Statement of Dr. Allen V. Astin
Director, National Bureau of Standards

before the

Select Committee on Small Business, U. S. Senate
June 23, 1953

I appreciate this opportunity to appear before the committee in order to attempt to clarify some phases of the controversy involving the work of the National Bureau of Standards on battery additives. First I should say I believe that on strictly technical phases of the battery additive problem disagreements should be resolved by a group of technical experts. I am pleased that a committee of the National Academy of Sciences was recently set up for such a purpose and I have no hesitancy in seeing the Bureau's work on this matter subjected to their critical scrutiny. I have, in fact, urged such an investigation ever since it was apparent that responsible individuals had doubts as to the adequacy of the Bureau's work on battery additives. There are, nevertheless, a number of aspects of the battery additive matter that can be readily discussed here.

In order to provide a suitable background for my statement on battery additives, I would like first to give a brief review of the Bureau's functions and operations and a description of its testing procedures.

National Bureau of Standards Functions

The authorized functions and activities of the National Bureau of Standards are given in the act of March 3, 1901, establishing the Bureau, 31 Stat. 1449, as amended by Public Law 619 of the 81st Congress. These are:

"(a) The custody, maintenance, and development of the national standards of measurement, and the provision of means and methods for making measurements consistent with those standards, including the comparison of standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government.

"(b) The determination of physical constants and properties of materials when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere.

"(c) The development of methods for testing materials, mechanisms, and structures, and the testing of materials, supplies, and equipment, including items purchased for use of Government departments and independent establishments.

"(d) Cooperation with other governmental agencies and with

upon the standard of length and associated instruments, measurement methods and calibration services. For example, the mass production of uniform pistons in the automobile industry depends initially upon calipers and micrometers used in the shop. These instruments are checked by a given company against its master gage blocks. The master gage blocks are periodically submitted to the Bureau for calibration against the Bureau's standards. The actual method of calibration is optical in nature, linked back to the standard meter.

Diversity of Basic Standards

The diversity in our basic standards is directly related to the diversity of our economy. Thus, standards exist and are needed in electricity, optics, mechanics, electronics, chemistry, atomic and nuclear physics, etc. Their applications take a similar diversity of form. Standard radio frequencies, obtained from crystal clocks of high precision and associated complex electronic instrumentation, are provided through continuous broadcasting over station WWV (Maryland) and WWVH (Hawaii). These frequencies are used in such ways as the following: broadcast stations use the signals to keep their transmitters in channel; manufacturers of electronic equipment use them to calibrate their oscillators and various electronic devices; musical instrument companies use them to calibrate the tone of their instruments; utilities use them to control the 60-cycle frequency of their electrical generators, ensuring, first, that the power produced will be appropriate for the various machines that are designed for such power, and, second, that such frequency-dependent devices as electrical clocks are kept accurate.

Even medicine and biology depend upon fundamental standards in the physical sciences. X-Ray standards provide proper dosage information and protection provisions not only for industrial X-Ray installations but hospital ones. Radioactive isotope standards provide a method whereby tracer research can be conducted and also provide the dosage and protective information needed for medical therapy.

Magnitude of Operations

The magnitude of the Bureau's operations can be appraised from a brief look at the operating budget. For Fiscal Year 1953 the total obligations will approximate 50 million dollars. Of these, about 42 million or about 85% represent work requested and paid for by other agencies of the Federal Government and justified before the Congress in the budgets of these other agencies. Within this 85% the primary effort is on important defense projects for the Army, Navy and Air Force and the Atomic Energy Commission. The remaining 8 million or approximately 15% represents the budget provided directly to the Bureau by the Congress to carry out its basic functions.

Basic Service Activities

Growing out of the latter portion of the program -- that comprising the 15 percent -- are the calibration, testing and related services, which constitute 4 percent of the total activity. The bulk of this activity -- approximately 3 percent -- has to do with calibration services. These are services characterized by the comparison of master standards in commerce and industry with the national standards (e.g., gage blocks from industry are periodically submitted for calibration, by optical means, in order to ensure that the gage blocks provide uniform and accurate measurements).

Commodity Testing

The testing of commodities done by the Bureau comprises approximately 1 percent of the activity. Most of this commodity testing is concerned with checking for compliance of materials purchased by the Government with the specification in the purchase contract. The Federal system of purchasing, in order to give all businesses a fair and equal opportunity to compete for Government contracts, involves the issuance of bid documents specifying what the Government wishes to purchase. These bid documents contain data describing the item to be supplied, and the data must be technically adequate wherever possible in order that the proper type of item be purchased and that the competing firms be, in fact, bidding to supply the same, desired item. Responsibility for specifications and the general procedures rest with the General Services Administration. The largest item -- totalling more than half of this 1 percent of testing done by the Bureau -- is cement.

Testing for Regulatory Agencies

A small part of this relatively small testing program, wherein the Bureau acts as a service laboratory for other Government agencies, is concerned with tests for agencies having regulatory authorities. The total of all regulatory-type testing done for these other agencies, at their initiation and request, is less than $25,000 per year. In short, testing of this kind done by the Bureau comprises less than a twentieth of one percent of the total NBS program. It is within this category that the Bureau's interest in the battery additive matter originated.

Altogether the Bureau makes about 300,000 individual calibrations and tests per year and in addition issues over 30,000 standard samples.

