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Featured Overview

The Point of a Monument: A History of the Aluminum Cap of the Washington Monument

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Editor's Note: For more information on George J. Binczewski and his research, see the article "LMD Member Pioneers Research into the Point of the Washington Monument" in this issue's edition of *Division News*.

Author's Note: When dealing with historical numbers involving monetary units, it is well to give the reader a perspective about the relationship to current times; it is insufficient to use the financial term inflation adjusted. The author prefers to compare the 1884 price of aluminum of $1 per ounce ($16 per pound) to the fact that in 1884 the wage of a laborer on the Washington Monument was $1 per day, and the workday was typically 10 hours or greater in length. Thus, the cost of one ounce of aluminum was equivalent to a full day's work. The highest skilled craftsman on the monument project was paid $2 per day.

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In the history of materials and human events it sometimes happens, however rarely, that a particular time and a consequent circumstance merge to create the opportunity for a happenstance event; subsequently, the event is accorded monumental status within its sphere of application. Such was the case of the small but very expensive aluminum pyramid that was set atop the Washington Monument on its completion in 1884 to serve the functional purpose of a lightning rod. In retrospect, this can be considered a watershed event in the subsequent emergence of the modern massive aluminum industry.

INTRODUCTION

In 1783, a thankful U.S. Continental Congress passed a resolution to keep alive the achievements and memory of George Washington by authorizing the erection of an equestrian statue in his honor. The subsequent history of this seemingly simple commemorative issue is a story that is fraught with the foibles of human endeavor. Suffice to say that nothing of substance was done. Finally, in 1848 a consensus among many involved groups was achieved, and the cornerstone of the Washington Monument was laid. It took another 37 years for the monument to be completed and dedicated in 1885. The history of this 102 year saga of the United States' efforts to honor its first president is well recorded in innumerable books, articles, and manuscripts.

Just as the Washington Monument is an important symbol for the people of the United States, so also is the aluminum pyramid cap at its apex a symbol for the aluminum industry. Indeed, it was accorded this high accolade 50 years after its placement by Edgar H. Dix, then chief metallurgist of the Aluminum Company of America (now Alcoa) when he declared "the crown jewel of the aluminum industry is the cap of the Washington Monument." He made the statement as one of a very small group of experts asked to inspect the condition of the pyramid after 50 years of exposure during the first refurbishing of the monument in 1934. Dix described his overall investigative appraisal in a published article.[1]

The remainder of this article concentrates on the little known and seemingly insignificant events associated with the choice of aluminum for the apex point, which marked the culmination of the monument's construction in December 1884. For a brief overview of the aluminum industry at the time, see the sidebar on page 21.

MAKING THE CAP

With the passage of decades, and then generations, it often occurs that facts associated with significant events are embellished by subsequent storytellers to enhance interest. Sometimes this results in the evolution of myths that raise the event to a legendary status. One such myth concerns the choice of aluminum for the pyramidal cap of the Washington Monument. A book published in the 1990s depicting the evolution of the aluminum can contains a chapter that espouses the attributes of aluminum and states "Americans wanting only the best to commemorate our founding father George Washington, fashioned the Washington Monument apex out of the uncommon metal."[2] Fortunately, the National Archives contain more accurate records of the facts associated with construction of the monument.

Aluminum was not the first choice for the pyramid, nor did the choice involve any material design evaluation, extensive tests, or lengthy comparative competition among available materials. Instead, aluminum was selected as an alternative material during discussions between the engineer in charge of the project and William Frishmuth, the only U.S. aluminum producer at that time.

The engineer in charge of completing the Washington Monument was Colonel Thomas Lincoln Casey, Corps of Engineers, United States Army. He was familiar with William Frishmuth since Frishmuth's foundry in Philadelphia had previously done some plating work for the monument. As the completion of the construction was nearing, Casey sent a request to Frishmuth asking if he could make a metal pyramid that was to serve as the lightning rod. Copper, bronze, or brass, plated with platinum, were the preferred materials. The actual letter is shown in Figure 1.

