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STRUCTURAL TREATMENT OF A MONUMENTAL JAPANESE BRONZE EAGLE FROM THE MEIJI PERIOD

Marianne Russell-Marti and Robert F. Marti

Background

In 1935 the Kansas City developer, J. C. Nichols, installed a number of sculptures on the green strip on the Ward Parkway to create a "Mile of Art". This major installation, which included sculpture, stone fountains and architectural elements, was intended to add beauty and interest to the roadway, and to attract developers to the fine new neighborhoods being built in this area of Kansas City, Missouri (Nichols).

A focal point of the installation is a massive Japanese bronze eagle located on the Parkway at 67th Street (Figure 1). The sculpture is of the Meiji period, dating from the late 19th century to the early 20th century. The eagle measures 7 feet from beak to tail, has a wingspan of 14 feet, and rests on a 5-foot tall mountain/base. The total height from base to wingtip is approximately 14 feet. Little is known of the provenance of this sculpture. It was reportedly exhibited at the 1904 Saint Louis World's Fair (Nichols), but research into documents from the St. Louis Fair and other International Exhibitions did not turn up any information on this particular sculpture. Certainly during the Meiji period a great deal of art was produced for export to the many International Exhibitions taking place all over the world, and it is possible that the eagle was one of these export pieces (Fairley 1991).

The sculpture was originally constructed and assembled in separate sections, which included the eagle body, the head and neck, the wings, and the mountain/base. These sections were originally fitted together by means of mechanical attachments tied in to an internal structure. The bronze base, or mountain, was cast in numerous smaller sections which were later joined, in some areas successfully, in some areas not, by fusing adjoining edges with molten bronze (Gowland 1915, Stewart 1976). In the modeling before casting, and in engraved details on feathers after casting, great attention was originally given to surface finish to create a decorative and at the same time a life-like presence. There are four basic styles of feathers on the eagle. These include both high relief and low relief feathers modeled in place prior to casting, and individually cast feathers and feather groupings which were applied after the bird was cast.

By the time the sculpture was installed on the Parkway in 1935, the original internal armature had deteriorated to the condition where it was no longer functional, presenting the Kansas City workers with the difficult problems of holding the very heavy, extended shapes of the individual sections of the sculpture together, and of supporting the eagle on its base. The solution in 1935 was to fill the entire sculpture with concrete, and iron reinforcing rods (commonly referred to as rebar). The reinforced concrete did hold the eagle together for over 50 years, but it also caused severe damage to the sculpture, cracking and splitting the bronze through the action of freezing water on the interior.
We carried out conservation treatment on the sculpture from August of 1990 to November of 1991. While the treatment addressed all of the condition problems described below, this paper will focus on the design and construction of a new internal support system for the sculpture. During all aspects of our treatment, decisions and solutions were based on the fact that the sculpture was going to be returned to the same outdoor environment it had been in for over 50 years, susceptible to the same wind and weather conditions, pollution, and the ever-constant potential of physical contact by the public.

Condition

The condition problems of the sculpture included the general loss of its original structural support system, problems related to previous repairs, missing parts, and corrosion of the bronze from being in an aggressive outdoor environment.

The combination of loss of structural integrity, a number of original casting flaws, and the presence of the concrete resulted in an extensive system of breaks and cracks running throughout the eagle and the base. In some areas the cracks ran through or across design elements (Figures 2 and 3). In many areas on the sculpture, the expanding ice had caused splitting along previous casting flaws, or "cold shuts", where the cast molten metal solidified before it could flow to fill an entire area and make it one cohesive unit of bronze. These areas had been masked at the foundry by soldering bronze feathers over the gaps, but had opened up due to freeze/thaw cycles subsequent to the sculpture being filled with concrete.

Previous repairs also accounted for aesthetic problems and damages. Large hex-head bronze bolts had been used to help hold the wings on and to strengthen ankle joints (Figure 4). These contrasted with the otherwise naturalistic appearance of the eagle. A number of detached sculptural elements, joints, and breaks had been repaired by welding. The welding was generally unsuccessful, often without proper bonding of the metal. Many of the welded areas had been roughly ground down using a grinding tool. Grinding had obliterated sculptural detail on the front planes of the wings.