Calibration Activity

In the calibration activity, which involves the comparison of measuring instruments with the national standards for physical measurement, the Bureau performs a unique service. Accordingly, this service is made available not only to other government agencies but to State institutions, industrial and university laboratories, and to the general public. In contrast, in the commodity testing activity, similar services are frequently available in private testing laboratories; therefore, the Bureau's work

in this area is confined to serving other government agencies in connection with their purchasing or regulatory responsibilities. Occasionally a testing problem arises where the Bureau's facilities are unique or where its services are desired for referee purposes, and under such circumstances a commodity test might be performed for the general public.

Testing Policies

The Bureau has no program of endorsing, approving or condemning proprietary products. This fact is frequently not understood by the public since we receive many requests for such service which have to be turned down. There are also occasional claims of NBS approval in the advertisements of some products. These can usually be corrected by correspondence.

Test Reports

The reports the Bureau prepares on tests of materials and products for other Government agencies are considered the property of the agency for whom the test is made. Consequently the control of the dissemination of the information in these reports is the responsibility of the agency requesting the test. Also, the application and interpretation of these reports to the operating requirements of these other agencies is the responsibility of the agency for whom the test is made.

Frequently in the course of its testing work the Bureau accumulates general information on classes of materials and products that is of interest and importance to the public. In many of these cases publications are prepared for general distribution in which reference to specific proprietary products is avoided. Occasionally there are publications, in which brand-name products are identified, but this is done with the consent and cooperation of the manufacturers involved.

A notable example is in the publication of data on the acoustical properties of materials. These data are determined at the joint request of building and manufacturing groups, and the results are of appreciable value to architects and construction engineers in their design problems. But even in this case no attempt is made to provide an overall evaluation or an approval of a particular item. Also in such cases the Bureau does not permit the use of its name by manufacturers for advertising or promotion purposes.

Technical Information

Legal authorization for the publication of information obtained by the Bureau in its operations is provided by the basic legislation previously mentioned. The act provides for: "the compilation and publication of general scientific and technical data resulting from the performance of the functions specified herein or from other sources when such data are of importance to scientific or manufacturing interests or

to the general public, and are not available elsewhere, including demonstration of the results of the Bureau's work by exhibits or otherwise as may be deemed most effective."

Publication Priorities

Since the act specifically refers to a consideration of the importance of the data to scientific or manufacturing interests, serious effort is made in establishing priorities in the Bureau's publications program, to making determinations of such interests. In fact, many of the Bureau's publications are initiated as a result of requests from professional groups or associations of manufacturers. In all cases, however, there is a careful attempt made to insure that the publication will be of broad general interest and that it will be completely impartial in the presentation of data. The latter requirement can be largely met by confining the reports to straight-forward presentations of scientific and technical data on the properties of the materials and devices investigated.

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 under the same set of environmental conditions. The publication of such data would not be considered as prejudicial to those interested in promoting the use of steel, rather the withholding of such data would be considered prejudicial to the interests of the general public and those interested in promoting the use of aluminum. In science and technology a specific, reproducible observation is a fact that knows no favorites.

Hearing Aid Report

An interesting example of the way the Bureau fits its publications program to the interests of the general public is given by a report put out sometime ago on hearing aids. The initiation of this report was due largely to requests received from medical groups and groups interested in the rehabilitation of the hard of hearing. There was also some interest in the publication on the part of the hearing aid industry. After the report was distributed some individuals in the hearing aid industry objected to the report on the grounds that it was prejudicial to their particular interests. Consequently an extensive survey was made of the entire hearing aid industry as to their interest in the report and its general usefulness to the public. Also included in this new survey were the groups initially responsible for initiating the request for the report. As a result of this survey a number of important suggestions were obtained for a revision of the report. Consequently the first report was withdrawn and a revised one issued which incorporated a broad concensus of interests and usefulness.

Testing Techniques

I would next like to discuss briefly some aspects of the Bureau's testing program, particularly in relation to the development of accurate

and reliable testing techniques and procedures. Here it is necessary to stress the importance of measurement in the progress of science and technology. The advancement of science and technology depends to a very appreciable extent on observations of materials and devices under various environmental conditions. In order for these observations to be useful in furthering the progress of science, it is essential that they be reduced to numbers so that comparisons can be made between the behavior of materials under different sets of environmental conditions.

Furthermore, it is important that these measurements be expressed in numbers which have the same meaning in different laboratories. This, in turn, means that we have to have units and standards for measuring. Providing the latter, of course, is a primary and unique function of the National Bureau of Standards.

Thus, the Bureau, because of its basic function, is very intimately concerned with the measurement problem. The organization, therefore, gives substantial effort and emphasis to the development of accurate and reliable measurement techniques. Appreciable attention is also given to the development of instruments and equipment by which measurements can be made under various environmental conditions.

Problem of Measurement

Because of the importance of instruments and measurement to all fields of science, most of the major professional societies have standing committees assigned to instrument and measurement problems. One very important group is the American Society for Testing Materials. This national society is an affiliation of leading professional organizations, and individuals, manufacturers and consumer groups with interest in the testing problem. The concern of the society is to develop uniform testing procedures so that when measurements on a particular material and device are made in one laboratory, these measurements will have a definite and reproducible meaning to an engineer in another laboratory.

