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Title: The Giants of the Nuclear Testing Era: The Works of Robert K. Osborne

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Report

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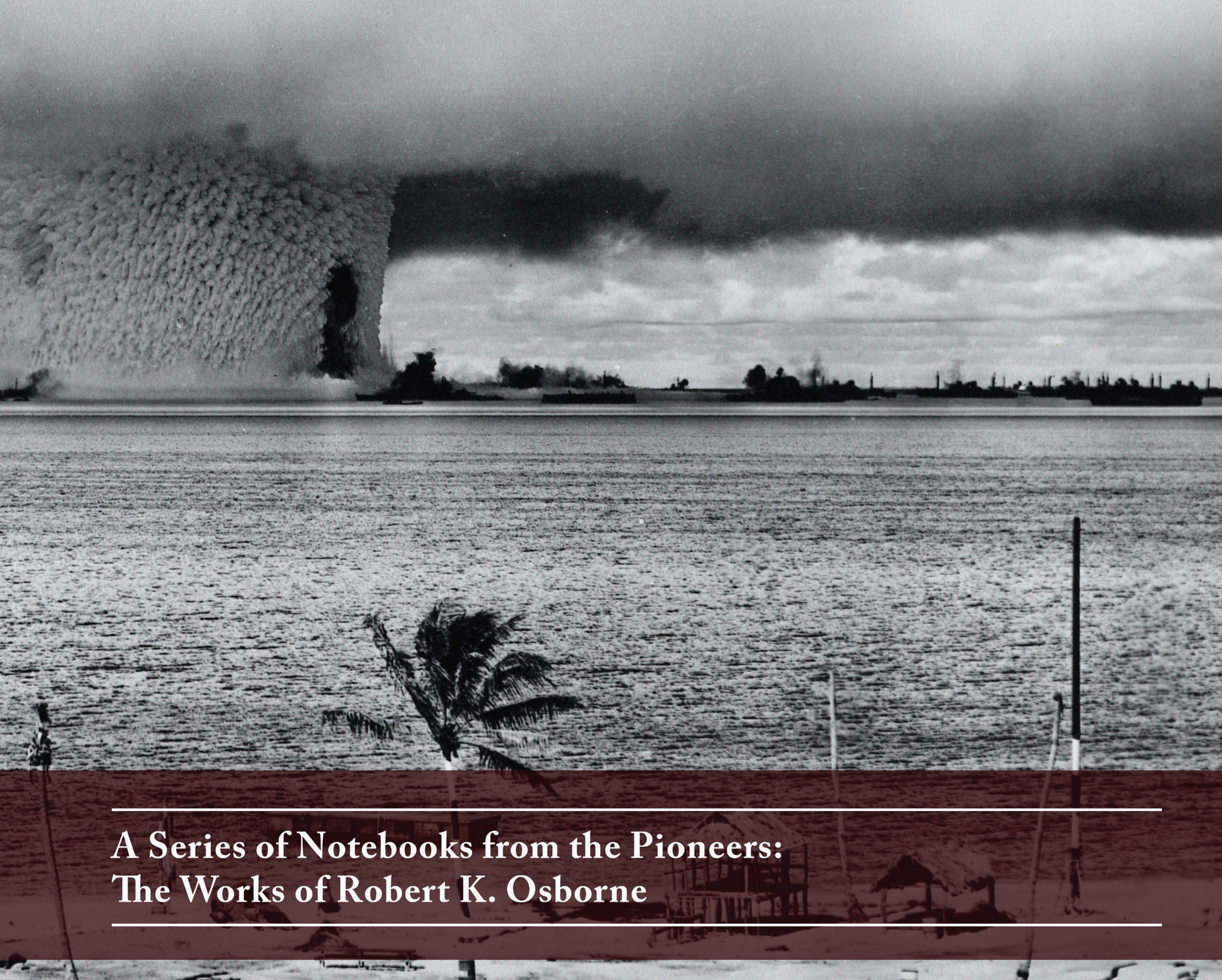
THE GIANTS OF THE NUCLEAR TESTING ERA



A Series of Notebooks from the Pioneers:
The Works of Robert K. Osborne

LA-UR-18 27654

This work is part of a series sponsored by the Archiving Data and Management (ADAM) program within the National Nuclear Security Administration's Office of Engineering Stockpile Assessments and Responsiveness (NA-115). The ADAM program is responsible for preserving the data and irreplaceable knowledge from the nuclear weapons testing era. This information continues to be used to support the current and future stockpile and also train the next generation of weapons scientists with no nuclear testing experience.

