History of Electronics: Looking at Things

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It is sometimes useful to think of a museum as assuming two roles. Like a library or archive, a museum collects and preserves and organizes–thus making the things for which it is responsible accessible to the public in general and to scholars in particular. But the museum also has taken responsibility for interpreting its collections, most obviously through exhibits but also through catalogs and other publications. In earlier times, extending up through the mid-twentieth century, this second function was commonly muted, and exhibits often seemed to have much in common with the open stacks of a library (indeed, this is often still the case, especially in art museums). But, driven in part by the increasing employment of historians in museums, and aided by relatively inexpensive graphic technologies, exhibits in the post-World War II era have tended more and more to be explanatory and hortatory and persuasive. They have been designed as stories with beginnings and ends, and plot lines connecting the two.

This means that instead of simply putting objects on the floor and letting visitors worry about what they mean, curator-historians are now making those determinations. Which implies that they have spent some time thinking about the kinds of information that can be contained in and conveyed by objects. The consequences of some of that thinking can be found in a book series *Artefacts*, a joint endeavor of the Science Museum (London), the Deutsches Museum (Munich) and the Smithsonian (Washington). [1] In these publications (four have appeared–dealing with medicine, electronics, transportation, images) we have been exploring ways that historians can make use of the evidence available in objects.

I would like to share with you today a tentative list of those categories, using electronic (or electrical) examples.

1. Emotional. You are sitting in an artifact right now. This building, like so many other "historic sites" is preserved because it provides a physical link with the past. On this very spot, within these very walls, events in which we have a special interest and understanding unfolded. We can almost feel the electricity (!) in the air. At the last conference sponsored by the IEEE History Center, in Newfoundland, we saw two other historic sites. One, Signal Hill–where Marconi detected the first trans-Atlantic wireless transmission, was devoid of any physical remains except the ground itself. The other, at Heart's Content–where the first successful Atlantic cable landed–not only sported the cable station, but also an array of transmitting and receiving apparatus.

These are examples of preserved sites that commemorate events. Another class consists of locations that were associated with people. For an indication of the range of associations that can be remembered in this way, consider those that have been preserved in Edison's name: the birthplace in Milan Ohio, a marker at the Menlo Park laboratory site, the West Orange laboratory buildings, his home in nearby Llewelyn Park, his summer home and laboratory in Fort Myers. And, if one will allow a slight stretching of my definition of historic site, the relocated and reconstructed Menlo Park buildings in Dearborn Michigan.

Which moves me in the direction of the artifact itself, no longer in a particular place, but very much a physical connection with a former time. Those vacuum tubes–or valves–that you have in front of you and may be holding in your hands are examples. For most of us they are quaint curiosities, relics of a bygone era. For a few, on the other hand, they may bring forth a flood of memories and emotional responses.

The value of such emotional connections can hardly be underestimated–least of all by museums and by the tourist industry. They are what pull people across long distances, and bring them through the door. These people want to be in the real place, they want to see the real thing. Furthermore, let me suggest that historians are not immune from such emotional pandering; indeed, that it often can act as a stimulus to research and for an understanding of the people and events associated with the "thing."

An example at the object level is the Apollo 11 computer described at this meeting by David Mindell: the emotional significance of that particular flight drew attention to the computer and stimulated analysis of its special characteristics. In the electronics volume of *Artefacts*, already mentioned, there is an article about the pacemaker developed by Earl Bakken, where the first practical design became a symbol for Bakken and for historians. [2]

Bakken Pacemaker
(Courtesy of Bakken Library and Museum)

2. Emotional-2. Because the site or the object is real, because it was there at the time when whatever-it-was-that-happened happened, we may be able to make some useful judgments about how the pertinent person or people at the time felt. Bletchley Park is an especially good example, because we–here, today--have a deeper understanding of what it was like during the war to be in these isolated and extraordinarily pleasant surroundings. And how this may have influenced the people who worked her under such extraordinarily stressful circumstances.

As for the vacuum tubes, I leave it to you to imagine the feelings of those who may have handled them for whatever reasons over the course of the past half century or so. And whether you are thereby provided with any historically provocative insights.