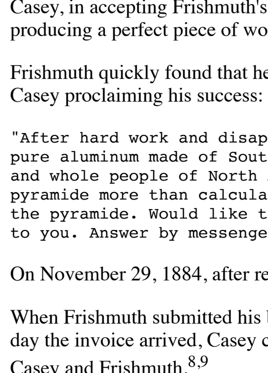

Figure 1. A copy of the original letter requesting a cast metal pyramid for the Washington Monument point.

During the next seven days, Casey and Frishmuth exchanged a series of letters. The actual chronology of the letters can be found in an earlier paper.[6] Frishmuth proposed that the pyramid be made of aluminum at a quoted price of $75, and if he was unsuccessful in casting it in aluminum he would cast it in aluminum bronze and plate it with gold for a total cost of $50, or, if platinum-plated, for $75. Aluminum bronze was an alloy of 90 parts copper and 10 parts aluminum and was quite abundant on the commercial market in 1884. The principal manufacturer was the Cowles Brothers of Niagara Falls, New York, who used a patented thermal process employing an electric resistance furnace and a raw material containing aluminum oxide and copper. The aluminum produced was always combined with the copper and could not be separated from it.

Casey, in accepting Frishmuth's proposal, admonished him that "It is desired that the cost be kept if possible, within the estimate which you submitted, but should that cost be necessarily and unavoidably exceeded in producing a perfect piece of workmanship, the account shall be submitted setting forth that fact."

Frishmuth quickly found that he could not use an ordinary sand mold for the casting and had to get an iron mold made. On November 12, 1884, within two weeks of Casey's request, he sent the often-quoted telegram to Casey proclaiming his success:

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"After hard work and disappointments, I have just cast a perfect pyramid of
pure aluminum made of South Carolina Corundum. Great honor to you, the Monument
and whole people of North America & a little to myself lent. Cost of
pyramide more than calculated. However will state the facts. When do you want
the pyramide. Would like to exhibit for 2 days in this city before express same
to you. Answer by messenger. "
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On November 29, 1884, after receiving the pyramid from Frishmuth, Casey sent a letter to Frishmuth stating, "the point is received and is acceptable in every way."[7]

When Frishmuth submitted his bill for the aluminum pyramid it was for $256.10. Keeping in mind that Frishmuth originally quoted $75 for the aluminum pyramid, it is understandable that Casey was quite upset. The very day the invoice arrived, Casey cut a military order dispatching his assistant, Captain Davis, to go to Philadelphia to investigate the matter. After Davis concluded his audit, a final price of $225 was agreed upon between Casey and Frishmuth.[8,9]

The capping ceremony of December 6, 1884, and the formal dedication of the monument on February 21, 1885, were given front-page publicity in the nation's newspapers and the aluminum point or apex was creditably described. Hundreds of thousands, perhaps millions, of people who had never before even heard about aluminum now knew what it was.

THE CASTING ACCOMPLISHMENT

The aluminum pyramid itself was only 22.6 cm in height, 13.9 cm at its base, and weighed 2.85 kg.

The pronouncement by Winckler[2] cited in the sidebar on the aluminum industry that "nobody knows how to cast it" (aluminum) was made only five years earlier in Europe, where almost all of the world aluminum activity had been occurring. Of course, Frishmuth had his own experience with the metal, but he was attempting to make a larger casting than anyone had previously done. (The sidebar below details Frishmuth's achievements.) He allowed himself the option of making the pyramid in bronze if his aluminum effort was not successful. Further compounding his difficulty were the demands made in Casey's subsequent agreement letter of Oct. 29, 1884, "to secure a solid homogeneous casting," and "a perfect casting of pure aluminum; producing a perfect piece of cast metal quality."Frishmuth knew that the pyramid's sides, after polishing, would be meticulously scrutinized and that any blemish, sand hole, inclusion, or porosity would be unacceptable.

