

Magnetic Survey to Find Axle from Observation (Ferris) Wheel Used in the 1904 St Louis World's Fair

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Background

The largest fair ever held in the country up to that time was the 1904 Louisiana Purchase Exposition in St. Louis. [See http://en.wikipedia.org/wiki/Louisiana_Purchase_Exposition] This 1904 'World's Fair' was the centennial celebration of that original historical event that established St. Louis as the de facto "Gateway to the West," commemorated in 1966 by the famous 630-foot Arch on the banks of the Mississippi River.

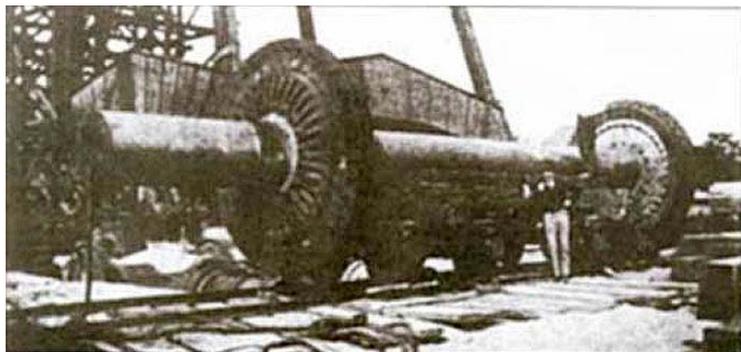
The St. Louis World's Fair featured, among many other spectacular attractions, an observation wheel, we now call a Ferris wheel, 260 feet tall, holding more than 2,000 passengers. Originally built for the Chicago World's Fair of 1893, it was purchased by the St. Louis organizers, shipped to St. Louis on rail cars and re-installed in St. Louis. [A complete account of the Ferris wheel, its design by George Ferris and construction appeared in Erik Larson's 2004 best-seller, *The Devil in the White City*.]



The Ferris wheel was arguably the most popular feature of the Fair. In 1906, well after the festivities had been declared over, the City officials ordered various structures and attractions to be removed. The Ferris wheel was demolished by dynamite which, contrary to the demolition engineers' hopes that it would fall over on its side, simply crumbled in place.

The scrap handlers used torches to dismember and reduce to a small, manageable size all the component parts except one: the axle. At the time of its manufacture by Bethlehem Steel Company, the axle was the largest single piece of forged steel

ever made in America. It was 45 feet long, 3 feet in diameter and weighed about 86,000 pounds. It was so massive with such a large thermal mass that torches were useless in cutting it down in size. And, it was too heavy and unwieldy to move it far in those pre-truck/tractor days, though teams of mules might have moved it a short distance.



Observation wheel axle - note 6' man standing at right

What happened next, no one knows. Normally, no one would care what happened to a then piece of scrap steel that having performed its function, was condemned to the scrap heap. Nostalgia and a keen sense of history has taken root in St. Louis over these past several decades, at least as far as the St. Louis 1904 World's Fair is concerned. The centennial of the 1904 held was celebrated three years ago. Historians and the public formed The Worlds Fair Society. The visual presence to practically everyone in or around the City of Forest Park, perhaps the most beautiful (after significant funds spent on a major facelift) of major urban parks and the scene of most of the Fair's attractions is there as a touchstone to the special spirit of that period. ("*Meet me to St. Louis, Louis, meet me at the Fair . . .*")

An imagined scenario in 1906 of that moment when a City official charged with cleaning up the area and getting back to the business of a city, ordered his crew boss, "Get rid of that hunka metal. Hide it, bury it, do whatever, but I don't want to see it anymore."

Stories abound about how it was melted down or taken away for its scrap value. Others have said it was probably pulled by a team of mules from the concrete Ferris wheel base to the nearby "Life-Saving pool" (lake) just west of Skinker Blvd at Forsyth (now covered by buildings) and the pool then back-filled. Still other stories related that it might have been dragged by those mules to a dump site near Wydown school where methane gas still emanates from decomposing debris.