The extent of the Bureau's interest in the important work of the American Society for Testing Materials is shown by the fact that a total of over 400 positions on ASTM committees are held by Bureau personnel. Of these, 13 represent chairmanships of main committees dealing with such diverse subjects as magnetic properties, cements, gypsum, asbestos products, porcelain enamel, electrical insulation, spectroscopy, textiles, wax polishes, plastics, adhesives and analysis of metals. In addition, 43 other staff members are chairmen of working sub-committees or special task groups.

Interchange of Information

Closely related to this example is the widely recognized fact that progress in science and technology is greatly dependent on the free interchange of information between specialists. Thus effective improvement

of measurement and testing techniques requires collaboration between the members of groups working on similar and related problems. For this reason the Bureau consults and cooperates with a wide range of industry and university scientists and engineers on a variety of technical problems of mutual interest. In the battery field we work closely with various experts in the battery industry, both in the development of new principles and techniques for new and improved types of batteries and in the development of more reliable evaluation techniques.

Statistics and Testing

Another example of the interest and effort the Bureau devotes to the development of advanced and reliable testing procedures is shown by the formation a few years ago of a Statistical Engineering Laboratory which gives substantial attention to the improvement of the techniques of experimentation. The statistical quality control procedures which have been so widely adopted by industry during the last decade are but a small part of the new statistical tools now proving invaluable in experimental work, whether this work is concerned with scientific research, engineering, development, testing or operations analysis. These new tools are especially concerned with the achievement of objectivity in experimentation, in testing, and in the setting of more exacting standards for drawing scientific conclusions.

The Bureau has taken leadership in applying modern statistical experimental design to large scale laboratory operations and has assembled an outstanding staff that has won a worldwide reputation. As a consequence this staff has been deluged with requests for lectures and many of the country's leading universities and other laboratories periodically borrow members of this staff. In fact, very frequently when difficult, expensive or crucial experiments are involved there is a strong likelihood that a visit will be made to the NBS statisticians. The Hoover Commission made particular reference to the outstanding work of this group.

As a technical laboratory, the National Bureau of Standards is concerned with the development of scientific and technical information and the analysis and interpretation of such information. As explained before, the information should be in a form that can be expressed in numbers with the conditions under which the information was obtained clearly and specifically defined. Since scientific analysis and conclusions must be based on well-defined observational techniques and procedures, it is not possible to give consideration to observations of a general qualitative nature and under environmental conditions which are poorly defined or not defined at all.

Problem of Comparative Measurement

Very often in scientific or engineering work one is concerned with the effect of some modification in the treatment or handling process on the behavior characteristics of the material or device under investigation. This involves comparative measurements and whenever comparative measurements are important, it is essential that there be a standard or base to which the measurements can be referred. Since we are concerned with the battery additive matter it will probably be best to take this as the example.

Types of Measurements on Batteries

First, we have to consider what measurements are of importance in evaluating battery performance. Batteries are intended to supply electrical energy. Hence, it is important to have some criteria by which a battery's ability to supply electrical energy can be measured. This is usually done in watt hours or ampere hours assuming a constant voltage.

The next most important characteristic in evaluating battery performance is its probable life. For automobile storage batteries this is usually expressed in terms of months or years. Another important measurement on a storage battery is its efficiency; this involves the ratio of the energy necessary to charge a battery to the energy the battery can return in doing useful work.

Many other types of measurements can be made on batteries such as voltage at the terminals, hydrometer readings, temperature, etc., but usually those observations are related to attempts to measure its ability to supply electrical energy or to its efficiency.

The rigorous measurement of the life of a battery is somewhat difficult and is usually related either to the condition when the battery will no longer supply sufficient energy to be useful or when its efficiency becomes so low that it is impractical to operate it further. In general, the efficiency of a battery will decrease as it ages and estimates of the expected life of a battery may be made by measurements on the change in efficiency with time or with use.

Effect of additions

If now we are concerned with the effect of a particular addition to the electrolyte of a battery on its performance we must first of all have a measure of the performance to be expected without the change in the electrolyte. This means that we must have measurements on two groups of the batteries, one in the original or unchanged state and one containing the modification which is to be evaluated. It is further important that the subsequent exposure or handling conditions of the two groups of batteries be as nearly alike as possible since changes in environmental conditions might themselves affect the measurements on performance. Also it is important that the two groups of batteries in their initial state be as nearly alike as possible. If there are uncontrolled variations in either the initial conditions of the two groups of batteries or their subsequent exposure conditions, it will be necessary to take observations on large numbers of batteries in the hope that the individual differences either in initial condition or subsequent exposure will be averaged out. In planning experiments to insure that such conditions are met, it is possible to make appreciable use of modern developments in the statistical design of experiments, as the Bureau has done.

Laboratory and Field Considerations

If one is able to discover in controlled laboratory experiments of the sort just discussed, an effect which offers improvement in battery performance, it would next be necessary to extend the tests to be sure the effect or improvement still persists under the more rigorous conditions of actual use. This would probably involve what have been commonly referred to as field tests. There has been some criticism of the Bureau's work on battery additives because we have not as of the present time resorted to field tests.

The Bureau has, however, had extensive experience in field testing procedures and in the development and evaluation of field testing procedures for a variety of purposes. One of the most important of these is in the ordnance work which the Bureau has done for many years for the Department of Defense. In the development of a new ordnance device the field test is the final stage of evaluation and approval.

Recourse to Field Tests

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 field test usually differs from the laboratory test in that the environmental or exposure conditions are either more severe than can be provided in the laboratory or more realistic than can be duplicated.