It should be remembered that during that period there was virtually no knowledge of the dissolved gas in aluminum and its manifestation as porosity in the finished casting. Sixty years later, Eastwood[10] cited the case of cast aluminum automobile steering wheels made in the 1915 period that "were polished to a high luster in which the condition of pinhole porosity stuck out like a sore thumb." Frishmuth's casting 30 years earlier avoided this. What did he know in preparing the metal?

There were no filtering or degassing procedures for casting aluminum in 1884. Melting, solidifying, and remelting was the primary means of improving final cast metal quality. The polishing methods for the large surfaces of the pyramid, together with the relatively soft aluminum metal, would have exacerbated any cast surface imperfection (e.g., the familiar comet tail encountered today by people inexperienced in polishing small aluminum metallographic specimens). Finally, the inscriptions engraved on the pyramid's sides would have been adversely affected by any surface imperfection and undoubtedly the meticulous Casey would not have tolerated or accepted this.

The casting's size was only one part of Frishmuth's achievement. The quality of it was quite another.

COMPOSITION

In the 1880s, chemical composition was determined by the wet analysis method, and with aluminum it required experience and care. Most analysis determined only iron and silicon—the major impurities with the metal produced by chemical reduction. The amount of aluminum present was reported by difference and typically was in the range of 97.5%.

Two sources reporting the composition of the pyramid indicate 1.70% Fe, 0.55% Si, and 97.75% Al, and 1.90% Fe, 0.61% Si, and 97.49% Al. Interestingly, during the 1934 refurbishment, it was reported that "several globules of aluminum, fused to the sides of the pyramid after the apex had been struck by lightning, were removed for examination and for microscopic studies." About 1/40th of a gram used for spectrographic analysis of the metal was found to contain 1.00% Fe; 0.75% Si; 0.30% Mn; 0.05% Cu; 0.02% Sn; 0.01% Na, and 97.87% Al (by difference).[1]

THE FUNCTIONAL PURPOSE

While the primary functional purpose of the aluminum apex was to serve as a lightning rod for the structure, it was relegated to a subsidiary role within a few short months. When completed in 1884, the monument was the tallest man made structure in the world at 169.1 m; even today it remains the tallest free-standing masonry structure in the world. Aluminum was chosen for the application because of its conductivity, color, and non-staining qualities. In essence, the aluminum point became a victim of the design application and the lack of data and experience concerning lightning strikes on tall structures.

The overall lightning protection system had seemed quite adequate when designed in 1880. It consists of four hollow wrought-iron columns that stand in the well of the shaft. These act as supports for the elevator machinery and serve as a guide to the car. These columns are 15 cm in exterior diameter and slightly more than 1 cm thickness. The columns rest upon cast-iron shoes that are set in the large drum pit below the monument floor. The cast-iron shoes are connected to soft copper rods that, in turn, lead to the bottom of a water well below the masonry foundation. No disruptive discharge of electricity was experienced between 1880 and 1884.

When the pyramidion was completed with the setting of the top stone in December 1884, four copper rods about 2 cm in diameter were run from each column to the top stone. There they were united with a 3.8 cm diameter copper rod that passed vertically through the top stone and screwed into the terminal aluminum apex. The entire system was completed, tested, and connected and its resistance checked on January 20, 1885.[8]

In June of that year, however, an incident occurred that forced another look at the protection system. In his report to the chief of engineers following the incident, Casey said:

