The Baghdad Battery—Myth or Reality?

By Dr. D.E. Von Handorf

Fig. 1—Drawing of vessel found by Konig.[2]

In 1938,[1] Wilhelm Konig, the director of antiquities at the Iraq Museum in Baghdad, was reviewing the findings of archeological digs of a site near Baghdad where the 1936 construction of a rail line had unearthed ancient remains. While it may not be unusual for archeologists to find items in gravesites for which the use is unknown, Konig was taken by one set of four unglazed ceramic vessels found in a grave that was dated in the time of the Parthians occupation of the area (248 BC–226 AD). Three vessels had copper cylinders made of copper sheet with a copper end that was lead-soldered to the bottom of the cylinders. One of these vessels had an iron spike inside the copper cylinder, with the remains of an asphalt-like plug, as shown in Fig. 1. The other two vessels did not have the iron spike inside, but there were other iron spikes in the grave. The fourth ceramic vessel did not have the copper cylinder. Inside the copper cylinders were flaky remains of a papyrus-like material. Konig decided that the vessels looked like galvanic cells that might have been used as shown in Fig. 2. Thus began the story of the Baghdad Battery, and the controversy that surrounds that description.

Nuts & Bolts: What This Paper Means to You

This one-of-a-kind paper is a change of pace for ***P&SF***. Electroplating is on the order of a century old, right? This paper talks about archaeology and plating. In 1936, several artifacts were discovered near Baghdad that have all the makings of galvanic cells. The author carefully discusses the pros and cons that these cells could have been used for electroplating . . . not just a century, but millennia ago. One of our reviewers found this "fascinating!" We hope you do, too.

To add to his commentary, Konig also reported that jewelers in Iraq, contemporary to his living in Iraq, used a rudimentary galvanic cell that reminded him of the finds. Figure 3 shows that the cell consisted of what electroplaters call a *porous pot* containing gold cyanide solution. The pot was placed into a saucepan containing sodium chloride solution. A piece of zinc was placed into the sodium chloride solution and attached with a wire to the item to be gold plated. The item to be plated was subsequently suspended in the porous pot containing the gold cyanide solution. The galvanic potential between the zinc and the item to be plated produced sufficient voltage to affect gold electrodeposition. The porous nature of the inner vessel provided the remaining electrical connection.

A number of reports can be found on the Internet[2,3] that even suggest that the ancients may have received this and other technology from visiting space travelers.[3,4] Gerhard[5] also provides a history of Baghdad battery theory.

A serious discussion by Kanani[6] presents a brief history of the region where these objects were found, and then goes on to demonstrate that a cell constructed like the ones found by Konig can produce about 0.5 V, and can indeed accomplish the electrodeposition of gold from a gold cyanide solution. Kanani also provides some examples of spectacular ancient gold-plated wine horns from the Pantian era, and suggests that only electroplating could explain the gold deposits found on them.

An alternate view is provided by Kurzmann,[7] who insists that the Parthians had no knowledge of batteries. Kurzmann points out that vessels of this type have been found in at least three different locations—some with bronze rods and some with iron rods. He goes on to describe the magic or spiritual meanings that ancient societies ascribed to certain metals and suggests that the vessels were intended to provide some magic to the occupant of the graves. Iron and bronze nails, sometimes with a ring on the end, also might have special meanings to the ancients. He points out that inscriptions on papyrus were sometimes found sealed inside vessels in ancient graves. Kurzmann also notes that the director of the museum of Islamic Art in Berlin agreed that the vessels may well have been symbolic foundations for the corners of the grave.

To provide an important background, Oddy's discussion[8] of the ancient art of gold plating on silver and copper should be considered here. The ancients used three types of plating: foil gilding, gold leaf and fire gilding. These methods were used until the recent invention (reinvention?) of electroplating. Foil gilding involved tucking a thin gold foil into the edges of an artwork, with the foil sometimes being held on the piece with some form of glue. The gold-leaf method involved pounding gold leaf into the art object.

Finally, fire gilding was a process used as early as the third century BC, and involved the use of gold in an amalgam with mercury.