The Giants of the Nuclear Testing Era

A Series of Notebooks from the Pioneers:

The Works of Robert K. Osborne

Los Alamos National Laboratory

“If I have seen further it is by standing on the shoulders of giants.”
-Issac Newton

Figure 1: Robert K. Osborne (1968)

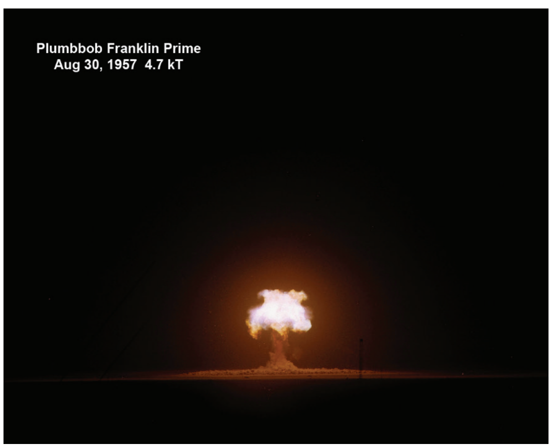


Figure 2: Operation Plumbbob - Franklin Prime

Preface

“With the advent of big computers, we have lost the ability to design a bomb on the blackboard. Guys like Bob could do that. He was one of our best primary designers.”

-John Hopkins, Principal Associate Director of Weapons Programs (retired), Los Alamos National Laboratory

Dr. Robert (Bob) Kidder Osborne was a key physicist and nuclear weapons designer—a giant, in fact, in the sense of Isaac Newton’s use of the term—at Los Alamos National Laboratory (LANL) during the days of weapons designing and testing (1943–1992). (See figure 1.) His career began a few short years after the end of World War II, in August 1949, and spanned over 30 years. He retired from the Laboratory in March 1981.

During his career, the United States was designing, building, and testing new nuclear weapons at a prodigious rate. Most of these designs were tested using full-scale nuclear tests (like Operation Plumbbob - Franklin Prime, shown in figure 2). Designers, like Osborne, relied on the results of these tests to prove, and improve, their designs. These improved designs led to developing weapons that contributed to a growing stockpile, which reached its numerical peak in 1967.[1]

Osborne was a major figure in the development of these advanced weapons designs. He was also largely responsible for the Laboratory’s development of one-point safety, hydronuclear testing, and he was the lead designer of the primary for the W76 nuclear warhead, which is the most numerous warhead in the current U.S. stockpile. Osborne was also an important mentor to many of the Laboratory’s weapons designers.

Biography

Osborne was born on February 9, 1921 in Kansas City, Missouri. In 1938, he attended the Massachusetts Institute of Technology (MIT), majoring in physics. He earned his Bachelors in Science in April 1942 after completing his thesis on nuclear isomers of lead.

Osborne continued working towards his PhD in physics (with a minor in mathematics), while conducting research in the decay of radioactive substances and teaching elementary physics at MIT. He graduated in June 1947.

After earning his PhD, Osborne continued to instruct physics at MIT. That is, until he was interviewed by a staff member from Los Alamos Scientific Laboratory (LASL, now LANL), at the New York meeting of the American Physical Society, in February 1949. After this interview, Osborne applied to be a technical staff member at LASL.

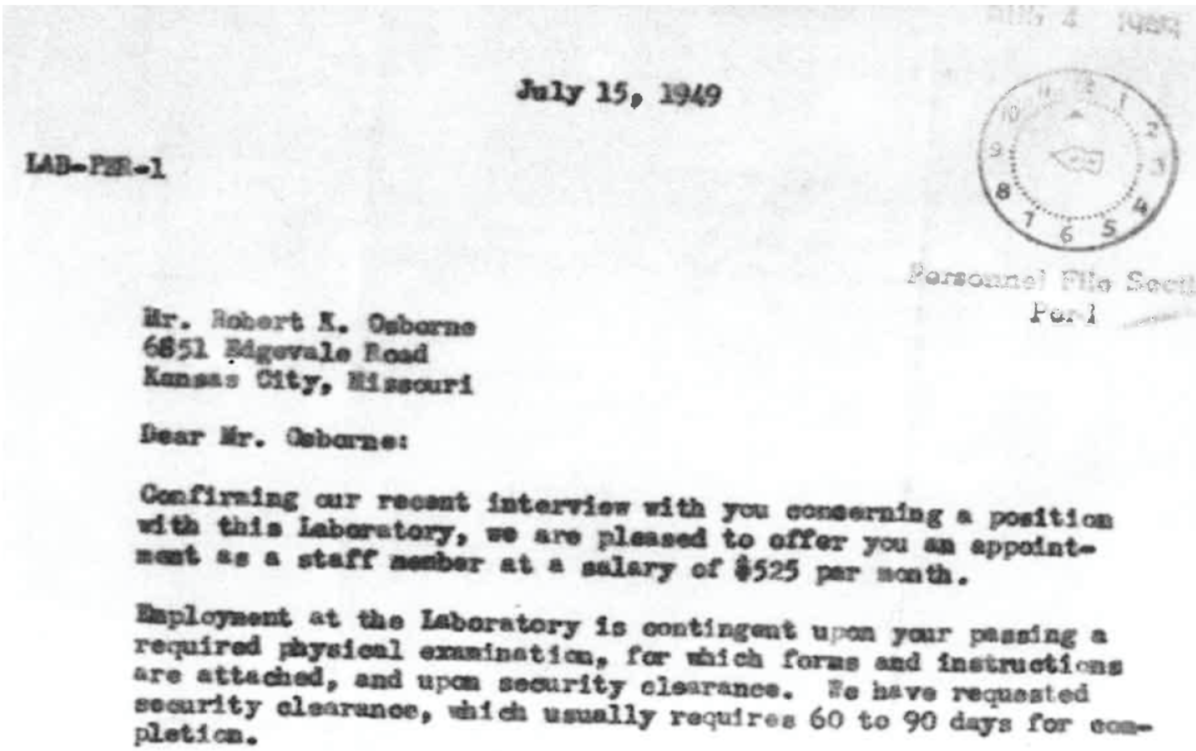
Osborne received a telegraph and official job offer letter in July 1949. (See figures 3, 4, and 5.) He would be working with the Laboratory’s nuclear weapons design group.