There were a number of missing parts and damaged areas on the sculpture. Losses included the decorative copper alloy insert in the left eye, and major damage to the insert in the right eye. The area underneath the tail was extensively damaged, missing most of the individual feathers and feather groupings. Many other feathers were missing throughout the sculpture, and a number of cast bronze vine leaves were missing from the base. Like many of the feathers, the vine leaves had been cast individually and applied to the base after it was finished, by means of copper rivet-like pins. Only about three leaves and fragments remained on the sculpture, the locations of the others indicated only by a number of small round holes.

While the sculptures are located in a well-to-do residential neighborhood, the Ward Parkway has
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become a major thoroughfare through Kansas City, with heavy automobile traffic day and night. As a result, the bronze had undergone deterioration from corrosion activity, resulting in pitting and loss of metal. The green and black corrosion products were visually disfiguring, were voluminous in some areas and camouflaged sculptural detail, and presented a very different appearance than the colorful and often naturalistic patinas generally associated with figurative sculpture of the Meiji period. Careful excavation through the layers of corrosion products under magnification did not reveal areas which we considered to be remnants of original patination.

Disassembly and Notes on Construction and Composition

The first stage of treatment was disassembly and removal of the sculpture to our workshop. The eagle was dismantled according to its original construction, at original joints. Disassembly, along with the removal of the nearly solid core of concrete from the interior of the sculpture, revealed additional information on the construction of the eagle and of the mountain/base.

The head and neck had been cast as one piece, and was attached to the body by eight tapered pins inserted through drilled holes in the feathers at the base of the neck. These connections held the head firmly, but did not provide sufficient overall support.

Removal of the head and neck revealed the extensive use of rebar from the 1935 repair inside the body cavity and wings. The rebar was of several different sizes, ranging from 1/2 inch round to 1 1/4 inches square. The rebar originated in the body cavity, and extended approximately one-third of the distance into the wings. The areas surrounding the rebar had been entirely filled with concrete.

The rebar was cut with a torch to allow removal of the wings. The wings are constructed to slide into receiving slots in the body cavity. The overlap of the wing base inside the body was probably originally secured by means of four bronze pins inserted through drilled holes in the wings and the shoulders. These pins had subsequently been replaced with the large bolts and nuts, probably dating from the 1935 repair. After much of the concrete was cleared from the wing cavities, a very deteriorated and apparently original wrought iron armature was found (Figure 12). The shape of the armatures is a general S shape, attached to the interior of the wing near its far end and to the interior of the body at the other end. The original anchoring system to the interior of the body was no longer evident. Conforming to the contour of the wing, the S shape allows for gentle compression and stretching of the armature with the up and down movement in a wind.

After the wings were removed, the body was lifted off of the base along the original joint of the ankles to the feet (the feet are cast as an integral unit with the top of the base). The eagle probably was originally supported on its mountaintop by two tapered bronze and iron extensions which were inserted into the feet, and likely would have been attached to a support structure.
inside the base. In cross section these extensions have a core of iron surrounded by cast bronze, indicating that the bronze was poured with the iron rods already in place. While the iron had almost completely deteriorated, the four-inch long bronze extensions remained at the ends of the legs. No trace of an original support for the eagle body remained in the mountain itself.

The mountain/base had to be cut along original joints in order to allow its disassembly. The bronze mountain was in extremely poor fragmented condition, with large areas of loss which had been bridged by the solid mound of concrete present on the interior (Figure 5). The foundry work on the base was very inconsistent. There were sections where the casting was flawless, of thickness slightly less than 1/4 inch, adjacent to sections riddled with cold shuts and ranging in thicknesses from 1/16 inch to over 1/2 inch.

Following disassembly, the concrete remaining inside the sculpture was removed using a 20 lb. electric hammer. It required one person working for five days to clear the interior of the sculpture. As the concrete was removed, large amounts of black core material were found adhered to the sides of the interior. The core material was a dense conglomeration of what appeared to be a natural cereal grain with tiny 1 mm "pebbles" embedded within the mass.