Two types of mercury gilding are described.[8] The first used mercury more as a glue. The art object was polished and a layer of mercury was rubbed into the surface. The gold leaf placed on this surface would partially amalgamate, and the amalgam would adhere to the object. True fire gilding involved the dissolution of the gold, and resulting amalgam was applied selectively to the desired areas. The mercury was then driven off with heat. Both types of mercury gilding are easily identified by the presence of traces of mercury in the gold plating.

The author has had discussions with members of the archaeology field who are not pleased with the battery theory. Peck,[9] of the Detroit Institute of Arts, feels that all of the plated objects from the cultures east of the Mediterranean can be identified as one or the other of the gilding types. In addition, she points out that clay and metal nails were used in Mesopotamia as parts of foundation deposits to magically and symbolically anchor a building for eternity. Peck also points out that the available reports, such as those from Al-Haik,[10] do not specifically state that the vessels and the nails were actually found together as a unit, but only at the same level (and, therefore, the same date).

The subject of the Baghdad Battery is an interesting one, especially to a modern electroplater. Unfortunately the vessels that Konig describes, and the items found with them, are kept at the museum in Baghdad, Iraq. Because of the current political situation, it would be difficult for a curious American AESF member to travel to Iraq to inspect these items. It could be very interesting, however, to consider the possibilities from the viewpoint of a chemist and an electroplater. Could electroplating have been invented in 200–300 BC? Were the materials available at that time? And finally, does the evidence presented in the papers provide convincing arguments that these vessels were, in fact, used as galvanic cells?

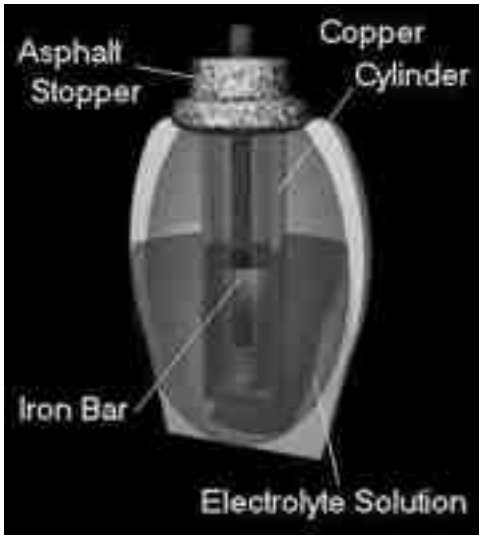

Fig. 2—Drawing of vessel in use as a battery.[4]

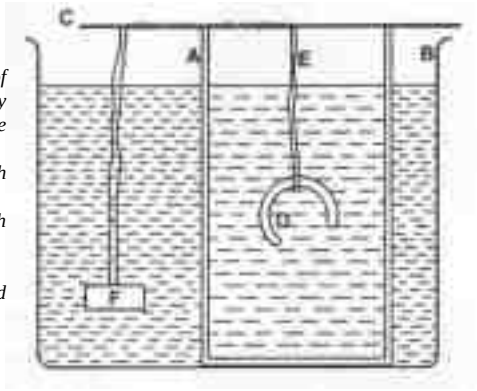

Fig. 3—Drawing of plating cell used by jewelers in the 1930s.[6]
a. Porous vessel with gold solution.
b. Outer pan with salt solution.
c. Suspension rod.
d. Object to be gold plated.
e. Copper wire.
f. Zinc bar.

Mesopotamia & the Tinkerer

While the average chemistry student is seldom very interested in history, we can remember that Mesopotamia—the area between the Tigris and Euphrates rivers—was the birthplace of what we might call "Western" civilization. Other civilizations were developing elsewhere over the millennia before Christ, but as "westerners," we tend to focus on that region and its development. It is also important to us because, during those ages, a tribe of nomads that lived in that same area was lead by the traditional Abraham, and that tribe developed its own culture—which became the basis for Judaism, Christianity and Islam. That tribe was the origin of the modern Jewish and Arabic peoples.