Osborne accepted and started as a technical staff member in August 1949. His class “Q” security clearance was granted the day after he accepted.

"Bob was the thirteenth member hired into the (weapons design group) at the Los Alamos Scientific Laboratory. He said when he hired on that he wasn't sure if it would be a long term job. But (then) the Soviet Union tested their first nuclear device on August 20, 1949, (and he'd say) there hasn't been much of a pause in the work for the group since."

-Don Wolkerstorfer, Weapons Designer (retired), Los Alamos National Laboratory

Osborne quickly made a name for himself as an efficient and productive physicist. This was a time of substantial growth for Los Alamos. The original Los Alamos-designed atom bombs that were used to end World War II were being optimized and improved in many ways.[2]



July 15, 1949

LAB-PER-1

Personnel File Sectio
Per-1

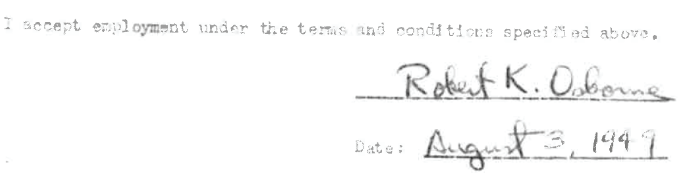
Mr. Robert K. Osborne
6851 Edgevale Road
Kansas City, Missouri

Dear Mr. Osborne:

Confirming our recent interview with you concerning a position with this Laboratory, we are pleased to offer you an appointment as a staff member at a salary of $525 per month.

Employment at the Laboratory is contingent upon your passing a required physical examination, for which forms and instructions are attached, and upon security clearance. We have requested security clearance, which usually requires 60 to 90 days for completion.

Figure 3: The job offer letter Osborne received from LASL



I accept employment under the terms and conditions specified above.

Robert K. Osborne

Date: August 3, 1949

Figure 4: Osborne's signature accepting the terms of employment at LASL

Figure 5: Osborne's photograph from his LASL application for employment.

Using Electronic Computers to Advance Nuclear Weapons Designs

Osborne was at the Laboratory as the nuclear weapons it designed for ending World War II were being advanced. The Laboratory was also advancing the knowledge-base in multiple related fields, including materials science, plasma physics, metallurgy, and explosives science.

Osborne was a physicist and weapons designer, so he had to have substantial knowledge in many of these different areas. One of those rapidly advancing areas then (and now) was in using electronic computers. Advanced nuclear weapons designs required using that era's highest performing computers, such as the IBM 700 series. (See figure 6.) These were the most advanced computers available and weapons designers needed them to design and predict the performance of new nuclear weapons systems. As a weapons designer in the late 1950s and early 1960s, Osborne helped calculate nuclear weapons performance.

