LEAD INDUSTRIES ASSOCIATION

420 LEXINGTON AVENUE

NEW YORK 17, N. Y.

May 26, 1955

SUBJECT: NINTH ANNUAL BATTERY RESEARCH AND DEVELOPMENT CONFERENCE

To Members of the Lead Industries Associations

The Power Sources Branch, Components Division of the Signal Corps Engineering Laboratories at Fort Monmouth, New Jersey, annually sponsors a Battery Research and Development Conference the purpose of which is to acquaint the battery industry with the progress of Signal Corps research and development programs in the battery field and to encourage interchange of information on batteries with the object of promoting more rapid advancement of knowledge in the battery art.

The Lead Industries Association, as it has in the past, was invited to send a delegate to this Conference which was held on May 18 and 19, 1955, in Asbury Park, New Jersey. Reports on those papers of specific interest to the lead industry are attached.

Very truly yours,

Robert L. Zeigler

Secretary.

May 10-19, 1955

NINTH ANNUAL BATTERY RESEARCH AND DEVELOPMENT CONFERENCE

NUCLEAR BATTERIES

by

J. H. Coleman, M. J. Cohen and H. C. Gibson, Jr.
Radiation Research Corporation

Purpose: To investigate the utilization of radioactive energy as a direct source of electrical energy for use as a portable battery having at least a 15 year operating life and an operating temperature of 160°F to -65°F.

History: It was found that good insulators under continuous beta radiation first decrease in resistance, reach a minimum, and then increase in value. A battery was constructed and demonstrated after a satisfactory accelerated life test on one insulator.

Experimental Work: Investigations on this project were continued along two lines: (1) measurement of conductivity induced in electrical insulators by beta radiation for general application in nuclear batteries and (2) fabrication of solid tritium-zirconium sources for tritium batteries using either a vacuum or solid dielectric.

(1) In the insulation tests, induced conductivity was measured as a function of three variables; rate of beta radiation, total dose of beta radiation, and total irradiation time. Empirical equations were derived to relate the conductivity to these variables. Close agreement was found between these equations and those used in photoconductor theory. Also, F. T. Farmer in England found similar equations for insulators under gamma and x-radiation.

Three types of batteries were designed using solid insulation. One type was fabricated using polystyrene insulation and a 10 millicurie strontium 90 beta source. This type of battery, which had an output current of 50 micromicroamperes at zero voltage, was found to develop over 20,000 volts with only a 1 cubic inch volume including the shielding which reduces the external radiation field to less than 10 mr/hr. A second type of battery was designed for higher currents with strontium 90 sources. Mica was selected as the insulator since life test data indicated a significantly higher dose of radiation could be received by mica before degradation compared to polystyrene. The third type, which is still in the research stage, uses a thin dielectric film with a tritium source.

(2) Several tritium beta sources were fabricated and tested in both sealed-off and demountable vacuum batteries. Sealed off models of tritium batteries utilized the beta emission from solid tritiated-zirconium sources, carbon collectors and vacuum insulation. The initial models of these batteries are being designed to yield 10^{-9} amperes at potentials to 1000 volts in a volume of 2 cubic inches. Improved construction techniques may reduce the volume to nearer 1 cubic inch. Demountable tritium batteries have yielded potentials of several thousand volts at current efficiencies of .75 micromicroamperes per millicurie with a porous carbon collector. Other promising materials for collectors include beryllium and boron.

To determine life characteristics, studies of helium evolution from the tritiated-zirconium due to tritium decay were made as well as the effect of gas upon tritium battery performance. The life of the battery appears to be in excess of 50 years based upon an extrapolation of our results to date. Also, tritium vapor pressure measurements from tritiated-zirconium to temperatures of 400°C demonstrate the thermal stability of the film.

Future Plans: (1) Continue fundamental studies on the induced conductivity effect in solid dielectrics for application in; (a) strontium batteries with higher currents and increased reliability, and (b) tritium batteries with gaseous or solid beta sources (thin films).