During this development, some very elaborate cultures rose and fell in such a way that some of the cultures were completely lost. We see reports in the popular press of archaeological discoveries rather frequently, and enjoy the visiting shows of artifacts from these cultures at our museums.[11] The artisans of these cultures were often very detailed—as evidenced by the work that survives—and the archaeologists have shown us some of the developments that must have been accomplished by a few "tinkerers" who were allowed to experiment. The gilding techniques described by Oddy[8] were developed by tinkerers over thousands of years. It appears that sometimes a technique was lost for awhile and then reinvented later.

Perhaps one of those tinkerers discovered a simple form of electroplating. While this ancient tinkerer would certainly not have understood the process as we do, he would have had to put all the necessary parts together. First, a means of obtaining an electrochemical potential is necessary. Second, a way to transport that potential to the object to be plated is needed. Third, a plating cell is required that contains the fourth item—a solution of the metal to be plated. The tinkerer would have to have the genius to put it together and recognize what he had accomplished. Perhaps this inventor was so highly respected that some of his instruments were buried with him when he died. He would have had to be highly placed to be given a formal burial, because most artisans were just skilled slaves. We don't usually find their bodies in the ancient graves unless they were killed and buried when the master died. We must examine each aspect of this puzzle and evaluate the information available.

The Source of Potential

The source of potential is the easy part of this analysis. An iron nail in vinegar or wine with the copper tube is all that is needed here. There is no question in any of the articles available that the vessel, as described by Konig, can produce the potential. The hard question is whether it was actually used that way.

While we should not expect the ancient tinkerer/inventor to subscribe to modern conventions, all modern batteries have obvious positive and negative terminals. Konig's vessel has an obvious negative terminal (the iron spike), but the copper cylinder is not made easily available for connection to a plating cell because it apparently was covered completely by the asphalt plug. We will discuss some other possibilities here.

Drawings of Konig's vessel (Fig. 2) that show it used as a galvanic cell usually show the vessel filled with a liquid, such as wine or vinegar. The copper part of the cell, however, is a cylinder with

a sealed bottom, not an open tube. The liquid in the vessel, therefore, would not take part in the electrochemical activities—only the smaller amount of liquid inside the sealed cylinder where the iron spike is suspended. Again, the liquid could have a function as discussed below.

If the vessel were indeed used as a battery when filled with an acid-like vinegar or wine, then copper would have dissolved into the solution. We would not expect to find obvious chemical evidence of the wine or vinegar, but we should see copious evidence of copper salts in the vessel that would not be associated with natural corrosion. The reports are silent about this.

The Transport of the Potential

The ancients did have wire for some of their stringed musical instruments. Most of the strings for instruments probably came from animals, but a lyre was found at Ur[11] from 4,500 years ago that seemed to have a metal wire. The wire had decomposed along with the wooden frame, but the archaeologist carefully filled the holes where they had been to obtain a plaster-of-Paris lyre that had once occupied the space. Although no wire was reported in any of the sites where these vessels were found, a thin wire might have decomposed with time and not been noticed. The extra iron spikes found on the site with the vessels are rather short for this purpose.

Then, as mentioned above, there seems to be no feature on the copper cylinder part of the cell to provide a convenient connection to an external plating cell. But again, the ancient inventor might not use modern conventions.

The Plating Cell

None of the reports from the sites where the vessels were found show us anything that could have been the plating cell. It is possible that the tinkerer/inventors were rather secretive about their art and never allowed anyone to associate the battery with any of the other apparatus. So, when they died, the only part buried with them that was associated with their skill was the battery. Perhaps, however, there were other vessels found in the sites that Konig did not report.

The plating cell described by Konig that was used by Iraqi jewelers in the 1930s is creative, but not at all like the ancient vessel he describes. With the jewelers' arrangement, the saucepan and piece of zinc are the battery and the inner vessel is the plating cell. The vessels found in the Panthian sites would have been the battery. The functions, therefore, are reversed.