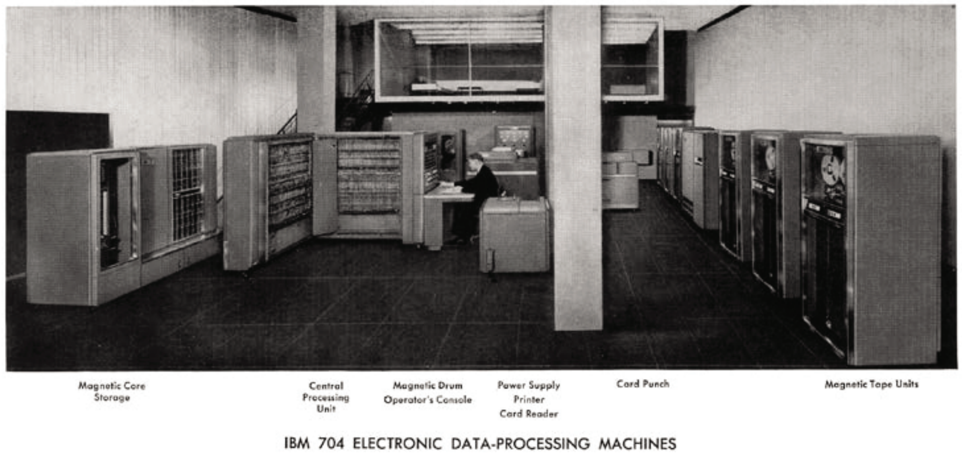
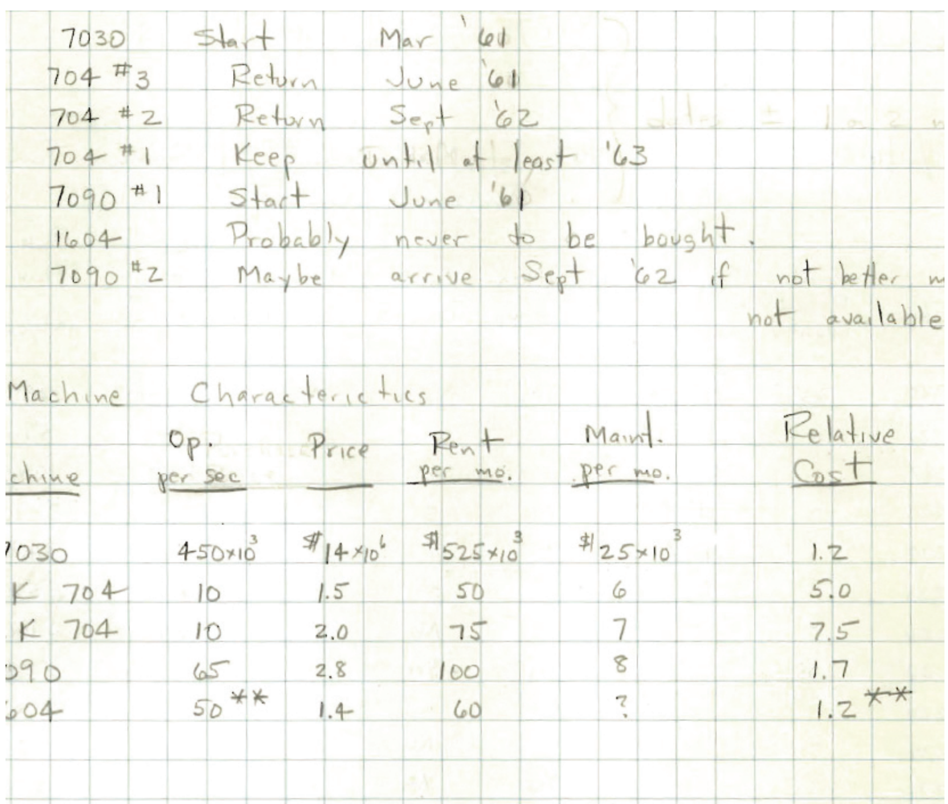


Figure 6: The IBM 704 computer at Los Alamos



7030 Start Mar '61
704 #3 Return June '61
704 #2 Return Sept '62
704 #1 Keep until at least '63
7090 #1 Start June '61
1604 Probably never to be bought.
7090 #2 Maybe arrive Sept '62 if not better w
not available

Machine Characteristics

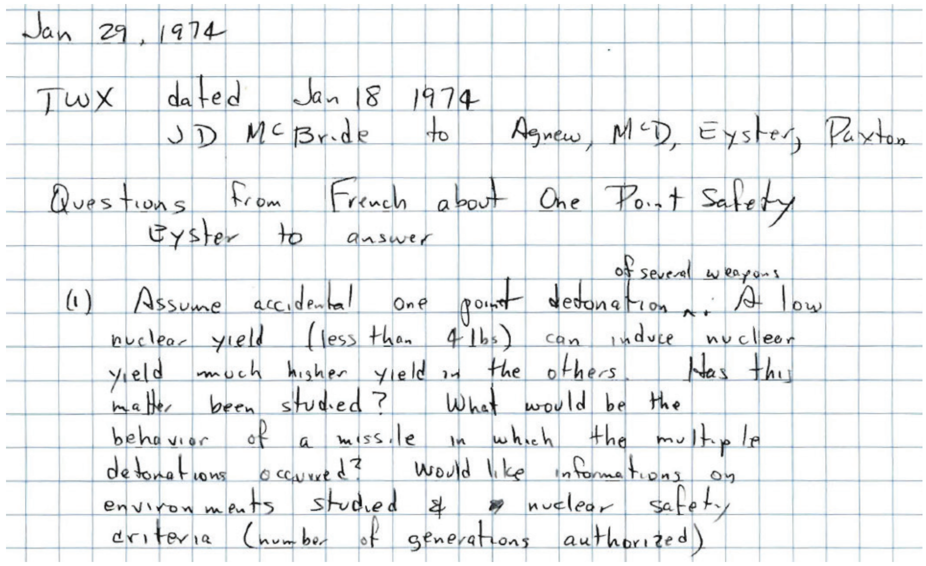
chine	Op. per sec	Price	Rent per mo.	Maint. per mo.	Relative Cost
7030	450×10^3	14×10^6	525×10^3	25×10^3	1.2
K 704	10	1.5	50	6	5.0
K 704	10	2.0	75	7	7.5
090	65	2.8	100	8	1.7
604	50 **	1.4	60	?	1.2 **

Figure 7: Osborne made these notes in 1960 regarding an IBM computer's costs versus power. (LA Notebook 10175)

Understanding the importance of using evermore powerful computers in weapons designs, Osborne played a key role in the Laboratory determining the design and development of the high-performance computers of the future. (The Trinity supercomputer in use at Laboratory today is capable of computing over 40,000,000,000,000,000 floating point operations per second: over 40 petaflops.) For example, Osborne was interested in the trade-offs between a computer's cost and its computational power that had to be made then, as they are now. (See figure 7).