(2) For application in vacuum tritium batteries, fundamental studies will be continued on; (a) helium and tritium evolution from solid tritated sources; (b) methods of improving the efficiency of the tritium source and collector for minimum volume (less than $\frac{1}{2}$ cubic inch for 1000 micromicroamperes).

Tritium battery requires no shielding for external radiation. Tritium emits no gamma rays.

NUCLEAR BATTERIES

by

Alexander Thomas
Tracerlab, Inc.

Purpose: Utilizing the principle of radio-ionization of a gas between dissimilar metallic electrodes, to develop a 60 volt and a 300 volt compact battery delivering up to 10^{-9} amperes and having a useful life of 15 years over a temperature range from -65°F to 165°F.

History: Combinations of electrode couples and insulators had been made into battery models. The result showed general agreement with theory and showed promise that all the technical requirements could be met with ultimate success.

Experimental Work: New test models made with different plastic insulators showed marked differences in characteristics with time, due to radiation conditioning and radiation degradation. As the current capacity was increased by increasing the amount of tritium per cell, the voltage was depressed because of radiation induced conductivity in the insulation. There was also a high temperature coefficient, which seemed contrary to the known theoretical considerations. Further modifications in the electrode couples and insulators have been made in order to improve the current-voltage characteristics and to reduce the effect of temperature.

Future Plans: If the present experimental program is successful, models of the 300 volt battery will be made and tested. Development of production techniques for parts, assembly, and capsulation of other designs filling specific requirements will then be undertaken.

To operate ordinary flashlight - the tritium required would cost $200, million dollars.

Takes several weeks to build up enough charge to fire flash bulb.

ATOMIC BATTERIES

by

P. B. Ohmart, H. L. Cook, R. Kerkhoff, W. W. Lyons
Ohmart Corporation

This paper describes investigations and research on atomic batteries which have been conducted during the last four years, with the result that a number of batteries have been developed.

One battery which has been developed as a source of constant current and constant voltage, specifically for Air Force applications, is 1-1/8 inches in diameter and 3 inches long. It generates currents of 5×10^{-9} amperes with an open circuit voltage in excess of one volt when excited by 10 millicuries of strontium-90. Measurements have shown the output of these batteries to be constant over long periods of time. They have low temperature coefficients, will operate over wide ranges of temperature, are extremely rugged, and will withstand severe mistreatment without damage.

Another battery that has been developed, is a multi-coaxial unit 1-1/2 inches in diameter and 2-inches in length. This battery has a center well in which the source is mounted. It has greater efficiency than the above battery.

The third unit has been developed for use with Ohmart Basity Gauges and is a variable current battery. These are used as compensating cells to furnish constant currents for nulifying purposes. In these batteries a source is mounted on the end of a micrometer screw so that the geometry of the source and cell can be changed, thus altering the output current.

Radioelectricity - generates trivial amount of electricity.

NICKEL CADMIUM

by

Dr. G. A. Baumstark and H. N. Seiger
Sonotone Corporation

The work done in the past year on this development contract has been directed toward three objectives: a study of charge retention over a range of storage temperature; improvement of high rate discharge performance; and development of a reserve type, "dry charged" battery.

The approach taken in the charge retention phase was to study this property using three-plate cells stored in a substantially oxygen-free atmosphere. The behavior of both plates was studied by selecting plate capacities so that in some cells the "limiting" electrode was the positive and in others, the negative. It was found that the rate of loss of charge is much greater for the negative than it is for the positive electrode. The data indicate that the latter will retain 30% of charge for twelve months at 40°F., nine months at 80°F., four weeks at 125°F and four days at 165°F.

The high rate performance program has been devoted principally to preparation of the cells for the test program described in last year's paper. Precautions have been taken to eliminate, as nearly as possible, the extraneous effects of "unknown" variables in sintering and processing the plates and assembly of cells.

Satisfactory performance has been obtained from "dry-charged" cells. However, unless stored in a dry, oxygen-free atmosphere, the rate of loss of charge is very similar to that of non-reserve type cells. Good low temperature performance is also given by these cells.