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. If a pertinent effect were found in the laboratory then a field test might be necessary before a final evaluation could be obtained. Since, however, no worthwhile effect has been found in the laboratory it has been concluded that the field tests would serve no useful purpose. Furthermore, in field testing, large variations in environmental conditions are likely and it requires much more extensive planning, larger samples, and more rigorous analysis of the data to obtain results of reliability and significance.

NBS Battery Work

The Bureau's work on batteries goes back to the very beginning of the organization at which time it dealt with work on the primary standard of electro-motive force, the volt. This standard was derived from a cell of very special construction called the Weston Standard Cell and throughout the years there has been appreciable work in improving the stability and reliability of the standard cell and on methods for measuring the voltage of the standard cell with greater accuracy.

Other work on batteries has involved investigations of the fundamental processes of converting chemical energy into electrical energy and in the development of a variety of types of batteries for specialized

applications. An example in the latter category is the development of a special reserve type battery for use in radiosondes, the devices with which information on weather phenomena in the upper atmosphere is obtained reliably, quickly and efficiently. In the reserve battery for the radiosondes it was necessary to obtain a battery very light in weight, of extremely long shelf life, and capable of operating at the very low temperatures of the upper atmosphere.

Other work in the development of batteries has involved applications to a number of specialized military requirements such as use in aircraft, in guided missiles, in submarines and in proximity fuzes. Thus, our staff is constantly alert and experienced in the development of new and better batteries.

Battery Evaluation Techniques

Closely related to our work on the development of batteries is our work on devising improved instruments and techniques for the evaluation of batteries. Many of the batteries purchased by other government agencies for their particular needs are ordered to conform to specifications designed to meet the particular requirements of the using agency and to insure that the government obtains the highest quality at the lowest cost. In order to determine conformance of batteries with specifications, it is naturally necessary to have well established techniques for testing and evaluating battery performance. In these activities the other government agencies have drawn extensively on the staff and facilities of the National Bureau of Standards for assistance.

Battery Additives

The Bureau's work with battery additives, materials intended to improve the performance of lead-acid type storage batteries, goes back to the early 1920's. A technical paper summarizing the results of these early investigations was published in the transactions of the American Institute of Electrical Engineers in 1925. Around this same period the Federal Trade Commission made its first request to the Bureau for the evaluation of an additive to determine if it conformed with the advertising claims made by its manufacturer. Also in 1925 the Bureau issued in its Technical News Bulletin a brief statement discussing the effect or absence of effect of battery additives on the performance of lead-acid storage batteries.

During the next six years a number of other additives were examined for such agencies as the Federal Trade Commission, the Post Office Department and the Navy Department.

Letter Circular 302

During this interval numerous requests for information on additives were received by the Bureau from the general public and in 1931 a mimeographed leaflet was prepared in order to facilitate the problem of replying to these inquiries. This leaflet was designated as Letter Circular 302 and entitled "Battery Compounds and Solutions." The leaflet provided some general information about battery additives and pointed out that the Bureau had found none of them to be effective in improving the performance of batteries.

Post 1931 Tests

From 1931 to the start of World War II nine other battery additive materials were investigated either for the Federal Trade Commission, the Post Office Department or members of the Congress. Most of these consisted primarily of combinations of sodium and magnesium sulfates, commonly known, respectively, as Glauber's salt and epsom salts. During World War II and since, fifteen new additives were tested by the Bureau (some for a second time) for other government agencies. Again most of these consisted of mixtures of sodium and magnesium sulfates. The Bureau also investigated a large number of materials considered as possible corrosion inhibitors to see if any of them would curtail the sulfation of lead-acid storage batteries that occurs on storage. This latter study was undertaken to determine the best means to recondition or store lead-acid batteries that were in surplus at the termination of World War II. Included in this latter test were again sodium and magnesium sulfate mixtures; they were found not to be beneficial. In response to the continuing demand for information from the public about battery additives, Letter Circular 302 was reissued in 1949 with only minor variations from its original form.

Battery AD-X2

The first recorded contact at the Bureau with the Battery Additive AD-X2 occurred in April 1948 when Dr. Merle Randall, consultant of Pioneers, Inc., wrote to Dr. George W. Vinal, then chief of the Bureau's electrochemistry section. Dr. Randall described AD-X2 (it was then called Protecto Charge) as a powder mixture of anhydrous sodium sulfate, and slightly basic nearly anhydrous magnesium sulfate and he claimed that this combination of the salts yielded results appreciably different from ordinary mixtures of the two salts. It might be of interest to point out that in this letter Dr. Randall claimed that the additive was an invention of one Donald Keefer, the patent rights to which had been acquired by Mr. Jesse M. Ritchie, President of Pioneers, Inc., the company which manufactures the additive. Dr. Vinal deferred replying to Dr. Randall's letter and again in June of 1948 Dr. Randall wrote Dr. Vinal, reemphasizing and expanding the claims made for this material in his first letter. Included with his second letter was a special test which we have subsequently called the Randall test and which was claimed to be a very severe test for these additives and which yielded "striking results."