Prior to beginning structural work, metal samples were analyzed by Inductively-Coupled Plasma (ICP). The three principal components of the bronze were found to be the following: Copper 73%, Lead 15%, and Tin 5.5%. The alloy corresponds closely with a Japanese art bronze alloy karakane, in which the proportions of copper may range from 71 to 80%, of tin from 2 to 8%, and of lead from 5 to 15% (Gowland 1915).

The high level of lead in the alloy is credited with giving karakane the following desirable characteristics: low melting point, excellent flow properties when melted, capability of reproducing fine and sharp surface details, low shrinkage upon solidification, smooth surfaces, and capability of receiving rich and varied patinas (Gowland 1896). The high amount of lead is also responsible for the extreme brittleness of this alloy, its chief disadvantage. Brittleness occurs because the lead is not fully dissolved in the alloy, but instead sits in the bronze as a separate phase. Excavation of the bronze under magnification, or even a look at a break edge on the eagle, showed shiny, distinct, soft chunks of lead embedded within the matrix.

**Treatment: Construction of a New Internal Support System**

Of primary consideration in the structural work was the need to give stability to the heavy and extended forms of the eagle. The eagle weighs approximately 800 pounds including the two wings, each of which weighs upwards of 200 pounds. The extreme thinness, faults and damages found in sections throughout the mountain/base meant that it could not function in a load-bearing capacity.
An internal support system was designed to solve these problems of holding together the various components of the eagle, and of supporting the eagle on its base. Based on our observations of the remains of the original structure, the original design of the bird's construction and support system was well-conceived, simple and elegant. We therefore tried to use and adapt these same concepts as we carried out the structural aspect of the treatment, but with different materials. We also retained the system of keeping the eagle in distinct sections, allowing for disassembly in the future.

Other aspects of treatment were taking place simultaneously with the structural work, and are briefly described below. However, the repair of the extensive damage to the original fabric of the sculpture -- closing cracks and cold shuts and filling losses -- was an integral part of the structural treatment, in that the individual components of the sculpture -- the base, the head and neck, and the body -- needed to have structural integrity themselves in order to be successfully incorporated within an overall structural system.

Prior to beginning work, we consulted the Copper Development Association (CDA) for advice on which alloys would be best for construction of the armatures, for welding and for repairs. For structural purposes, the metal needed to be of the proper composition and dimensions to offer sufficient strength, yet not add excessive weight to the sculpture as a whole. For welding and patching, the alloy needed to be of the right composition to blend with the old when chemically patinated, and in all applications new metal needed to be chosen which would not promote corrosion through galvanic activity between adjacent new and original sections.

A tower was constructed inside the base, designed in such a way as to support the eagle independently of the base's bronze skin (Figure 6). Square tubing (0.049 inches thick) of a copper-zinc alloy (called red brass) was used for the tower, chosen because it is strong and lightweight. The support structure rises inside the base, ending just short of the top of the mountain. The tower welded to the interior wall of the base at the top and at the bottom. A number of additional attachments were made in the lower third area of the mountain, making the tower and the base an integral unit, and giving added structure to the inherently fragile base (Figure 7). When assembled on site, the mountain is anchored with bronze bolts to a stone and concrete pedestal.

Two round brass tubes or sleeves were incorporated into the upper configuration of the tower to receive the structural support system for the eagle body (Figure 8). Aluminum-nickel bronze rods were welded into the bronze extensions at the ends of the legs, replacing the deteriorated iron rods (Figure 9). When the sculpture is assembled, these new extensions pass through the openings in the bird's feet on top of the mountain and slide into the brass tubes in the top of the new structural tower inside the base. The rods, designated C630, are one inch in diameter. We used this stock because of its high tensile strength, comparable to mild steel yet more compatible with the original fabric of the sculpture. When the two parallel rods are in place in the receiving sleeves of the base, no additional anchoring is required.
The welding wire used throughout the project was designated AWS A5.7 9, 0.030 inches in diameter. The CDA advised us to match the tin content of the eagle and that of the welding wire as closely as possible in order to achieve a good color match when repaired areas were repatinated. Welding of the eagle sculpture proved to be extremely difficult because of the high lead content of the bronze. Throughout the project we were very fortunate to work with Walter Breidenbach, a welder with over 30 years' experience, who had the skill, the interest and the patience to successfully weld this very difficult material.