In addition to work done on this contract, some other interesting observations and data are presented concerning the performance of cells and the individual electrodes after several years storage and after extended accelerated cycling.

NICKEL-CADMIUM

by

Arthur Fleischer
Nickel Cadmium Battery Corporation

Purpose:

Research investigations have been extended to include the positive sintered plates and separators after the completion of the study of negative plate characteristics. The program is aimed at an improvement of performance over a wide range of temperature and discharge rates.

Experimental Work:

The studies on negative plates led to the discovery of the "extender" or "expander" properties of alkaline electrolyte-soluble cellulose derivatives. The effect of the addition of such compounds on the cycling characteristics of negative sintered plates will be reviewed. The absence of a similar effect in structurally analogous compounds has also been determined.

It has also been found that high charging rates tend to eliminate the adverse effect of cycling on the negative plate capacity. An increase of charging current density from 0.03 ampere per square inch to 0.14 ampere per square inch with the same total input is sufficient to accomplish this favorable effect.

It has also been found that the increase in the open circuit stand of a discharged negative plate from three hours to one week prevents loss of capacity on cycling, even at the low charging rate. This fact appears to be in contradiction to the expected behavior and is not in conformity to probable recrystallization processes in the active material.

Studies on separators for alkaline batteries have been undertaken with a view to find porous separators having the least effect on the discharge voltage curve, especially at high rates. These results will be supplemented by shrinkage and life determinations, as well as by determinations of electrical resistivity in the hope of correlating cell behavior with testing methods.

Studies on positive plates have been initiated with regard to the effect of various preparative conditions. The principal difficulty has been in the absence of correlation of results at low temperatures with the known performance of large batteries from 70 to 150 A.H. in capacity. It is probable that the three-plate test cell will have to be changed to cells having closer similarity in plate numbers and relative volume to actual battery cells.

Future:

Tests on separators and positive plates will be continued with emphasis on the effect of added impurities and modification of the positive active material. Additional tests will be devised to attempt to define charge acceptance, particularly at low temperatures.

NICKEL-CADMIUM

by

E. Willihnganz
Gould-National Batteries, Inc.

Hermetically sealed nickel cadmium batteries are now being made in the United States. This sealed construction is such an operating convenience that the entire field of battery applications can be reviewed to learn where the new battery has possibilities. Such a review must be based on the characteristics of the nickel cadmium sealed cell.

At present only "D" size and "F" size flashlight batteries are being made. Designs are available for a series of smaller sizes, and where capacities of 0.01 to 4.0 ampere hours are required, batteries can be provided.

The batteries were assigned for service at the five hour rate. At higher rates there is some falling off of capacity, but even at the 30 minute rate, they still deliver 50% of their rated capacity. Where higher rates are demanded, it appears possible to design the battery to produce them, although up to the present such batteries are not available.

The batteries maintain their capacity and voltage at low temperatures, so that where sub-zero conditions are encountered, these sealed batteries may perform satisfactorily where primary batteries may not be able to supply the required current.

The batteries have good shelf life. There is some loss of capacity during the first few weeks of storage, but the subsequent self-discharge is slow, and it looks as though there will be 50% of the rated capacity remaining after one year.

The battery can be stock-piled. Batteries can be put in storage for several years, and when a situation appears to warrant, the batteries can be charged. If the emergency does not develop, the batteries can be returned to stock to await the next time, or if a continuing alert is necessary, the batteries can be kept on a float charge for several years.

The batteries can act as voltage regulators. When the battery is put on charge at somewhere near the rated current, the cells develop a counter EMF which is only slightly affected by the charge rate or the temperature. Special cells are made without active material for use as voltage regulators. Assemblies of these cells can, therefore, be built up to give a stabilized voltage at any desired level, and various cell sizes can be used depending on the range of current to be supplied at the controlled voltage.

ZINC-SILVER OXIDE

by

J. S. Bono
The Eagle-Picher Company

Purpose:

To conduct investigations relating to the development of high rate reserve and non-reserve batteries utilizing the zinc-silver oxide system. These investigations also encompassed development of remotely controlled activating devices.