There followed during the next month several letters between Dr. Vinal and Dr. Randall in the last of which Dr. Randall stated, "I do not wish to unduly prolong our conversations" which Dr. Vinal apparently interpreted as an opportunity to break off the correspondence since the letter was unanswered. In these comments Dr. Vinal attempted to point out to Dr. Randall where some of his claims were not in accordance with accepted theory and in which Dr. Randall indicated that the statements made in the Bureau's Letter Circular 302 were true for all other additives but not for AD-X2. Also, in one of Dr. Randall's letters of July 1948 was a statement that in one experiment with these additives, treated batteries had remained in service without a single failure for as long as 17 months. This is interesting in the light of more recent statements that the additive was not invented until the fall of 1947.

1948 Inquiries

Late in 1948 the Bureau received inquiries about Mr. Ritchie's product from two new sources. Senator Knowland sent to Dr. Edward U. Condon, then director of the Bureau, a file forwarded to him by Mr. Ritchie with the request, "if in line with the policy of the Bureau of Standards, it would be appreciated if such a test could be made so that this product could stand on its own merits." Mr. Jack A. Harris, then general manager of the Better Business Bureau of Oakland, California, wrote to Dr. Vinal requesting that the Bureau make a test of AD-X2. Also there had been correspondence with the National Better Business Bureau requesting guidance in handling claims that AD-X2 should be exempted from the general statements of battery additives in Letter Circular 302.

In Dr. Condon's reply to Senator Knowland, he pointed out that tests on the material were currently being made by the Signal Corps Laboratories at Fort Monmouth and by the New York and Mare Island Navy Yards, and accordingly, tests by the National Bureau of Standards were probably unnecessary.

First Test of AD-X2

About the first of January, 1949, the Bureau had started a series of tests on another battery additive for the Federal Trade Commission and it was decided that it might be of interest to run along with these tests an evaluation of AD-X2. Samples which had been transmitted by the Oakland Better Business Bureau were used for this purpose. Part of these tests included careful chemical and physical determination of the constitution and structure of AD-X2 since Dr. Randall's letters had claimed that the combination in AD-X2 had unique properties and was not a simple mixture of sodium and magnesium sulfates.

The Bureau's tests have shown that the material is primarily a simple mixture of sodium and magnesium sulfates and that there is no evidence of a compound or alum structure. The analysis also showed a number of trace elements but for the most part these are the same trace elements usually found in varying amounts in commercial grades of sodium sulfate and magnesium sulfate or in the normal battery electrolyte. It is also pertinent to note in connection with the claim of the uniqueness of the composition of AD-X2 that our analyses have shown variations between samples as high as 19 per cent in the ratio of sodium sulfate in AD-X2 to the magnesium sulfate. The ratio of the quantities of trace elements also varies appreciably.

The results of these tests showed that the effect of AD-X2 in a battery electrolyte was no different from that of other mixtures of sodium and magnesium sulfates and that none had any measurable effect on the performance of a lead-acid storage battery. Two testing procedures were used. One was the Randall test which was claimed by Mr. Ritchie's consultant to yield striking results; the other was a modified life cycle test, similar to the standard test which is widely used to estimate the life of a storage battery under normal use conditions. A life cycle test is used by the government in its specifications for the purchase of batteries for its own use.

Circular 504

The results of these investigations which were begun in January 1949 were ultimately incorporated in the Circular No. 504, "Battery Additives," issued in January 1951; copies of which have been furnished to all members of your committee.

Preparation of the material for Circular 504 was initially planned as a revision of Letter Circular 302. The incentive for this revision was provided partly by the National Better Business Bureau in order to

have a more thorough and up-to-date statement on the subject of battery additives. Requests for the revision for the circular began in June 1948, apparently largely as a result of representations made to the National Better Business Bureau by Pioneers, Inc., that AD-X2 should be exempted from any general statements made about battery additives. Correspondence and discussions as to what the new circular should contain continued for many months and interim statements were prepared for the National Better Business Bureau in March of 1949, and April and July of 1950. The first of these made no reference to specific brand name products but the latter two made specific reference to AD-X2. This deviation from the usual practice was at the request of the National Better Business Bureau in order to reply to statements made by the proponents of AD-X2 that the generalization made in prior bulletins did not apply to that product and that it had not been tested by the Bureau.

Here it is interesting to quote from a letter from the Oakland Chamber of Commerce to the National Better Business Bureau, a copy of which letter was sent to NBS by the Chamber: "We realize that for the protection of the public your pamphlet, 'Battery Compounds and Solutions,' has a definite place and were it not for the pamphlet there would be more evidence of the existence of the 'battery dope racket.' However, Pioneers, Inc., should, in our opinion, be definitely excepted as regards such publication. With all due respect to the National Bureau of Standards whom you quote in your pamphlet, we feel that they have not been exactly cooperative regarding the product 'AD-X2' manufactured by Pioneers, Inc."

This quotation is interesting in two respects. First, as to the claim that there is a battery dope racket and that technical information such as was supplied by the National Bureau of Standards to the National Better Business Bureau serves a useful purpose. Second is the reference that the National Bureau of Standards has been uncooperative. There have been many similar statements from other proponents of Battery AD-X2 regarding not only lack of cooperation but even unfairness on the part of the Bureau. I would like briefly to examine this phase of the problem.

Why AD-X2 was Tested

First, 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 pressures of the proponents of AD-X2. The Bureau became aware of the existence of the product first by approaches made by the manufacturer, and initially declined to make any tests on it because there was no reasonable evidence that the product was, in fact, different from any of the other numerous additives the Bureau had previously tested, and also because the Bureau does not evaluate proprietary products for individual manufacturers.