The fact that the vessels are unglazed might be important. This would allow them to be used as "porous pots." If Konig's battery vessel was immersed into a larger vessel containing a gold salt solution, then it might be possible to hold the item to be plated on a hook and touch the hook to the iron nail of the battery. The porous pot would provide the second electrical connection. Although there are no reports of hooks found with the vessels, the extra iron spikes found in the graves might have served this purpose. There is another issue. If the vessel were used in this way (*i.e.*, immersed in the plating bath), there would be evidence of gold or silver salts imbedded in the vessel walls. Any larger vessel used should also show traces of gold. No analysis of this sort has been presented.

The Metal Solution

The assumption all along has been that the ancients used the battery to plate gold or silver. In general, in order to plate gold or silver, the plating bath has to have some cyanide. It happens that cyanide is naturally present in our world. Dini[12] recently provided a list of natural food crops that contain significant amounts of cyanide compounds. One of these is a tuber called cassava, which is used as a staple in Africa and apparently has been available since antiquity. The people who use cassava know that it must be soaked in water to leach out the poisons. There are reports,[13] however, that occasionally people neglect to provide the traditional soaking—either because they forgot the tradition or from lack of water. These people are reported to suffer from several degenerative diseases from the constant intake of small amounts of the cyanide compounds.

The cyanide compounds were available from a number of sources, and the ancients were probably well versed in the natural poisons available from the environment. The tinkerer could have experimented with the most powerful materials available, and could well have learned that some gold leaf mixed with concentrated cassava leachings provided the necessary source of a gold solution.

Summary

As practicing electroplaters, we would find it very exciting to believe that electroplating was used thousands of years ago. It is possible that an ancient tinkerer/inventor could have invented an electroplating process using a galvanic cell such as the one discovered by Konig. The electroplating process that Konig found used in Iraq in the 1930s would not be the one used by the ancient artisans of Mesopotamia. The position of the battery would be reversed. The source of potential would be the inner vessel, rather than the outer vessel. A metallic hook could have been fashioned from iron or copper to connect an art object to Konig's vessel while it was immersed into a gold-containing solution. The necessary gold or silver cyanide solution could possibly have been prepared from the cyanide compounds produced by plants—such as the cassava root—that were surely present in ancient times.

There is a question, however, as to whether archaeologists would even have found specimens of this type of art. We must assume that they could not have plated non-conductors like pottery or horns unless some other metal foil—copper foil, perhaps—were first fixed to the art object. Generally, we would expect the artwork to be made of base metals, such as copper, brass, bronze or iron, that would be decorated by this type of plating. Reports from archaeologists[11] suggest that items found in Mesopotamia are usually found heavily corroded. The very thin gold plating from this hypothetical technique could easily have been obscured by the corrosion, and when the archaeologists cleaned the items, the presence of gold or silver could easily be missed. So if such specimens actually existed, they might have been overlooked.

In the end, unfortunately, there are a number of problems with this approach. Konig's vessel should have copper salts on the inside of the ceramic vessel and gold or silver salts on the outside. The iron spikes that were used in the cell should have some immersion-plated copper as a result of being used in a copper-containing solution. There have been no vessels reported from the three sites where Konig's vessels were found that could have been the plating cell. There are no analytical reports showing the presence of gold or silver on the vessels, as would be likely if they took part in gold or silver plating. Finally, there are no plated specimens known to the archaeologists that do not exhibit the traditional forms of gilding. The gold-plated items shown by Kanani[6] may well be examples of mercury gilding.

From the reports that are available, there just isn't enough evidence to allow us to conclude that the artisans of Mesopotamia discovered and used an electroplating process. The presence of papyrus inside the copper tube does strongly suggest that the vessels were used to store written messages on papyrus for the afterworld, which were sealed in the vessels with asphalt plugs. Perhaps the residents of the afterworld received the messages as intended—but Konig obviously did not.

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About the Author

Dr. D.E. Von Handorf, writing under a pen name here, has worked as an R&D chemist in the electroplating field since 1980, and has published approximately 35 papers in the chemical and metal finishing literature. This paper is the first one that was "just for fun."

Editor's note: Questions regarding this paper can be directed to Dr. James Lindsay, technical editor (techeditor@aesf.org).