An internal support structure was welded inside the eagle's body and in the neck (Figures 10 and 11). The same lightweight square tubing used inside the mountain was used inside the eagle. The head/neck assembly was fitted with a brass extension which slides into a receiving slot built into the body armature. The neck is further secured by eight tapered brass pins, using the same holes as the original system.

Access panels were cut into the underside of the outermost areas of the wings, to allow removal of the deteriorated original wrought iron armatures. Aluminum-nickel bronze rods, one inch in diameter, were welded inside each wing at one end, at the same locations as the connections of the original rods (Figure 12). The new rods were shaped to the same S conformation as the originals. The access panels were put back in place by welding. The free ends of the new rods were threaded, and slide into a receiving section in the eagle body armature (Figure 13). They are drawn into a snug fit and secured with brass nuts. The wings are further secured to the body with tapered bronze pins at the shoulders, replacing the large nuts and bolts (Figure 14).

The entire sculpture can readily be disassembled in the future when necessary. This would be accomplished by 1) removing the pins around the eagle's neck, 2) sliding the head/neck assembly out of the interior body armature, giving access to the interior of the sculpture, 3) unbolting the wings from the body armature and removing the pins at the shoulders, followed by removal of the wings, 4) lifting the eagle body up out of the armature inside the base, and 5) unscrewing the bolts out of the top of the pedestal, to release the mountain from its anchoring. The weight of the entire new armature is less than 200 pounds.

Summary of Additional Treatment Steps

Repairs

Extensive repairs were carried out on all of the sections of the sculpture. Repairs included patching holes and casting flaws, and welding sections of the sculpture back together. All patches were put in place by welding. The patch material was 1/16 inch sheet, copper alloy designation C510, phosphor bronze. It was chosen because the copper, tin and the zinc content of this alloy were the closest to the copper, tin and zinc content of the sculpture. Repair work included approximately 500 hours of welding, and nearly 1,500 hours of chasing, or finishing, the welds.
Replacement of Missing Parts

New eyes, numerous missing feathers, and leaves on the base were made for the sculpture. The eyes were reconstructed according to the typical Meiji design of inset gold eyes with a dark pupil (Fairley 1991, Gowland 1915). Based on the fragment of the insert remaining in the eagle's right eye, it was clear that the eyes were of this configuration.

The duplication of missing feathers was generally straightforward, as most losses were within areas of a repeating design motif. In these areas replacement parts were made to match the basic design of the surrounding feathers. Feathers and leaves were cast in bronze, using molds taken of several original feathers and leaves on the sculpture. In some areas, feathers larger than the repeating feather motifs needed to be made. These were constructed using the C510 sheet bronze. The missing feather grouping underneath the tail was almost entirely reconstructed with the new cast bronze feathers, using evidence of the original configuration of the tail as a guide (there were traces of solder indicating where feathers had been placed). As a deterrent to vandalism, the new feathers and leaves were secured to the sculpture by means of plug welding. There were several areas on the eagle where we did not feel confident in replacing losses, as there was no clear indication of what the design could have been.

Surface Treatment

In areas where a brown oxide layer was found, the overlying green corrosion products were removed from the bronze using a 50:50 mixture of ground walnut shells (60/100 mesh) and glass beads (140 mesh) at 35-40 p.s.i. A 30:70 mixture of walnut shells to glass beads, at 50 p.s.i., was used to remove corrosion products where no brown oxide layer was present.

The sculpture was patinated using heat applied by torch, and dilute solutions of cupric nitrate and ferric nitrate. Where it existed, the brown oxide layer was incorporated into the new patina. As no documentation could be found describing the appearance of the sculpture prior to surface deterioration, the coloration of the patina was based on other Meiji bronzes, especially sculptures of eagles.