Father of One-Point Safety

One of Osborne's most well-known and important contributions to nuclear weapons design is called "one-point safety". There was an enterprise-wide concern that if the high explosives around the primary are detonated at any one point from an accident, intentional sabotage, or misuse that the device might produce a dangerous amount nuclear yield. One-point safety refers to the science and engineering fixes that prevent this from ever happening. One-point safety is largely attributed to Osborne, and it used throughout the entire weapons enterprise to ensure the safety of U.S. nuclear weapons: all of the weapons in the U.S. stockpile are now one-point safe.



Jan 29, 1974

TWX dated Jan 18 1974
J D McBride to Agnew, McD, Eyster, Paxton

Questions from French about One Point Safety
Eyster to answer

(1) Assume accidental one point detonation of several weapons. A low nuclear yield (less than 4 lbs) can induce nuclear yield much higher yield in the others. Has this matter been studied? What would be the behavior of a missile in which the multiple detonations occurred? Would like informations on environments studied & nuclear safety criteria (number of generations authorized)

Figure 8: A 1974 memo by Osborne listing questions regarding one-point safety (LA Notebook 18068)

The need for developing one-point safety originally came during a visit to an Air Force nuclear bomber base by Harold Agnew, who would later become the Laboratory's third director. There, he saw how the young airmen handled nuclear weapons and he became alarmed about the possibility of an accident, such as dropping a weapon on the tarmac. Agnew wondered whether this type of accident could produce a detonation with any nuclear yield, and if so, how to prevent it.

Agnew returned to Los Alamos and immediately consulted Osborne about the possibility of developing one-point safety and how to test it. Osborne began to work the problem. (See figure 8.)

Finding a solution to the problem required multiple tests in the mid-to-late 1950s devoted to studying one-point safety. The first of these was the Project 56 series of test conducted at the Nevada Test Site (now called the Nevada Nuclear Security Site), followed quickly by the Project 58 series. (See figure 9.) After these two series of dedicated tests, the one-point safety tests were then integrated into most of the test series conducted at Nevada. However, before an adequate amount of data on one-point safety could be obtained, the first nuclear test moratorium, from November 1958 to August 1961 and in collaboration with the Soviet Union, was initiated.

Figure 9: Shot Coulomb-C, one of Project 58s one-point safety tests

In spite of the moratorium, the furious pace of one-point safety tests was not to be fully curtailed; the issue was too important to lie fallow. Naturally, Osborne was on the Laboratory committee that helped shape the plan of how to continue one-point safety tests.

Father of Hydronuclear Testing

Osborne and the committee devised a series of ingenious, novel, underground, small-scale "hydronuclear" tests (eventually named Operation Hood). Hydronuclear tests are designed to use special nuclear materials and create fission, but are engineered so that the tests cannot generate significant nuclear yield. Hydronuclear tests would thus generate the data needed to further study one-point safety (i.e., whether or not the weapon will detonate with significant yield), while still fitting within the bounds of the test moratorium.[3]

Hydronuclear testing was proposed for approval to the Atomic Energy Commission (the predecessor of the U.S. Department of Energy). After much deliberation the tests were approved by President Eisenhower, but they were to be conducted at the Laboratory in Los Alamos rather than at the Nevada Test Site. This was an important restriction intended to ensure that the Los Alamos designers would not be tempted to "intentionally" go over their low threshold for nuclear yield—because if they did, they risked violating the test ban or even blowing up the town.

These hydronuclear tests were subsequently very carefully approached and executed. Ultimately, they advanced the development of one-point-safety design and engineering, and improved the understanding of how much fissile material could be used in a pit and remain safe, in almost any conceivable accident scenario.[4] This knowledge continues to be used today in the subcritical experiments that are safely conducted at the Nevada National Security Site.

As the Laboratory's "father of hydronuclear testing", during this period Osborne travelled to the Lawrence Radiation Laboratory in California (what is now Lawrence Livermore National Laboratory) to consult on how to develop their version of the Los Alamos hydronuclear testing program, which they conducted in Nevada.

His development of hydronuclear testing is recorded in Osborne's notebooks and these can, because of the efforts by Los Alamos and the National Nuclear Security Administration (NNSA) to catalog and curate his (and other staff) notebooks, be accessed and used by current scientists and engineers, making it possible to, in Newton's terms, "see further by standing on the shoulders of giants".

Father of the Primary for the W76 Warhead

Into the 1960s, Los Alamos and Livermore were designing primaries that were huge by today's standards. This changed, beginning in 1967 and into the early 1970s, with the Defense Department's drive to obtain smaller, lighter, and more efficient (greater yield for the weight) primary designs: primaries that would then reduce the size and weight of the entire warhead. The Defense Department's goal was to develop ballistic missiles that would carry multiple, independent reentry vehicles (MIRVs) aimed at multiple targets. Such warheads required a revolutionary new primary design.