The initial tests made by the Bureau came about largely as a result of inquiries and suggestions from the Oakland Better Business Bureau and from Senator Knowland, their inquiries in turn being instigated by Pioneers, Inc. The subsequent dissemination of information about battery additives came about largely as a result of pressures applied to the National Better Business Bureau to make unwarranted exceptions in the case of Battery AD-X2.

1950 FTC Request

In March of 1950 the Federal Trade Commission requested the Bureau to make tests on AD-X2. A report was sent them on May 11, 1950, incorporating the results of the tests which had been initiated in January 1949. Late in 1951 many members of the Bureau staff gave testimony at the Federal Trade Commission hearing on still another additive and, at that time, members of the Commission stated that they wanted further tests on AD-X2 since the Bureau had used in its earlier report results of tests made from samples submitted by the Oakland Better Business Bureau and not by FTC. The Commission formally requested the additional tests in February 1952 and a report based on this new series of tests was submitted in July 1952.

1951 Post Office Request

In September 1951 the Post Office Department requested tests on AD-X2. The Bureau submitted a report in December 1951 again based on results of tests obtained on the sample submitted by the Oakland Better Business Bureau. Following receipt of this report, the Post Office Department also requested additional tests on samples submitted by them. Accordingly, the National Bureau of Standards initiated still another series of tests of AD-X2.

Results of FTC and PO Tests

The results of the tests made for these two agencies disclosed no beneficial effect of the additive on the operational characteristics of lead-acid storage batteries. The major testing procedure used in the investigations for the Post Office Department and the Federal Trade Commission was the Randall test which has been referred to earlier.

Congressional Correspondence

Beginning in July 1951 the Bureau began receiving numerous letters from members of the Congress requesting information about AD-X2. In general, these letters were instigated by various distributors of Pioneers, Inc., through writing to their Senators. During the last half of 1951, 28 Senators and one Congressman transmitted queries about this material. In ten cases, second letters were involved, and in one case, a third letter was received during this period. To facilitate the handling of these inquiries, the Bureau prepared in August 1951 a mimeographed leaflet touching on many of the common points in the letters.

Manufacturer's Campaign

An indication of the motivating force behind this letter-writing campaign can be seen from the following excerpt from a nine page memorandum of August 21, 1951, sent from Battery AD-X2 Plant No. 236 to "All Distributors, Prospective Distributors and Interested Parties" on the subject "National Bureau of Standards versus Battery AD-X2"; "We are now trying to bring to bear sufficient pressure to cause a Senate investigation of the National Bureau of Standards. We certainly have reason to believe that an investigation and perhaps a shake-up are in order. A few days ago, about the time that all distributors of Battery AD-X2 were writing their Senators (see attachments 'F', 'G', and 'H'), Dr. Edward U. Condon, for many years the Director of the National Bureau of Standards, suddenly resigned. We believe that this is significant and we like to believe that we had something to do with the resignation."

Congressional Interest in Further Tests

Most of the letters from the Congress were routine memoranda transmitted with the letters they had received from distributors in their areas. Others suggested the desirability, if possible, of the Bureau's making additional tests in order to settle the controversy. For example, the following request was received from the then Senator Nixon in February 1952:

"On January 24 you forwarded a copy of your reply to Mr. Jess M. Ritchie, President, Pioneers, Inc. with reference to the controversy existing on the testing of battery additives.

"As you will recall, Mr. Ritchie is the manufacturer of AD-X2, which he contends has been under condemnation by certain publications of the Bureau of Standards.

"It is my understanding that essentially the arguments put forth by Mr. Ritchie are; first, in the testing of selected battery additives, including AD-X2, the tests are not conducted under conditions that exist in actual practice; second, that in proclaiming the non-utility of battery additives based on these tests, AD-X2, to say the least, is indirectly condemned.

"The evidence, as I see it, is conflicting. On the one hand, there is a history of a successful use of this product over a substantial period of time and on the other, repeated tests that result in unfavorable decisions.

"In view of the extensive correspondence and discussions which have taken place as a result of these claims, it is my desire to resolve this disagreement once and for all. Therefore, I would appreciate your advising me of the methods which might be pursued to conclude this controversy in a manner which would convince any reasonable minded individual."

House Small Business Committee

In March 1952 the Executive Director of the Select Committee on Small Business of the House of Representatives made the following request:

"This is in further reference to the complaint of Mr. Jess N. Ritchie, President, Pioneers, Inc., Oakland 12, California, relative to the refusal of the Bureau of Standards to approve his Battery AD-X2.

"Because of the claims of Mr. Ritchie and the evidence of wide acceptance of this product, I am requesting that you make a new test of his product and submit a report on specific results of your testing."

NBS Runs Manufacturer's Test

As a result of interest of the members of the Congress and also as a result of communications I had been having with Mr. Ritchie since December 1951, I agreed in May 1952 to run a new series of tests on Battery AD-X2, using a test procedure which Mr. Ritchie guaranteed would demonstrate the merits of his product. One of the major claims made by the distributors of AD-X2 in their letter-writing campaign to the Congress was that the testing procedure which had been used by the Bureau was not suitable to disclose the merits of the battery additive.

Although I had no reason for questioning the adequacy of the test procedures the Bureau had used previously, I had hoped that by using a procedure described by him, the matter could be settled decisively for all concerned. A report describing the testing procedure and the results obtained therefrom has been furnished to members of your committee.