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"On the 8th of June 1885, during a thunderstorm, a disruptive discharge was
seen to pass between the summit of the pyramidion and the cloud. Upon examining
the structure, a crack was discovered in the north face of the pyramidion just
under the top stone. A small piece was forced outward 3/4 of an inch. It was
forced back into place and bolted to the solid stone from which it had been
torn."[8]
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This event caused considerable concern and resulted in Casey seeking the advice of professional consultants from John Hopkins University, the U.S. Navy, and the U.S. Signal Service. Upon examining the monument and appraising the conditions, modifications were recommended and implemented. This consisted of four 1.27 cm copper rods, fastened by a copper band to the aluminum terminal and led down the corners of the pyramidion (approximately 18 m), then passed through the masonry and joined to the internal iron columns of the elevator shaft. Numerous other copper rods were added in the interconnecting network. All of the added exterior copper rods and bands were gold plated and studded every 1.5 m of their lengths with copper points 7.6 cm in length, gold plated, and tipped with platinum.[8] Eight points were also added to the top edge of the copper band mechanically affixed to the aluminum pyramid. These are visible in Figure 2.

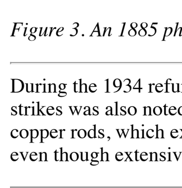


Figure 2. A depiction of 1885 modification to the lightning rod system with gold plated copper bar girdling the aluminum pyramid near its base and s erving as an attachment point for gold-plated copper rods added to full-length corners of the pyramidion.

In a sense it was fortuitous that the construction platform (Figure 3) on the pyramidion was still in place during the middle of 1885, having been left there to complete some finishing touches. It provided a means of assessing the lightning strike damage and also a scaffolding to install the additional lightning arrester hardware.

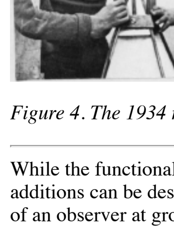


Figure 3. An 1885 photograph of the construction platform used to complete the pyramidion. (Source: National Archives, record group 42.)

During the 1934 refurbishment of the monument's exterior, it was noted that lightning strikes had blunted the tip of the aluminum apex and some globules of aluminum had fused to the sides. Some deterioration from strikes was also noted on the original gold plated copper points inserted vertically into the copper band affixed to the base point perimeter of the apex in 1885. It was decided to replace this band and points with eight larger copper rods, which extended in a slightly different configuration 15.2 cm above the aluminum apex itself (Figure 4). Essentially, only refurbishment rather than redesign of the lightning protector system was done in 1934, even though extensive design experience had been gained in this field during the preceding 50 years with the building of massive, taller, city skyscrapers.

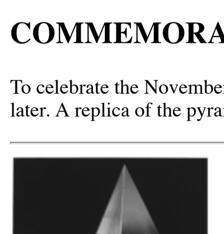


Figure 4. The 1934 refurbishment with workmen setting larger rods into the copper bar girdle.

While the functional purpose of these rather massive vertical rod additions may be justifiable from an engineering standpoint, it certainly detracts from the architectural aesthetics of the monument. These post capping additions can be described as constraining the aluminum pyramid with a girdle of copper bars and topping it with a crown of thorns. In this sense, it is just as well that the monument tip is really not visible to the human eye of an observer at ground level.

At this juncture, it was of no consequence whatever that the reason given by Casey for choosing aluminum for the apex in 1884 was "because of its whiteness and the probability that its polished surfaces would not tarnish upon exposure to air."[8] Essentially this was achieved since the original 1884 inscriptions were still readable in 1934.[1]

The obvious question this raises is why was aluminum not used in 1885 for the four rods run down the external corners to the base of the pyramidion? Additionally, these were tied with more such rods that circled its girth in several locations. There are several answers: aluminum was not commercially available in that size of rod form at that time, while copper rods had long been a market commodity; the amount of aluminum needed was about 59.6 kg while Frishmuth's total 1885 production was only 28.3 kg spread throughout the year (aluminum could have come from France where there was plenty of it, but it would have taken months to arrive); and the girdle bar of copper fastened by set screws to the aluminum pyramid was added to facilitate the connection of the added copper rods on the edges to the central conducting conduit that included the aluminum pyramid.