Using technical means to attempt to locate the axle, Professor Patrick Shore of the Physics Department at nearby Washington University and his class in 1996 conducted a magnetic survey on the golf course in northwest Forest Park. They did succeed on confirming the location of the Ferris wheel foundation by its large steel bolts and other steel framework -- but no axle. Another remote sensing survey this time using a ground-probing radar, was conducted and appeared to show something along Alexander Drive just west of Skinker. Still another survey, this time using an infrared scanner, was flown over the area and claimed to be able to see thermal indications of the axle under Alexander Drive just a hundred yards or so from Skinker. Based upon that indication, a local TV station sponsored the use of a backhoe to dig at that site, finding only some clay water pipes.

Magnetic Survey

For yet another try to locate this putative axle through technical means, I was invited to ply my skills. My technical background is geophysical exploration for natural resources. As an avocation, I have applied one geophysical method, magnetic surveying, to find items of cultural or sometimes strategic interest. [<http://www.breiner.com/sheldon/press/merlin.html>] With this background, I was contacted by Gene Kiernan, an old friend and a member of the St. Louis World's Fair Society, to conduct a magnetic survey over prospective sites in and around the original location of the Ferris wheel. I was introduced to an archaeologist from Washington University, Dr. Carol Diaz-Granados, who has written papers on, among other things, the subject of the World's Fair. For this survey, I worked closely with her and was guided by her knowledge and judgment of the most likely locales. I considered both the lore and the confirmed background regarding what might have

happened to the axle. The dimensions and general ferromagnetic properties of such a piece of steel were sufficiently known to allow me to plan the survey. Also, I am familiar with the geology of the St. Louis area as it pertains to possible magnetic interference.

The prime areas deemed worth surveying were:

- That part of the golf course just east of Skinker Blvd. and south of Forsyth, and adjacent Skinker near the original site of the Ferris wheel
- The debris burial areas near Wydown School
- Wydown Blvd. from Skinker to the west for about 400 yards
- Alexander Dr. from Skinker to its intersection with Woodbourne Dr.



Proposed areas to conduct magnetic reconnaissance survey, May, 2007

I had arranged for the loan, at no charge, of a very high sensitivity Model G-858G cesium magnetometer (<ftp://geom.geometrics.com/pub/mag/DataSheets/858ds-hires.pdf>) courtesy of its manufacturer, Geometrics of San Jose, California. [Note: access to this \$35,000 instrument at this time was primarily based upon my commitments to conduct a survey for a Manila galleon onshore and offshore at a designated location in Oregon, a project already scheduled to begin two days after the start of my work in St. Louis. Hence, I had little time to devote to this effort.]

Based upon my analysis of the probable magnetic anomaly magnitude and aerial extent, sensitivity was of no importance. The important considerations for success of this survey and its described target in the middle of this urban area over an area of half square mile were: speed of survey, automatic logging of the data, simultaneous input and synchronization of GPS location, and the availability of differential GPS (1 foot absolute position accuracy).

The survey was conducted from 8 AM to 8 PM on Sunday, May 13th, 2007 and 8 AM to 2 PM the following day. I initially conducted several short reconnaissance surveys to assess the magnetic noise background, presence of magnetically-disturbing under-street utilities and possible false magnetic targets. I quickly learned how to react to certain practical considerations such as ducking golf balls on the fairway, dodging cars in the middle of Skinker and avoiding long conversations with locals interested in knowing what in the world I was doing. I covered the various above locations listed and circled in red on the aerial photo/map.



The magnetic target for this survey is large, long, made of steel and, if still present is located in a reasonably small area. The fact that it is long and certainly buried horizontally allowed rather wide spacing of the survey lines. That the axle is made from steel and not just iron means that the magnetic anomaly is due to permanent magnetization, always much larger and easier to detect and/or map. Similarly, the fact that this object was cast as a single piece of steel rather than a number of parts also produces an anomaly which is large and without self-canceling individually-magnetized component parts.