3. Mere existence. In the basic, archaeological sense, the presence of an artifact can provide critical historical evidence–assuming dating and other pertinent contextual information are

available. What was true for prehistoric times is true in the recent past even when documentary evidence is available: we are well aware that a published patent, or an entry in a notebook, or a press release is no guarantee that an invention was actually produced. Antonio Meucci's claims to having invented a telephone would be immeasurably strengthened if someone were to find, someplace in Cuba, the instruments that he later claimed to have made there. Just as the mere survival of several Reis telephones helps to bolster his standing.

It is not unreasonable to presume that a large-enough sample of tubes, taken from a large-enough sample of radio receivers, would provide evidence for the popularity of some manufacturers for whom records are not available. That's a lot of work, which is what being a historian is all about.

Among the telegraph instruments for which I have responsibility there are a number of Morse registers (receivers) from the 1840s and 50s. They are all basically the same, yet also different in various non-essential features. More important, they bear the imprints of different instrument makers, which happens in several cases to be the only evidence we have that those instruments makers made telegraph instruments, or indeed that they made anything at all. Furthermore, this array gives substance to other indications that the companies operating under the Morse patent got their instruments from several sources.

Morse transmitter and receiver
(Courtesy of Smithsonian Institution)

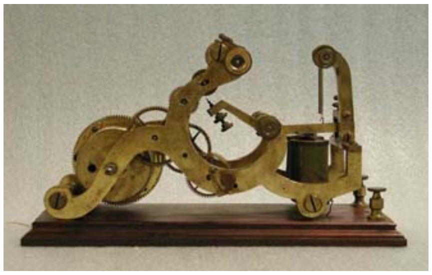
4. Distribution. This is a category for which I don't have a ready example. But one can easily imagine that if I had enough of the above-mentioned telegraph registers, and if I knew where they all were used, I then could draw some conclusions about the popularity of certain makers and the territory they were able to cover.

5. Questions of Design. Arthur Harrison, in an elegant article chronicling the advent of single-control tuning for radio receivers in the 1920s, found that the most effective arrangement–with capacitors mounted on a common shaft–was consistently avoided by manufacturers in favor of side-by-side ganging (using pulleys or a rack-and-pinion arrangement). [3] He argued, persuasively, that the reason for this was a conservative approach to design that dictated sticking with the elongated, shallow box shape associated with multiple-tuning receivers. This bias was broken in the early thirties with a new approach that included incorporation of the speaker into the receiver.

Moving to the microscopic level, Ross Bassett compared Lee Boysel's AL1 chip with Intel's 4004 and 8008. [4] It had the same elements that would have justified calling it (as Intel did for theirs) a "computer on a chip," a view that is reinforced by inspection of design details. Bassett argued that it was differences between the two companies that encouraged different interpretations. For Four-Phase (Boysel) the chip was an element in their own computer product; there was no incentive to emphasize its unique properties–indeed there was a disincentive to do so in order not to encourage copying. For Intel, however, the chips were products in themselves, for which the hyped-up term "computer on a chip" was part of a marketing strategy.

Sometimes a circuit design can help point to the person who constructed it. Paul Ceruzzi has presented evidence that such was the case for the dense-packing techniques of Seymour Cray, giving him clues if not definitive proof regarding the ancestry of a machine he collected for the Smithsonian's Air & Space museum. [5]

A personal example–from the edge of the electronic age–was presented by me in the last conference. Well into the 1920s new graph cable amplifiers were being developed in accord with a sensitive electro-magnetical design invented by William Thomson in the 1870s–even for instruments that incorporated vacuum tubes. I used this in supporting a contention that the industry had become extraordinarily conservative. In the accompanying figures, note that, like Thomson's siphon recorder, in each of the later receivers the recording mechanism is driven by threads connected to a coil suspended between the poles of a magnet.