COMMEMORATING THE CASTING

To celebrate the November 12, 1884, casting of the original aluminum pyramid for the monument, a commemorative centennial event was held in the same Frishmuth building that was still operating as a foundry 100 years later. A replica of the pyramid, exact in size, weight, and composition, was cast on November 12, 1984 (Figure 5), and was again displayed by Tiffany's in New York (Figure 6).

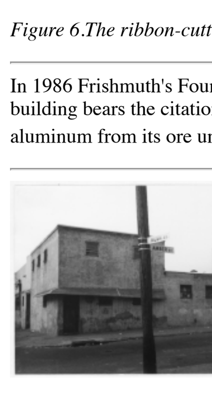


Figure 5. Polished and engraved replica of the aluminum pyramid cast in the same foundry 100 years later\emdash November 12, 1984. The two views show the engraving on the four sides of the pyramid.

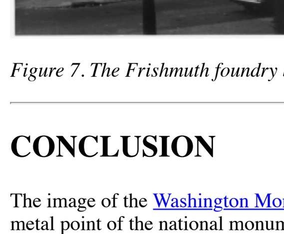


Figure 6.The ribbon-cutting ceremony at Tiffany's at their New York location on November 15, 1984.

In 1986 Frishmuth's Foundry at Rush and Amber Streets in Philadelphia (still producing commercial castings) was declared a historical landmark by ASM International (Figure 7). A cast aluminum plaque affixed to the building bears the citation "Colonel Frishmuth's Foundry has been designated an Historical Landmark .... The site of the first commercial aluminum reduction facility in the United States of America and the only producer of aluminum from its ore until the late 1880s." The casting of the Washington Monument pyramid point is not mentioned.[14]

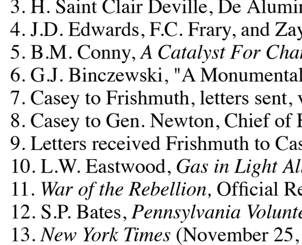
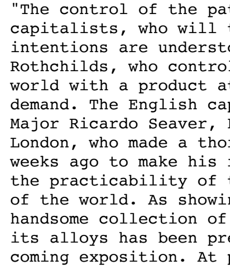


Figure 7. The Frishmuth foundry building in 1983 operating under the name Eastern Nonferrous Foundry. The street signs are made of aluminum.

[illegible]

Figure A. An elaborate aluminum surveyor\rquote s transit made in Troy, New York, with the metal source attributed to Wm. Frishmuth Manufacture. It was exhibited at the 1876 Centennial Exposition.



Frishmuth's patent for making aluminum was an improvement over the Deville method and avoided the need for the expensive solid sodium. Instead, he generated sodium vapor in a retort that contained sodium carbonate and a reducing agent. In a separate retort he produced aluminum chloride vapor. The two vapors were combined at elevated temperature, and the chloride was reduced producing a mixture of aluminum and sodium chloride in liquid form. The raw materials Frishmuth said he used were cheap and abundant. The process was also reported to reduce wear and tear on the equipment, a very important consideration at that time. (I once arranged an experimental duplication of the teachings in the Frishmuth patent. This verified that aluminum metal was produced when the gases of aluminum chloride and sodium were combined. No attempt was made to appraise the economic factors in terms of conditions existing in the 1880s or the 1980s.)

Frishmuth, like most inventors, was quite secretive about disclosing specific details of his process. He was always seeking process backers and many of his patent assignments reflect this. Perhaps the most revealing status of Frishmuth's achievement is contained in a 1,500 word article that appeared in the November 25, 1884, edition of the *New York Times*. The article's final paragraph presents a most favorable and optimistic assessment. It reads,