After traces of patination chemicals were rinsed from the bronze with water, the sculpture was given several spray applications of the protective coating Incralac. Some areas of patina were adjusted with thin applications of pigmented wax, followed by another spray application of Incralac.
Final Comments

The eagle was reinstalled on the Ward Parkway in time for a rededication ceremony on November 11, 1991. The instability of the sculpture, and the extensive damages, required a course of treatment more involved than is generally needed for outdoor bronze sculpture, and the extent of obviously missing design elements called for a high amount of restoration. Still, more work could have been done on the eagle, especially in the reconstruction of missing parts. Perhaps further historical research will turn up additional information on this sculpture to aid in a more complete reconstruction. However, the treatment has given stability to an otherwise unstable, even precarious sculpture, and the restoration of some of the losses allows the eagle to be experienced as an intact representation of the wonderful sculpture of the Meiji period.

Acknowledgments

Many people helped us in all aspects of this treatment. Our heartfelt thanks and admiration goes to Walter Breidenbach, our welder, without whom the project might not have been possible. We are very grateful to Dr. Daniel Kremser, of the Department of Earth and Planetary Sciences at Washington University, for arranging the ICP analysis, and to Dr. Leon Stodulski of the Detroit Institute of Arts and Dr. Bill Blanchard (formerly of the DIA) for analysis of the corrosion products. Many thanks to Dr. Carl Dralle and other corrosion engineers at the Copper Development Association, for their invaluable help in the structural issues, including review of our proposed solutions, and suggestions for materials. We are grateful to Mr. Emil Schnorr of the G.W.V. Smith Art Museum, for referring us to the writing of W. Gowland. A very special thanks to Mary Kastens, for her creative and untiring research into this sculpture and the art of the Meiji period. We would like to acknowledge our clients, the City of Kansas City Departments of Parks and Boulevards, especially Mr. R. Peter Loughlin, Landscape Architect, for providing support and working with us closely in all aspects of the work. And many thanks to Andrew Breidenbach, Clyde Adams, and Francis Marti, for long and cheerful hours of "hands on" work throughout the project.

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References


Nichols, undated. Unpublished scrapbooks of the J.C. Nichols Company. Volume 12, numbers 234-38 included a brief 1935 newspaper clipping and the minutes of a meeting regarding the donation of the eagle. The scrapbooks are stored at the University Archives, University of Missouri -Kansas City, Newcomb Hall, Room 302, 5100 Rockhill Road, Kansas City, Missouri 64110-2499.


Endnotes

1. Photographs and catalogs from the following international Exhibitions were searched: 1) the 1876 Philadelphia Exposition, 2) the 1893 Columbia Exhibition in Chicago, and 3) the 1904 St. Louis World's Fair.

2. Besides the documented artwork displayed at the exhibitions, a number of sculptures were created for use as architectural ornaments at the elaborate fairgrounds. These were later sold off after the exhibitions closed. It is possible that the Kansas City eagle was such a piece. (Personal communication with Mr. Francis Caro, Jr.)

3. Samples of green, red, and black corrosion products were taken from several areas of the sculpture and sent for analysis by Dr. Leon Stodulski at the Detroit Institute of Art. A discussion of the analysis is not within the scope of this paper, but interested parties are encouraged to contact the authors for more information.

4. The core material has not been identified by analytical methods, but was readily recognized by Mr. Takuya Kosugi, a Japanese metal artist knowledgeable in traditional metal working techniques. Mr. Kosugi identified the grains in the mixture as rice husks, a traditional agent in core material mixtures.
The complete analysis of two samples is the following (the analysis was carried out by Dr. Ted Huston at the University of Michigan):