Sheldon Breiner on Skinker Blvd.
with cesium magnetometer, GPS

I modeled the size of the magnetic anomaly to be expected from the axle, starting with the local properties of the earth's magnetic field (using a geomagnetic calculator <http://www.ngdc.noaa.gov/seg/geomag/jsp/struts/calcGridIGRF>)

Intensity 53,472 nanoTesla (0.53 Gauss, or oersteds)
Inclination -67.371° down from horizontal and just east of true north
Magnetic Declination +0.441 °

Consider axle properties relevant to its magnetic detectability:

- 86,000 lbs, or 43 tons
- cast in one piece
- made of steel
- approx 45 feet long
- buried horizontally
- buried locally, due to its large, unwieldy mass

Starting from basic fundamentals, as found in *The Applications Manual for Portable Magnetometers* (<http://www.georentals.co.uk/ampm-opt.pdf>), average iron and steel objects of mixed parts and metallurgy, the intensity is approximately 1 nanoTesla (nT) for one ton at 100 feet. In this case, since it was cast in one piece, the permanent magnetization is the dominant magnetization and larger by a factor of 2 to 3 times what a mixed or mostly induced iron object would exhibit. Thus, 1 ton of such a permanently magnetized single object of average steel would be about 3 nT at 100 feet. The axle weighs 45 tons and would therefore be about 135 nT at 100 feet. At the far-field, the magnetic intensity of an object would vary inversely as the cube of the distance from the magnetometer sensor to the axle center of mass.

The magnetometer sensor would be carried 6 feet above the ground to minimize the magnetic effects of underground utilities, while not diminishing much the very large anomaly of the axle. The axle, if buried under the pressure of a quick burial in 1906,

would not be far from the Ferris wheel and would likely be buried in a shallow trench -- best guess, at about 10 feet deep to its top, or about 12 feet to the center.

Under these assumptions, then, the distance of the magnetic sensor 6 feet above the ground to the center of the axle would be about 18 feet. The anomaly would thus be about $(100/18)^3$ times the magnitude of its magnetic anomaly at 100 feet, or, $166 \times 135 = 22,500$ nT. Added to the earth's magnetic field in St. Louis of 53,000 nT, the sum of the earth's magnetic field and the axle anomaly at its maximum would be thus be about 76,500 nT.

Survey Results

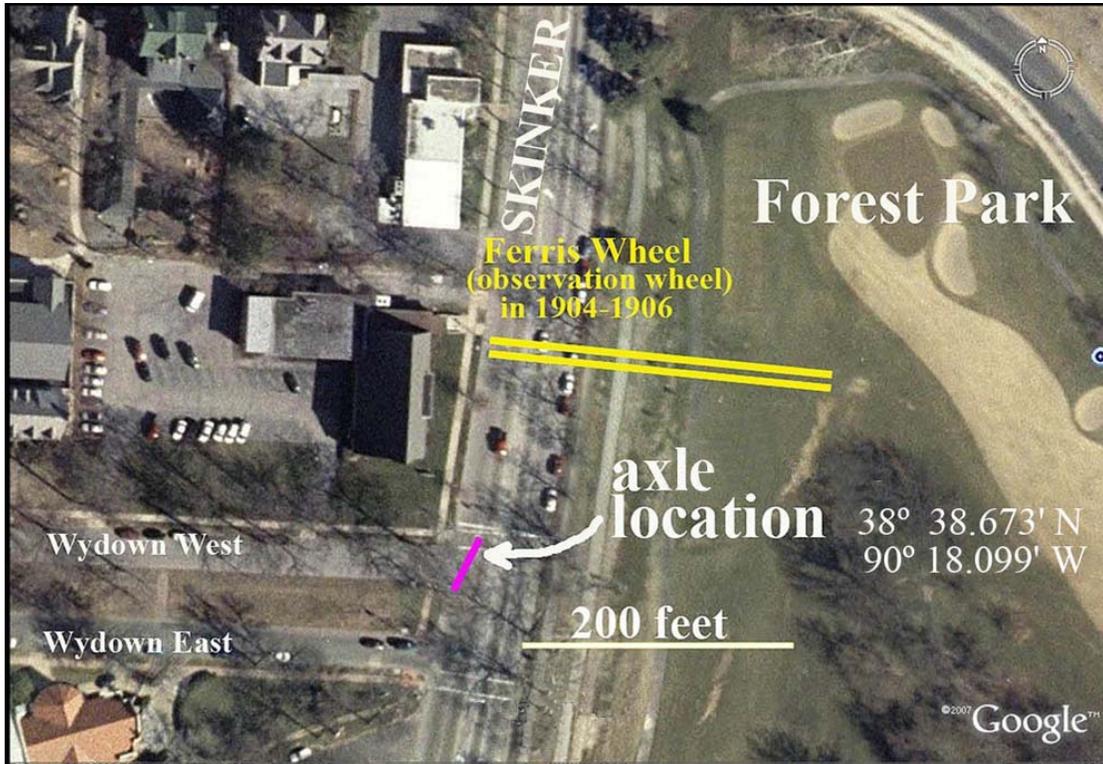
The proposed areas were walked carrying the magnetometer in what is termed, 'search mode' where the data are not recorded, but observed as one walks, making note in real time of anomalies. The sensor on the golf course was carried affixed to the staff with the staff held horizontally about 2' above the ground. In the streets, the sensor was carried at about 6'. Many anomalies were noted on the golf course, some of which were undoubtedly the steel bolts and fixtures related to the Ferris wheel foundation. However, some large anomalies were also noted under Skinker adjacent to the golf course. It was quickly noted that anomalies due to parked (or passing) vehicles were small relative to the very large anomalies noted under Skinker.