Manufacturer Approved Batteries

An essential feature of this test which was carried out in June 1952 was that the batteries which were used for the test were to be disassembled and inspected by Mr. Ritchie or his representative and returned to the Bureau as suitable for complying with the objectives of the test. This was done by Mr. Ritchie and Mr. F. A. Harrell in the latter's battery shop in Arlington, Va. Mr. Ritchie did say that these batteries were not as badly sulfated as he had hoped, but that he did believe them suitable for the test. Most certainly the test would not have been conducted if he had not given such assurance.

Incidentally, the batteries were obtained from another government agency as non-usable batteries and the representatives of this agency told representatives of the Bureau that they had made prior unsuccessful attempts to charge the batteries. There was definite evidence when the batteries were disassembled and inspected that prior attempts had been made to charge them. This was concurred in both by the Bureau's representative and Mr. Ritchie. All of these batteries took a good charge and there was definitely no superiority in the performance of the treated over the untreated batteries.

Here I believe that it is important to point out that had we put AD-X2 in all of the batteries rather than in just half of them, we would have duplicated the experience reported by most of the proponents of AD-X2. Here was a group of batteries which a prior owner had claimed would not take a charge. AD-X2 was put into one-half of them and they took a charge. However, nothing was put in the remaining half and they also took a charge and performed just as effectively as the treated batteries.

Minor Deviations

Some minor deviations were made in the testing procedure in the interests of expediting the test and insuring uniformity in the handling of the treated and untreated batteries. Most of these deviations involved technical considerations, but which could not conceivably make any difference in the outcome of the tests. In any case this is a point which the National Academy committee is qualified to settle very promptly.

In the test there were two groups of treated and untreated batteries. In accordance with Mr. Ritchie's specification one group was to be examined visually and manually for the physical condition and appearance of the battery plates after the charging process was completed. The other group was to be tested for electrical capacity.

Manufacturer's Claims for Treated Batteries

For the group which was to be subjected to visual inspection, Mr. Ritchie claimed, for the treated batteries, "The paste will be found to be soft and porous and the active material in both the positive and the negative plates will be found to be in firm contact with the grids. There will be little peroxidization of the grids in the positive plates. There will be no warping or buckling of the plates and little shedding. The overall appearance of these batteries will indicate many months of useful service."

Manufacturer's Claims for Untreated Batteries

He claimed that for the untreated batteries: "It will be noted that the positive grids are largely, if not entirely peroxided out in the positive plates and that the plates will disintegrate under pressure and twisting. The active material in the negative plates will be found to be pried loose from the grid which will cause it to be chunky and sandy. (The plates may or may not be warped.) Shedding of the active material from the plates will be considerably heavier than in the treated batteries. The condition of these batteries, if they were truly sulphated at the beginning, will show that they have little, if any, life expectancy, or they may be inert."

Manufacturer Participation Rating

The attempt to verify these claims was made by a group of judges including Mr. Ritchie and an assistant of his. None of the judges knew which plates came from treated and which from untreated batteries; they were asked merely to compare the plates and to rate them. None of the judges, including Mr. Ritchie and his assistant, was able to tell any consistent difference between the treated and untreated batteries.

Analysis of Electrical Properties

Also in the group tested for electrical capacity there was no consistent or significant superiority of the treated over the untreated batteries. It is important to emphasize that in this series of tests the personnel conducting the tests did not know which batteries were treated and which untreated. This procedure provided a very effective means of insuring complete objectivity in running the test because if, by any remote chance, bias happened to be present on the part of an observer he would not know where to place his bias. Criteria for the modern design of experiments strongly recommend such a procedure whenever possible.

After all the observations were taken both on the group of batteries for electrical tests and the group for visual inspection of the plates, the information was turned over to the Bureau's Statistical Engineering group, previously mentioned. These analysts were first directed, also without knowledge as to which batteries were treated, to look for evidence of two groups of batteries with distinct performance characteristics. Had the additive produced a real effect on battery performance, this would have been possible. When no pattern of this sort developed, the analysts were next provided with the information as to which batteries were in each of two groups, but not told which group was treated. After analysis showed no significatnt difference between the two groups they were told which group had been treated and they proceeded with the preparation of the report.

Report of Test

A report on the results of these tests was submitted to the Small Business Committees of the House and Senate, and to other members of the Congress who had been interested in the matter, Mr. O'Connor of your Committee had requested that we make every effort to expedite the report and as a result it was distributed before a sufficiently thorough check had been made for transcription and typographical errors. These were checked

later on a low priority basis and in September correction sheets covering the errors were sent to all recipients of the report. It should be noted that the errors were all trivial in nature and in no way modified the conclusions of the report.

We had fully hoped that this report would dispel all doubt as to whether battery additives of sodium and magnesium sulfates were beneficial to the operation of lead-acid storage batteries. This however, proved to be a false hope since the proponents of AD-X2 began looking for minor flaws in the report and the testing procedure, ignoring the major conclusions of the report.

As a result of the dissatisfaction on the part of the proponents of Battery AD-X2, Mr. O'Connor asked me later in the summer if we would be willing to run still another test. I informed him that we would attempt to run one under two conditions, first that it be designed to establish some pertinent factor not included in the tests run the preceding June, and second, that Mr. Ritchie would furnish for the tests batteries which would not take a charge. Also during this period we had frequently pointed out that if the claims made for the Battery AD-X2 were true, then it certainly should be possible to relate these claims to some pertinent phenomena which could be consistently measured and reproduced in the laboratory.