Experimental:

The shelf life at 125°F has been increased to approximately twice that previously reported. This has been brought about by increasing the specific gravity of the electrolyte, the use of nylon in conjunction with Visking and Viskon and the use of solderless terminals.

The use of amino ion-exchange films, in conjunction with Visking, has proven satisfactory in cycled cells up to thirty cycles.

The methods of activating both "A" and "B" batteries have been improved by use of vacuum techniques. Two advantages are immediately apparent: The "B" batteries can now be constructed without manifolds, thereby increasing shelf life of smaller "B" batteries and all cells of the larger "A" cell components may be filled simultaneously.

A workable method for activating both "A" and "B" batteries by remote control has been developed. Such batteries have been activated under load in one second or less.

Future Plans:

Future work will continue along present lines with emphasis being placed on further improvement in shelf life of activated batteries; continuation of the cycling program; and additional development and design of remotely controlled activating devices for diversified requirements. Work on activating devices will be directed toward a final design which will be readily adaptable to all units of the standard lines of "A" and "B" batteries.

ZINC-SILVER OXIDE

by

Paul L. Howard
Yardney Electric Corporation

Although the Silver-Oxide - Zinc system has been known for many years, the first successful Silver-Oxide - Zinc secondary battery was developed by Mr. Henri Andre. Since World War II Yardney Electric Corporation has developed this system into the present successful product.

Over this period, rechargeable cells have been improved from a few cycles with several weeks life up to cells with over 300 cycles during a period of 26 months and still operating at reduced efficiency. Cells with capacities ranging from .1 A.H. to 100 A.H. are standard production items in any of three types as follows:

1. HR cells built for high rate discharge for 10-15 cycles over a six - nine month period.
2. HR-V cells built for medium and moderately high rate discharges for 30-40 cycles over a nine - twelve month period.
3. LR cells for medium and low rate discharges for 100 - 300 cycles over a year's period.

General performance characteristics are given and methods of more efficient use of the battery at low temperatures down to -65°F will be given. Charged shelf conditions and length of stand are given. With proper storage conditions batteries have a charged shelf of over one year with 80% capacity maintenance.

The research and development program is continuously carried on by Yardney Laboratories under direct company funds to further improve the life and performance of the system. This has brought about improved wet shelf life and it is hoped will make still greater improvements.

TEST METHOD

by

Dr. Karl Kordesch
Signal Corps Engineering Laboratories

The determination of the stage of charge of alkaline storage batteries has gained in importance in recent years because of the increasing use of such batteries. To overcome the uncertainties of the ordinary test methods which failed because of the extremely flat discharge characteristic of these batteries, a new method was developed several years ago which eliminated the errors due to the resistance losses in the internal and external circuits. At this conference, last year, the basic test equipments and preliminary results were disclosed. This year, further improvements and some practical applications will be discussed, including the possibility to extend the basic method to other types of galvanic elements.

The main principle of the test procedure is to apply a pulsating charge or discharge load to the battery and measure the voltage during the no current periods between the load pulses, thus obtaining a potential free of the voltage drop created by the current across the internal resistance. The polarization of the battery is equal to the effective current flow.

Additional principles are to measure the voltage under load at different time intervals to eliminate the uncertainty of the starting point of the test, or to apply two different current loads and determine the corresponding voltage differences, thus compensating for differences in current densities within individual batteries.

A different method is used on high current-rate batteries where a pulsating load is impractical from the standpoint of equipment design. The battery is put on a heavy constant resistor load and at the same time, the internal resistance is measured, making it feasible to find the actual E. M. F. using a simple graph.

Based on these principles, equipments were constructed to fulfill special test requirements with the minimum of necessary parts, decreasing weight and size of the testers. Four types of such test circuits will be described and circuit features will be shown.

Up to the present time, the test methods have been applied to Ni-Cd, Ag_2O-Zn, Lead-acid and MnO_2-cells. Test results will be shown and the recommended future program will be outlined.