The local park on Wydown due east from the school, had virtually no magnetic anomalies of any kind, though it was suspected as being a possible dump site for the Fair. A quick walk-through was carried out in search mode along Wydown Terrace, Alexander Drive, the school yard adjacent to Wydown School and along the east- and west-heading lanes of Wydown near Skinker and the median strip in between.

The gross calculations of magnetic anomaly size and configuration cited above, for what one might expect of the buried axle were, of course, based upon some general assumptions of depth of burial and magnetization (related to its metallurgy and mechanical history). This allowed me to make real-time mental judgments of observed anomalies noted during these reconnaissance surveys in the streets and parkland. As a consequence, I disregarded any anomalies less than, say 5,000 nT or 10,000 nT. Due to limits of survey time or inaccessibility (such as the "Life-Saving Pool" under some buildings near Forsyth), I only covered the areas mentioned. In some sense, I eliminated those areas, with some degree of confidence, if there were no very large anomalies present. This was possible even in the presence of many parked and moving cars since the axle anomaly was estimated to be equivalent to the magnetic effect of 25 average-sized automobiles.

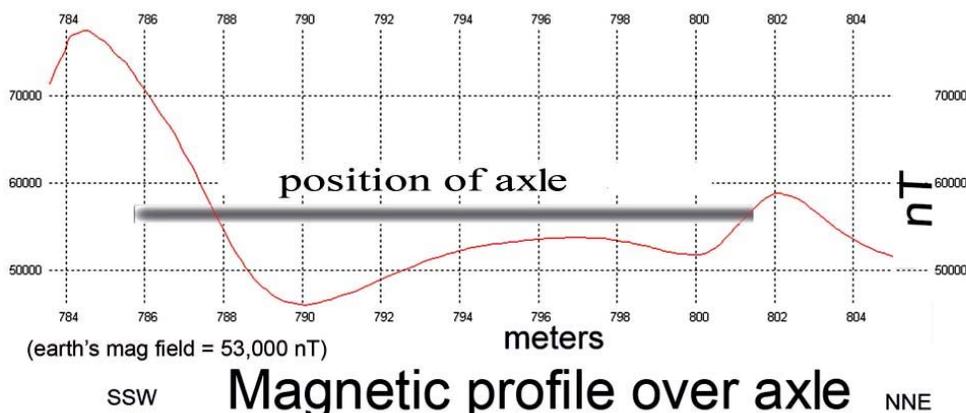
The only anomaly in the areas covered that was large enough to evaluate seriously was found under the southbound lanes of Skinker roadway at its intersection with Wydown. This anomaly was first noted on extensions of lines walked out from the golf course onto Skinker. In the times between traffic flows and stop-light-mediated times, I surveyed all around the site of the anomaly, first in search mode and then, using the differential GPS, in 'survey mode' where the data are recorded. It was important to see if there were any other such large anomalies possibly associated with it, so I surveyed the