September 1952 Meeting

As a result of these discussions with Mr. O'Connor a meeting was set up at the Bureau late in September to discuss possible future tests and also to hear reports from Dr. Harold Weber of the Massachusetts Institute of Technology on an effect he had found due to the introduction of Battery AD-X2 in a storage battery. No definite conclusions were reached at this meeting about subsequent future tests, although the possibilities of carrying out additional tests both at the Bureau and at MIT were discussed.

It was, however, generally agreed that the possibilities for additional tests would be further pursued and also that Dr. Weber would furnish the Bureau a copy of his test results and of the experimental procedure by which they were obtained. Following receipt of this information the Bureau's statisticians were to give Dr. Weber an estimate of the number of samples necessary to establish definitely the existence or non-existence of the effect reported by him. It should be noted that the effect reported by Dr. Weber was not observed under normal operating conditions but only when the normal electrolyte in the battery was dumped and replaced with a very dilute solution of sulphuric acid. Specific information as to Dr. Weber's testing procedure and result was not received by the Bureau until the MIT reports was released by the Senate in December 1952.

At the September meeting there was some discussion about Bureau participation in MIT tests if such tests took place, but no definite decisions were reached. When the Bureau was informed that MIT was planning to make tests and invited to have observers present, it was concluded after some serious deliberation that it would be better if the Bureau did not participate in these tests. A major factor influencing this decision was Mr. Ritchie's attitude toward the Bureau and Bureau personnel. He stated

emphatically at the September meeting that he would believe no results which were not favorable to his product and that he did not believe Bureau personnel could be depended on to give a fair test. In our desire to bring this controversy to a satisfactory close, we concluded that it would be better if MIT carried out its tests completely independently.

NBS Tests Following MIT Report

Following receipt of a report of the MIT tests a new series of tests was started in the Bureau in an effort to determine the reproducibility of the MIT test results and their applicability to normal storage battery operation. The major results of these subsequent Bureau investigations were incorporated in a report made to the House Interstate and Foreign Commerce Committee on February 10, 1953. This latter committee has legislative jurisdiction over the functions of the National Bureau of Standards in connection with a review the committee made of the Bureau's functions in February, this report was requested by the Chairman of the Committee. A major conclusion of the Bureau's investigations with respect to the effect reported by MIT is that the effect is observable in the batteries only with electrolyte of extremely dilute acid concentration, so dilute in fact that it appears to be of no significance whatever in normal storage battery operation.

Subsequent to the preparation of the report for the House Committee, Bureau scientists sought to find more information as to the basic mechanism of the effect reported by MIT. These subsequent investigations have shown very definitely that at extreme acid dilutions, as well as at normal acid concentrations, the addition of sodium and magnesium sulfate mixtures inhibits the charging process by a small but definitely measurable amount. Thus it now appears that these mixtures inhibit rather than assist the reduction of sulfation in lead-acid storage batteries, although in normal operation the effect is so small as generally to be non-observable. The effect reported by MIT is one of enhancing the discharge of the battery at extremely dilute acid concentrations. Thus, under these unusual conditions the additive inhibits the charging process but so facilitates the discharging process that there appears to be a gain. This apparent gain, however, is a delusion because it is encountered only in the part of the discharge process where there is insignificant useful energy left in the battery.

These later results of the Bureau together with its prior tests on AD-X2 have been summarized in a detailed report which will be made available to the Committee set up by the National Academy of Sciences. The report could also be made available for the record of this committee if the chairman so desires.

Tests by Other Laboratories

The Bureau's experience with battery additives is not unique, since other laboratories both within and without the Government have also investigated them and for the most part as far as we have been able to

determine, arrived at similar conclusions. I believe your Committee is familiar with most of these other investigations since many of them were criticized in your release last December. I do not believe it appropriate for me to comment on the work in these other laboratories. Rather, I believe that if the Committee is interested, it might call individuals responsible for these other tests and have them tell you about them here.

Objectives of NBS Work

In conclusion, I would like to emphasize that throughout the period of its experience with battery additives, the Bureau has been motivated by one major purpose: the determination of scientific information. In other words, we have been primarily concerned with determining the measurable effects produced by the addition of these agents to the electrolyte of the battery, and relating these measured effects to battery performance. We would welcome the discovery of any phenomena which would clearly and unmistakably improve storage battery performance.

- Our work with battery additives has, almost in its entirety, been done as a service to other agencies of the Government. Most work of this sort is considered a chore. We do not seek it but we do welcome the opportunity to be of service. Furthermore, we recognize that the Bureau is not infallible. We have made mistakes in the past and expect to make mistakes in the future. It is, however, important that when mistakes are made that we correct them promptly and take measures to insure that similar mistakes do not occur again. If we did not remain open-minded to the correction of past errors and to the acceptance of new ideas, we would immediately lose that objectivity which is necessary to the vigorous and healthy operation of any scientific laboratory.

We at the National Bureau of Standards are hopeful that the investigations of this Committee and of the National Academy Committee will settle this matter conclusively and finally. We have tried to the best of our ability to be thorough and accurate in our studies. If, however, these investigations develop any scientific or technical information that is pertinent to this matter and which we have overlooked, we will have no hesitancy in considering the new data and amending our conclusions if these new data provide a sound scientific basis for such action.