At Livermore, Seymour Sack's smaller, lighter, and more efficient primary design was reasonably well developed. His was the leading design for a MIRV warhead used on the Minuteman and Titan II missiles.

To successfully advance upon Sack's design Osborne, who had experience working on a previous effort to improve primary designs, took the lead on the Los Alamos design efforts. His result, after designing and testing multiple variations, was the primary used in the W76 warhead that arms ballistic missiles carried on the Navy's Trident-class nuclear submarines. (See figure 10.) The W76 is the most numerous warhead in the U.S. nuclear stockpile.

Figure 10: Sea-launched ballistic missiles can carry MIRVs armed with the W76 warhead

Nuclear Testing

Before new nuclear warhead designs could enter the stockpile they had to be tested, and in the early 50s there were substantial above ground nuclear weapons tests. These tests were conducted at both the Nevada Test Site, for smaller above ground tests, and at the Pacific Proving Grounds for the larger thermonuclear tests.

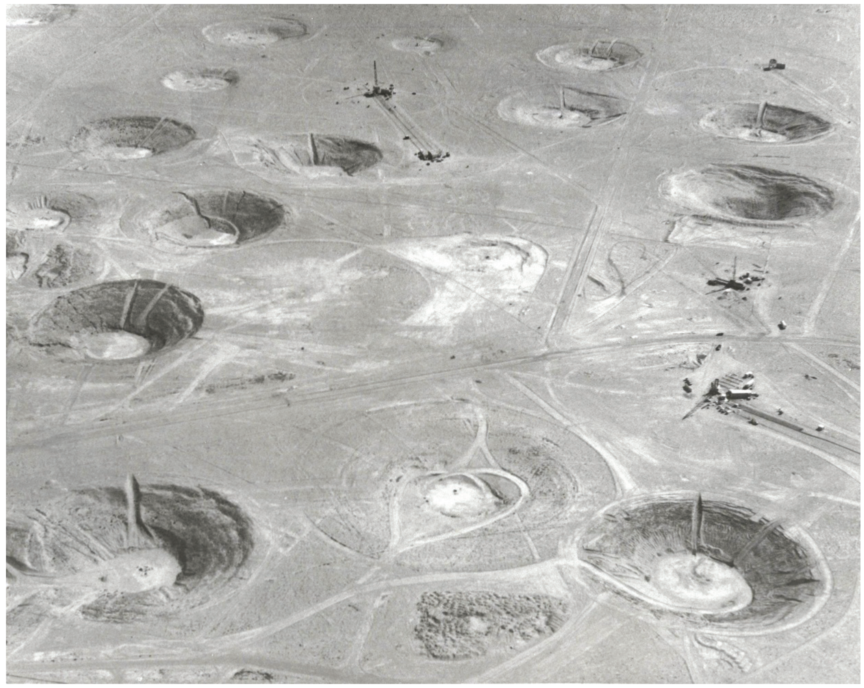
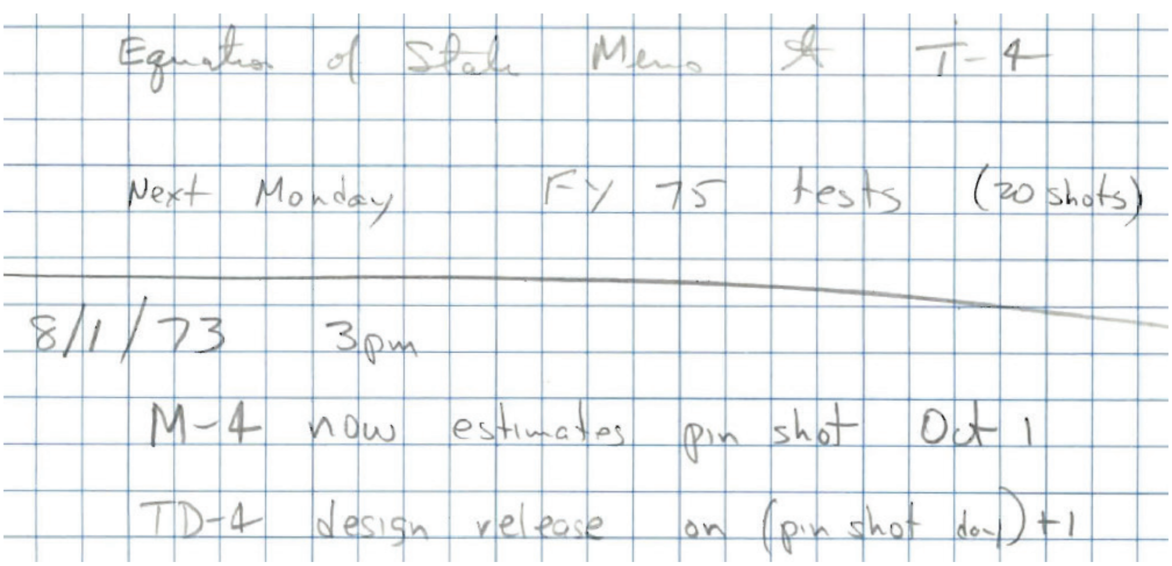


Figure 11: Yucca Flat's underground testing craters at the Nevada National Security Site (1967)

The extensive underground testing program during the 1970s and 1980s provided the test data needed to create the nuclear weapons test database used today in the Stockpile Stewardship Program. For example, the evolution to developing the W76 primary used in today's stockpile required many underground tests. (See figure 11.) These tests are captured and clearly articulated in Osborne's notebooks. The depth and breadth of knowledge regarding the W76 that is contained in these notebooks make them a priceless resource to the current designers and engineers who are required to understand and maintain these warheads decades beyond the weapons' life-expectancy.