Telegraph Register by Tillotson, NY
(Courtesy of Smithsonian Institution)

Telegraph Register by Williams, Boston
(Courtesy of Smithsonian Institution)

Telegraph Register by Burritt & Son, Ithaca
(Courtesy of Smithsonian Institution)

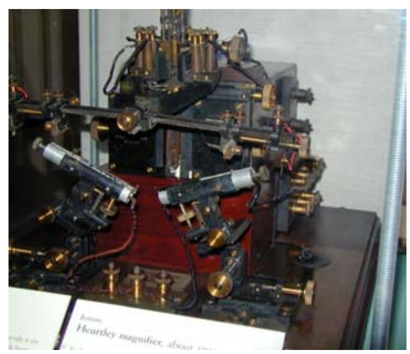
Telegraph Register by Knox & Shain, Philadelphia
(Courtesy of Smithsonian Institution)

And, in this conference, Arthur Bauer provided examples of German developments in diecasting technology in the 1930s to meet chassis design restrictions.

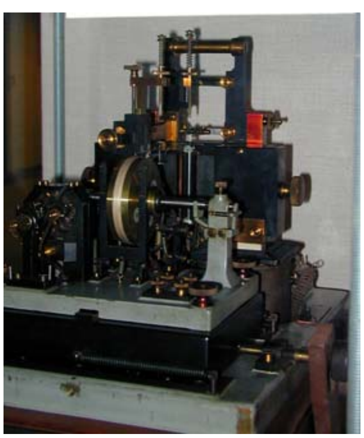
6. Choice of material, evidence of wear, aesthetics, size, etc. These and other physical characteristics can provide important–sometimes unique--information about an object and its history. Some years ago I was involved in putting together a proposal to examine glassware associated with Franklin on the chance that this would help to answer questions about their origins. The proposal was never funded, and the questions remain. A seemingly minor puzzle (to me) involves the use of different materials in the clamps Edison used to hold the filaments in his early lamps. It is possible that a thorough inventory of lamps in various collections, combined with examination of the notebooks, would provide new insights into his inventive process; or perhaps it wouldn't. Or perhaps it would tell us something else.

In a more general sense, consider Morse's original telegraph instrument. The receiver is a rather crude assemblage of wooden clockwork, a magnet, a pencil-holder–all mounted on an artist's frame (canvass-stretcher). The transmitter is a simple crank-driven mechanism for pulling shaped under a lever arm to produce short and long pulses of electricity. In an exhibit we use this as a way of showing that Morse had limited mechanical skills (regardless of how good an artist he was) and that he couldn't afford to hire someone else to make his apparatus for him.

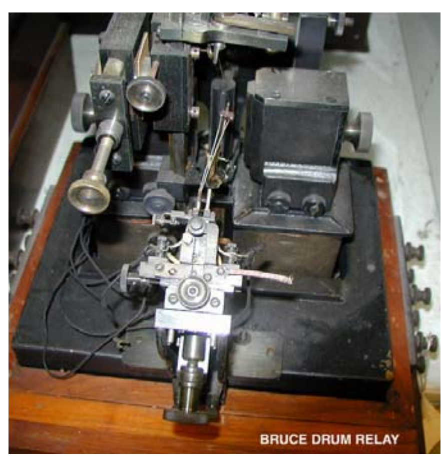
Siphon Recorder
(Courtesy of Smithsonian Institution)



Heurtley Magnifier
(Courtesy of Smithsonian Institution)



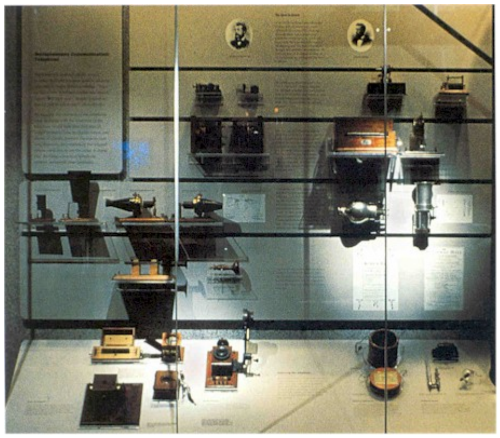
Brown Drum Recorder
(Courtesy of Smithsonian Institution)



Bruce Relay

(Courtesy of Smithsonian Institution)

In another exhibit, a side-by side comparison of surviving artifacts from Bell and Elisha Gray show how close they were to doing the same thing at them same time, thus allowing us to speculate that it was a combination of vision and a lack of experience as an electrical inventor that propelled Bell in the direction of the telephone and kept Gray trying to improve the telegraph.



