the sense of satisfaction which comes from participating, even in small ways, in the solution of problems of national importance.

We believe also that for federal employees loyalty to our country includes, in addition to the more commonly accepted values, loyalty to the institution for which we work and for its traditions, and loyalty to the administration which shapes its policy.

These represent some of the tradition and creeds of the staff of the National Bureau of Standards. I hope thereby to have given you some impression of why the staff is so intensely loyal to the organization and our Country, and why the staff is so interested in the Bureau's future. We know that the Bureau's work is critical in the Nation's scientific and technological progress. Furthermore, we know that the opportunity to assist in attaining these goals affords a high degree of intellectual, moral, and spiritual satisfaction.

U.S. Department of Commerce
Malcolm Baldrige, Secretary

National Bureau of Standards
Ernest Ambler, Director

National Bureau of Standards
Gaithersburg, MD 20899
301/921-1000

National Bureau of Standards
Boulder, CO 80303
303/497-3000

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