In the absence of underground nuclear testing, the nuclear weapons test database continues to be the basis for conducting experiments, improving nuclear test codes, and ultimately underwriting how scientists and engineers understand how best to maintain the nuclear weapons stockpile—so that it will continue to provide a warm blanket of freedom and deterrence every day.

Notebooks, like those Osborne meticulously kept, continue to help Los Alamos designers and engineers understand the thought process and design decisions the authors used to create the warheads in the stockpile. (See figure 12.) These notebooks are the tangible, corporate-knowledge base of the U.S. nuclear weapons enterprise. In lieu weapons designing and testing, they are the textbooks needed to grow and develop the current and future generations of weapons designers and engineers.



Equation of State Memo A T-4

Next Monday FY 75 tests (20 shots)

8/1/73 3pm

M-4 now estimates pin shot Oct 1

TD-4 design release on (pin shot day) +1

Figure 12: Osborne's notes regarding nuclear tests in 1973 (LA Notebook 16840)

Primary Resources: Osborne's Notebooks

Osborne's notebooks are critical as they capture his extensive work and knowledge, and so are also critical for the nuclear weapons work that continues at Los Alamos. His notebooks (and those of the other "nuclear giants") are primary resources; they contain the original ideas and data from which the U.S. nuclear weapons in today's stockpile were designed and built. As current weapons designers have never designed, built, and tested a nuclear weapon the knowledge in these notebooks provides key elements necessary to perform stockpile stewardship, and to design new weapons should the Laboratory be ordered to do so.

In addition to weapons designs, his notebooks also capture other key information such as the types and amounts of weapons materials coming in from the reactors at Oak Ridge, Hanford, and Savannah River, new ideas to explore, complex calculations used to predict weapons performance, and descriptions of nuclear tests conducted (See figure 13.) In an era when new data from underground nuclear testing hasn't been generated in over 25 years, these calculations and the original test data are, in particular, profoundly important to the new weapons designers.