width of Skinker and the length from just south of Alexander to a hundred yards north of Wydown. I found no other significant anomalies, though I did not have time to conduct a systematic, gridded survey of the remaining section of the golf course around the Ferris wheel base, nor the area northwest of the Ferris wheel foundation, where the Life-Saving pool was located (buildings there).



Location of axle under Skinker Blvd. at its intersection with Wydown Blvd.

When the anomaly was finally delineated, it appeared to be caused by a long, possibly horizontal, source, trending in a NNE direction, about 200' south of the Ferris wheel base. See graph, below. The observed principal anomaly at its south end was 32,000 nT peak-to-peak and 24,000 nT positive, above the ambient field of 53,000 nT, (77,000 nT). Representing about 50% of the value of the earth's magnetic field., this anomaly is considerably larger than anything originating from sub-street utilities or from any other possible industrial source. The anomaly is not of geologic origin as much of Eastern Missouri is underlain by limestone, a rock which is normally as close to being non-magnetic as any of the common rock types.



That this size agrees fairly well with my crude estimates is largely circumstantial, as the basic fundamentals represented only rough averages accumulated from years of experience of the magnetic effects of iron and steel objects in an urban or industrial context for a variety of unusual industrial, military and cultural/historical objects. Still, I did derive the estimates weeks before I actually arrived on the scene in St. Louis.

Several profiles were obtained along and across the presumed location of the axle. The profile and the modeled profile based upon a steel cylinder 45' long and 3' in diameter are shown in the figure. The south end of the axle is at a depth of between 7' and 10' beneath the pavement at the location indicated in the images shown here. The north end of the axle is not as well defined and could be somewhat deeper, perhaps as a consequence of halting, in mid-stage, the efforts to bury the axle

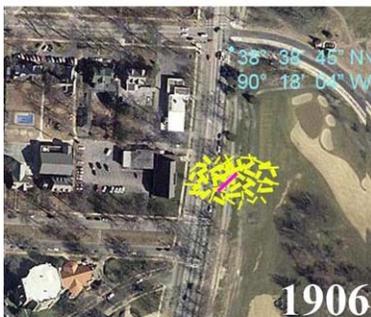


Location of axle under Skinker
(looking NE towards Forest Park)

Below: the axle in its various locations (small pink bar, but actually 45' long)



at the St Louis Fair in the Observation Wheel



immediately after demolition of the Wheel



and today, under Skinker Blvd. at Wydown



Conclusions

Many have a story about what has happened to the axle of the famous Observation Wheel, aka Ferris wheel. Life and spirit revolved -- both figuratively and literally -- around this icon of days gone by from its creation for the 1893 Chicago fair to the 1904 St. Louis Exposition, and since. It continued to have a life for the next century, too, essentially a symbolic one. While no one has set eyes on or touched this steel behemoth since its burial in May, 1906, it appears to have been rediscovered less than 200 feet from its last known sighting.

Let's dig!

Acknowledgments

I want to thank Geometrics, San Jose, CA, for their generous use of the cesium magnetometer. It was a pleasure collaborating with Carol Diaz-Granados on the background history of the axle. I would not have come to St. Louis for this undertaking were it not for the gentle prodding of Gene Kiernan, my fellow Cub Scout in University City in the late 1940s and classmate in University City High School, Class of '55.

Magnetic surveying, see <http://www.georentals.co.uk/ampm-opt.pdf>
sheldon@breiner.com -- in subject line, insert "AXLE"