Bell and Gray instruments in Smithsonian Exhibit *Information Age*
(Courtesy of Smithsonian Institution)

In the present conference, it seems to me that in Kent Lundberg's account the development of the monolithic operational amplifier was strongly influenced by considerations of size and simplicity.

7. Does it work? And how well? One of the puzzles associated with the early history of the telephone has been why Bell, after achieving successful transmission with a variable resistance transmitter, quickly abandoned it for a marginal induction device, reverting back to a carbon resistance design (by others) a little over a year later. A repetition of his experiments with an iron needle dipped in acidulated water confirmed that conversion of voice sounds to undulating electric currents could indeed take place, and that the sounds could be heard with a Bell receiver. [6] But the effect was marginal, and increasing the voltage made things worse instead of better because of static produced by decomposition of the water. This then led us to pose an explanation for the frustration that Bell so forcefully expressed in notebook accounts of his own experiments, as he found that he couldn't reproduce his results from one day to the next. There is no indication that he was concerned about the polarity of his battery, yet depending on which way he connected it in the circuit he would generate oxygen or hydrogen at the interface between the needle in the water–in the latter case producing twice as much gas (and twice as much static) as in the former. Which was just enough to make a marginal success into disappointing failure.

Sticking with telephones for a moment, Sylvanus Thompson provided pretty good documentation that the telephone designed by Philip Reis did indeed transmit speech more than a decade before Bell asked Watson to "come here." [7] But Reis's explanation of the mechanism–

he thought that tones could be produced by intermittent metal-to-metal contact--was almost certainly wrong. Experiments with one of his surviving instruments confirmed its ability to act as a transmitter–though only if one was careful to speak softly and assure that there was no break in contact but rather a change in pressure and therefore of resistance.

Brian Bowers, in his biography of Wheatstone, examines an experimental magneto from about 1860. It has a special feature, the purpose of which, Bowers concludes, must be to sample the output voltage at any of 32 positions as the armature rotates through one cycle–which Bowers does in order to plot a waveform. **[8]** No written record corroborates this interpretation, so the object is left alone to tell us not only how clever Wheatstone was, but also to help explain his approach to future generator designs.

A common experience of those of us who have looked to objects for information is that we don't know what questions to ask, so we don't know what answers we will find. In short, we need to be prepared to expect the unexpected.

Sources:

1. Robert Bud, Bernard Finn, Helmuth Trischler (eds.), *Artefacts: Studies in the History of Science and Technology* (London: Science Museum).

2. David Rhees, Kirk Jeffrey, "Earl Bakken's Little White Box: The Complex Meanings of the First Transistorized Pacemaker," in *Exposing Electronics* (*Artefacts* vol 2, 2000), 75-114.

3. Arthur Harrison, "Single-Control Tuning: An Analysis of an Invention," *Technology and Culture* 20 (1979), 296-321.

4. Ross Bassett, "When is a Microprocessor not a Microprocessor: The Industrial Construction of a Semiconductor Invention," in *Exposing Electronics* (*Artefacts* vol 2, 2000), 115-134.

5. Paul Ceruzzi, "'The Mind's Eye' and the Computers of Seymour Cray," in *Exposing Electronics* (*Artefacts* vol 2, 2000), 151-160.

6. Bernard Finn, "Alexander Graham Bell's Experiments with the Variable-Resistance Transmitter," *Smithsonian Journal of History* 1, no. 4 (1966), 1-16.

7. Sylvanus Thompson, *Philip Reis, Inventor of the Telephone* (London: E.&F.N. Spon, 1883).

8. Brian Bowers, *Sir Charles Wheatstone, FRS, 1802-1875* (London: HMSO, 1975; 2nd edition, : Institution of Electrical Engineers, 2002).