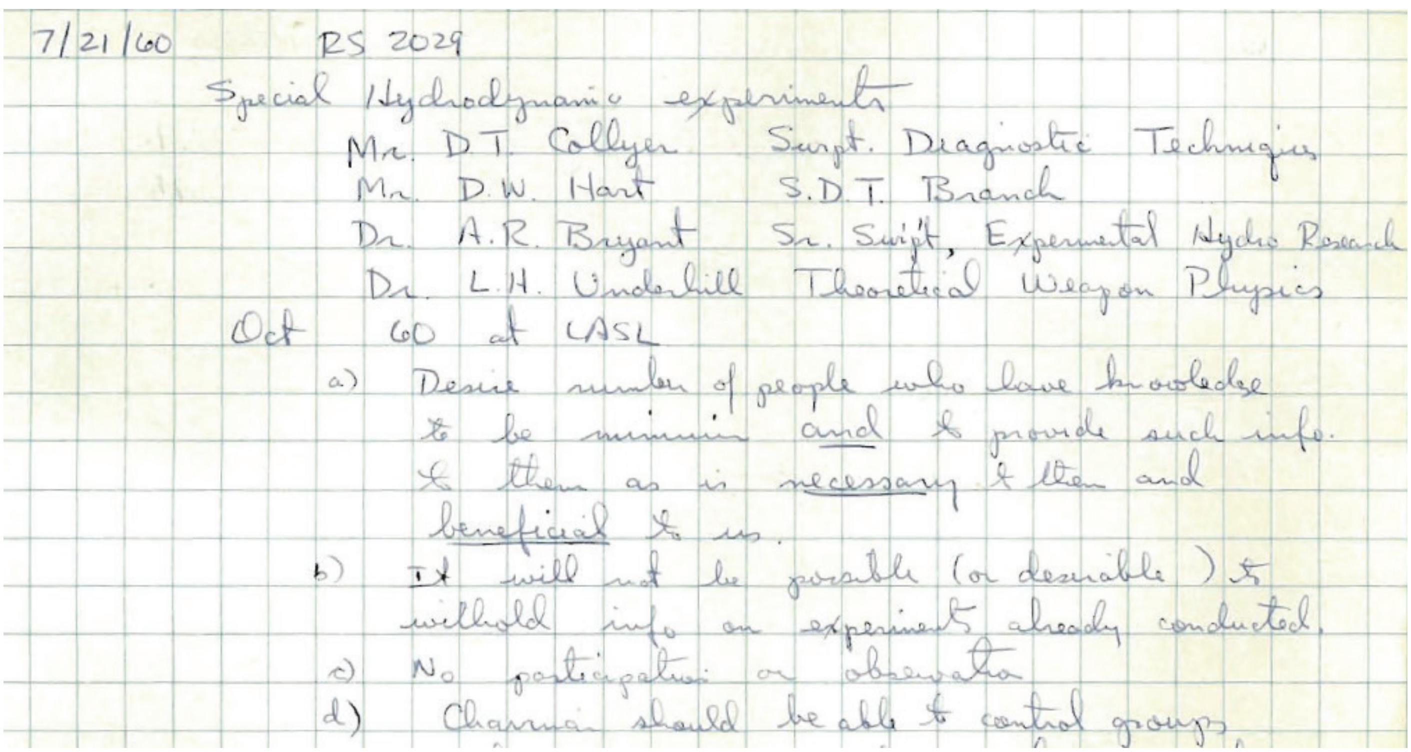

7/21/60 RS 2029
Special Hydrodynamic experiments
Mr. D.T. Collyer Supt. Diagnostic Techniques
Mr. D.W. Hart S.D.T. Branch
Dr. A.R. Bryant Sr. Supt, Experimental Hydro Research
Dr. L.H. Underhill Theoretical Weapon Physics
Oct 60 at LASL
a) Desire number of people who have knowledge to be minimum and to provide such info. to them as is necessary to them and beneficial to us.
b) It will not be possible (or desirable) to withhold info on experiments already conducted.
c) No participation or observation
d) Chairman should be able to control groups,

Figure 13: 1960 note regarding Osborne's hydrodynamic experiments (LA Notebook 10175)

Master and Mentor

> *"The most telling indicator of the impact that Bob had is the overwhelming success that accompanied those staff members that he directly mentored."*
>
> *-Gary Wall, Weapons Designer (retired), Los Alamos National Laboratory*

In a profession like nuclear weapons designer there is no academic path leading to it and no graduate degree to earn in it. There is only on-the-job training under the tutelage of a master. Osborne, the master, served as a mentor to many who went on to become some of the most successful staff at Los Alamos. His mentoring is still considered by those he mentored, and by his peers, to be his most substantial contribution to Laboratory, and to the U.S. nuclear weapons complex.

While Osborne's contributed substantially to various revolutionary developments in nuclear weapon design, due to that era's culture of "distributed attribution" and the academic nature of their teamwork (e.g., mentor and mentee), Osborne tended to push attribution to the team and to younger staff members, even from the beginning of his career.

Thus, it is sometimes difficult—except in his personal work notebooks—to find explicit examples of exactly how he individually contributed to key developments.

> *"He was very quiet, always wore the same glasses, same starched white shirt, a little stooped in stature, and extremely intelligent. (He encouraged) his protégés to be 'rebels' and think outside the box."*
>
> *-John Pedicini, Weapons Designer (retired), Los Alamos National Laboratory*

TITANS Program

Osborne's continued to write and contribute to the Laboratory weapons programs after he retired in 1981. Most notable are the series of papers he wrote that summarize the weapons work at the Laboratory from after World War II until 1981. They also succinctly summarize most of Osborne's technical experiences throughout his career. Many of his works are used on a daily basis by Laboratory staff, and several were used in writing this article.

Indeed, Osborne's works are considered essential reading for educating the designers and engineers enrolled in the Los Alamos TITANS program. TITANS is a two-year program developed as a graduate-level course to train new staff in nuclear weapons design. TITANs helps to fill the gap created by a lack of weapons-design academic programs at universities. The program covers both historical and current stockpile systems. It is the only such program in the country, and it is critical to training new staff so that they have the knowledge and skills required to maintain the nation's nuclear weapons capabilities.

Epilogue

"Bob was extremely meticulous in his work and the notes he took. He mentored the same way, always being willing to listen, provide feedback, and yet make pointed observations. He was known as the expert on one-point safety, and many at the Laboratory consulted him often on their designs, as well as the safety aspects of new designs. He was always helpful to those who sought his expertise on design and one-point safety. He was the lead on the W76 warhead, and yet still found time to review the new (insensitive high-explosive) designs of the W80 and B61 that were being developed in the 70s."

-Gary Wall, Weapons Designer (retired,) Los Alamos National Laboratory

Figure 14: Robert K. Osborne (1961)

Osborne passed away in April 2009, in Santa Cruz, California. Osborne left his imprint on multiple nuclear weapons designs and tests, one-point safety, hydronuclear testing, the development of the W76 warhead, the many influential designers he mentored, and the invaluable notebooks he wrote. Through his written works, he continues to educate and mentor Laboratory staff today. Because of his work, the nation's nuclear deterrent remains safe, secure, and effective.

With the support of the NNSA, Los Alamos continues to scan, digitize, and archive his irreplaceable notebooks (and those of other Los Alamos staff) for use by current and future weapons designers and engineers.

Author: Jeremy Best, Program Manager, Principal Associate Directorate Weapons Programs, Los Alamos National Laboratory (jbest@lanl.gov, 505-667-4765)

Footnotes

(Note: all documents are classified)

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NNSA
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