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"The control of the patents for the new process has been secured by foreign
capitalists, who will thus have the whole world for their market. Their
intentions are understood to be similar to the policy pursued by the
Rothchilds, who control the Quicksilver mines of the world, viz to feed the
world with a product at a reasonable price, and regulate the supply by the
demand. The English capitalists controlling the patents some time ago sent over
Major Ricardo Seaver, F.R.S.F., late Government Inspector General of Mines, of
London, who made a thorough examination of the process. He returned home a few
weeks ago to make his report. He is said to have been thoroughly satisfied with
the practicability of the process and its successful application to the needs
of the world. As showing what has been done at the Philadelphia works, a
handsome collection of the metal in bulk and articles manufactured from it and
its alloys has been prepared and sent to New Orleans for exhibition at the
coming exposition. At present anyone in New York or vicinity wishing to see a
specimen of the product can do so by visiting Tiffany's, where the apex for the
Washington Monument at the National Capitol, manufactured by order of the Government, is now on exhibition."
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Frishmuth has not been accorded the honor and recognition for his manifold achievements and contributions. His technological accomplishments are exemplified by his 12 patents in the fields of electroplating, aluminum production and casting, galvanic batteries, and portable electric lights. His strong socio-political convictions and service to President Abraham Lincoln are a testament to his character. His business acumen and public relation activities indicate a perceptive person who knew how to deal with people.

By the early 1890s, the chemical reduction method for making aluminum had succumbed to the new low-cost electrolytic process of C.M. Hall. Frishmuth became the victim of a combination of business, legal, and personal difficulties. On the morning of August 1, 1893, William Frishmuth was found in his Philadelphia home at Frankford Avenue and Tioga Street dead from a self-inflicted gunshot wound in the head.

—SIDEBAR 3—

ANECDOTES

Another example of the fiscal responsibility and frugality of Casey takes on an almost humorous bent in the context of our own times. On November 14, 1884, Casey wrote a letter to the first controller of the U.S. Treasury Department explaining that 10-15 men were working on the top of the monument and "are much exposed to the weather and are frequently chilled through and through." Therefore, in the interest of completing the monument before February 22, 1885 (George Washington's birthday), he asked to "issue hot coffee in moderate quantities to the end that the best services of the workmen in the construction be secured." Casey concluded by asking the controller "I shall be pleased if my accounts for this expenditure will receive the approval of your office." Here we see a person who has the responsibility for the entire monument project extending over several years not having the discretion for such a trivial expenditure; a pound of coffee in 1884 cost less than ten cents. Where and when did the government lose that type of fiscal responsibility? It should be mentioned that the treasury controller's response to Casey stated that his bills for coffee furnished to the workmen would be allowed.

It is a notable aside that all of the correspondence on this subject in the National Archives files is in handwritten form, even received Western Union telegrams. While various models of typewriters had been in commercial use by 1884, they had not yet been standardized and were too expensive for government agencies or small foundries such as Frishmuth's.

The ceremony for the placement of the aluminum point appeared as a large 17 cm by 25 cm sketch in the center of the front page of the Washington Post 16 hours after the fact in its December 7, 1884, edition. This picture has been reproduced thousands of times and is today prominently displayed whenever the monument is described. It appeared as a finely detailed, five-color lithograph in the December 20, 1884, issue of *Harper's Magazine*. *[The sketch is reproduced on the cover of this issue.—ed.]* While the art of photography was well established by 1884, the gale force winds and driving rain at the 169 meter platform level precluded the taking of an actual photo. An artist's sketch of the event had to suffice.

Frishmuth's public relations savvy and skills are exemplified by his ability to get the attention of the famous Tiffany's jewelry store in New York. In late November 1884, Tiffany's displayed the polished aluminum pyramid for the benefit of "thousands of New Yorkers who delighted in being able to later say `I stepped over the top of the Washington Monument."[13]

Frishmuth created much consternation for Casey by delaying the delivery of the pyramid to Washington, D.C. while he publicized and displayed it in different places. After Casey literally threatened him, Frishmuth sent the pyramid with a letter request to Casey to exhibit the point in the House and the Senate.[9]

Frishmuth's self satisfaction and pride in his accomplishment is exemplified by his request to Casey to have the pyramid wiped with a chamois to remove fingerprints after it had been set in place atop the monument.[9]

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