<table>
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<tr>
<th></th>
<th>Sample from Base</th>
<th>Sample of Feather</th>
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<tbody>
<tr>
<td>Zn</td>
<td>2.3</td>
<td>0.53</td>
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<tr>
<td>Cu</td>
<td>73.5</td>
<td>72.7</td>
</tr>
<tr>
<td>Pb</td>
<td>14.3</td>
<td>15.0</td>
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<tr>
<td>Sn</td>
<td>5.6</td>
<td>5.4</td>
</tr>
<tr>
<td>As</td>
<td>0.6</td>
<td>0.40</td>
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<tr>
<td>Fe</td>
<td>0.35</td>
<td>0.15</td>
</tr>
<tr>
<td>Ni</td>
<td>0.15</td>
<td>0.14</td>
</tr>
<tr>
<td>Sb</td>
<td>less than 0.05</td>
<td>0.65</td>
</tr>
<tr>
<td>Ag</td>
<td>0.07</td>
<td>0.02</td>
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<td></td>
<td>96.5</td>
<td>95.0</td>
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Gowland discusses the brittleness of items cast from karakane as follows: "They are often low in tenacity, and offer but little resistance to bending and torsion when compared with simple copper-tin bronzes, ... . Their use is hence almost limited to the production of objects of art. And even for those art castings, such as, for example, large equestrian or other statues, where a considerable strain has to be borne by certain parts, their use is inadvisable. ...I do not think they could be advantageously used for statues or monuments exposed to the weather in the impure atmosphere of our great towns, but for castings protected from these combined adverse influences I think the Japanese bronze "karakane" is worthy of a trial." (Gowland 1896, p. 645)

The composition of C630 is Cu 82%, Al 9.5%, Fe 2.5%, Ni 5.0% and Mn 1%.

The composition of AWS A5.7 is Cu 95.87%, Sn 4.0%, P 0.10 %, Al 0.01%, and Pb 0.02%.

The composition of C510 is Cu 83.7%, Sn 5.0 %, Zn 0.3 %, Pb 0.1%, P 0.05%. It was not an issue to match the lead content of the sculpture, as the high amount of lead is not truly part of the alloy.

Meiji eyes of this style were composed of gold foil over a copper alloy inset, with a central pupil of shakudo. Shakudo is a copper alloy containing silver and approximately 4% gold. It is used because it acquires a distinct and beautiful blackish color when patinated.

Incralac is a proprietary coating developed for use on copper alloys, containing Acryloid B-44 (Rohm and Haas) and the corrosion inhibitor benzotriazole. Available from Stan Chem, East Berlin, CT (203) 828-0571.
Figure 1. General view of sculpture in situ, before treatment.
Figure 2. Detail of proper left side of neck, showing the extensive cracking and breaking of bronze due to ice formation. The concrete used in the 1935 repair is visible on the interior of the neck.
Figure 3. Diagram used in our initial Examination Report and Treatment Proposal (April 2, 1990), showing the crack systems and other damages to the eagle.
Figure 4. Detail, front view of eagle before treatment. Note the large bolts at the shoulders, and the icicle hanging from the proper left wing. The eye insert is also damaged and incomplete.
Figure 5. Section of mountain/base, during removal of the concrete. The base is lying on its side, bottom towards the right.
Figure 6. Middle section of new tower inside mountain/base. The upper section of the mountain is being lowered over the tower.
Figure 7. Interior support structure, looking up from the bottom of the mountain/base.
Figure 8. Detail of the support structure, looking up from bottom; shows one of the brass tubes welded into the tower, to receive the leg extensions of the eagle body. The tube is lined up with the opening in the bird's feet at the top of the mountain.
Figure 9. New bronze rods welded into the original extensions on the eagle's legs.
Figure 10. Support structure inside the eagle's body, designed to hold the head/neck and the wing armatures.
Figure 11. Support structure and extension inside eagle's head/neck. (Also refer to Fig. 14 for a more complete depiction of the configuration of the head/neck armature.)
Figure 12. Detail of wing with access panel cut out. The original wrought iron armature is shown lying on the outside of the wing. The new wing armature is visible on the interior, welded at one end, in the same location as the previous armature.
Figure 13. Detail of the body end of wing, showing the threaded end of the new armature. The photograph also shows bronze shims and partial end-plates, tack-welded in place, to achieve a snug fit of the wing in the body.
Figure 14. Diagram giving an overall view of the new support structure of the eagle.
Figure 15. General view, in situ, after treatment.